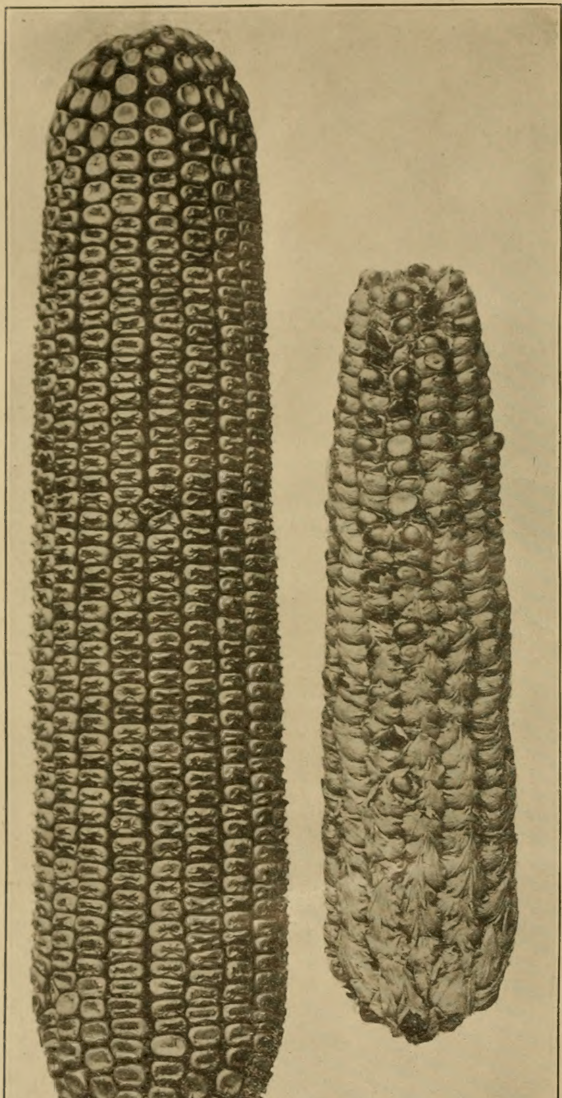

Fig. 1.

THE EAR AS IT IS TODAY AND AS IT WAS (ORIGINALLY).

Pod Corn on the right, and the "Pascal Ear" (Reid's Yellow Dent), Champion of America in 1907, on the left. This ear sold for $150 at the auction of the Iowa Corn Growers' Association.

(*Frontispiece*)

CORN

GROWING JUDGING
BREEDING FEEDING
MARKETING

for the
FARMER *and* STUDENT *of* AGRICULTURE
A TEXT-BOOK *for* AGRICULTURAL
COLLEGES *and* HIGH SCHOOLS

By

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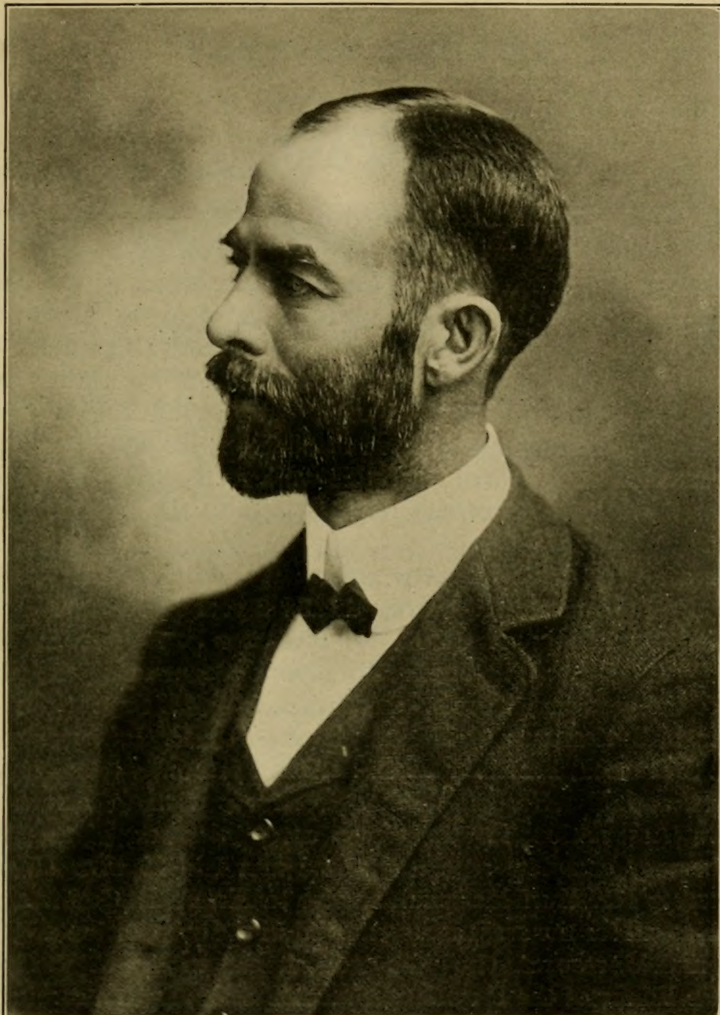
AMES . IOWA

PUBLISHED BY THE AUTHORS

THE KENYON PRINTING & MFG. CO.
PRINTERS AND BINDERS
DES MOINES, IOWA

THIS book is dedicated to one of God's noble men; a kind hearted, whole-souled, untiring laborer for better agriculture; your friend, our friend, Professor P. G. Holden.

The Authors.



With Best Wishes

P. G. Holden

PREFACE

For years there has been a great demand for some book covering more completely the various phases of corn growing, judging, breeding, feeding and marketing. It has been the object of the Authors to make this book of the greatest possible value to the farmer, to the student, and to every one interested in this, America's greatest cereal crop—Corn. Particular pains have been taken to gather and to present in this book the most valuable material that the corn grower and the Experiment Stations have to offer on this subject. No time or expense has been spared to do this work as thoroughly as possible. How well we have succeeded must be left to the judgment of the reader.

We are very much indebted to Professor P. G. Holden, who has frequently been consulted during the 3 1-2 year's time in which this book has been in preparation. To Professor S. A. Forbes, Illinois State Entomologist, who has kindly permitted our using the illustrations of the corn insect pests. To Professor A. H. Snyder, Dr. R. E. Buchanan, Professor L. G. Michael, Professor J. E. Guthrie, Professor W. H. Stevenson, Professor H. G. Bell, Mr. James A. King, Mr. L. C. Burnett, and Mr. Geo. A. Wells, Secretary of the Western Grain Dealers' Association, for their very careful reading of manuscript. For the very complete report and data found in Chapter II, we are indebted to Mr. Murl McDonald. Also to Mr. A. E. Quaife and Mr. E. S. Haskell for the assistance rendered in the preparation of Chapter XVII and V, respectively. We are indebted to Mr. C. V. Gregory, Bulletin Editor of the Iowa Experiment Station, for his careful proof reading and assistance in the preparation of the Index.

The Authors.

Ames, Iowa, October 27, 1908.
Issued December 1, 1908.

TABLE OF CONTENTS

CHAPTER XIX.

THE VARIETIES OF DENT CORN NOW PRINCIPALLY GROWN IN THE CORN BELT.

CHAPTER XX.

CORN BREEDING.

THE FARMER AS A CORN BREEDER.

CHAPTER XXI.

CORN BREEDING.

FROM THE STANDPOINT OF REMAINING PERMANENTLY IN THE BUSINESS.

CHAPTER XXII.

CORN BREEDING.

ILLUSTRATIONS

ILLUSTRATIONS.

ILLUSTRATIONS.

SPECIAL SERIES IN REGARD TO HANGING THE SEED CORN.

DIAGRAMS-MAPS-CHARTS.

COLORED INSERTS OF INSECTS.

CHAPTER I

HISTORY OF THE CORN PLANT

The word "Corn" has been in use from earliest times. At first it signified a grain as we use the term today when speaking of a single kernel, seed or particle. Later the name was applied to all cereal crops in general, and in Europe this custom still prevails. It was not until during the early colonization of America that the name "Corn" was legally accepted in its present application. In one of the counties of Pennsylvania a man had been indicted for stealing so many bushels of corn, and in course of the conflict his counsel took exception to the word as it was used, on the ground that this was not the perfect description of Indian corn. The exception, however, was overruled by court, who thus decided that corn was the established name for Indian corn. The old name Maize is still used to some extent. It is a later construction from ma-hiz, a Haytian word. We also find the term "Indian Corn" used considerably even in the present day.

Derivation of word "Corn"

Some authorities claim that corn is of Eastern origin, and to substantiate this statement they have attempted to show that the cereal was menioned in ancient Chinese literature before Columbus discovered America. Some of our most eminent botanists, however, such as Humboldt and Sturtevant, have very successfully refuted this argument, and they have been able to show conclusively that America is the original home of corn. Traditions have it that as early as the year 1002 A. D. Karlsefn, and again in 1006, Thorfin, both Norsemen, each saw and brought in their ships ears of corn from what is now Massachusetts. But stronger evidence is presented in the ears of corn which have been found with mummies of Mexico and Peru. We know, too, that Columbus discovered corn when he first landed on American soil.

Is corn of eastern origin

As to the distribution of corn in Europe, it is claimed by good authority that Columbus took it back to Spain with him, on the return from his great voyage. From Spain it was taken into France and Italy, although we know that its spread must have been very slow, for it was nearly a hundred years after the discovery of America before we find any mention made of corn in France. From Italy corn was taken into

Spread of corn in Europe

Switzerland and Hungary, and from Hungary to Austria and eastern Europe. From Switzerland it was taken into the valley of the Rhine, and from Portugal corn was introduced into Asia.

Corn culture by the Indians

Indian corn entered into the mythological and religious ceremonies of the Indians, both of South and North America, long before they were disturbed by civilization. When the white man came to live among them they told him how to select the best ears for seed and how and when to plant it. To be sure, their methods were very crude. Since the land was covered by a dense forest it was necessary first that this should be cleared away. This the Indians did by burning a ring around the base of the trunk of the tree and by scraping away the charred bits until the tree could be blown over. Often, however, they would first girdle the tree with a rough stone axe and allow it to die before burning was attempted. When spring came, the squaw, who did the most of this work, proceeded to plant the corn. With a sharp stick she made holes in the ground about four feet apart, and after putting a fish or several crawfish into each hole she planted the seed on top of this and covered it over with soil. The fish were used as fertilizer. In the fall the corn was picked and stored away in pits dug in the ground. Such then, we are led to believe, were the methods adopted by our forefathers when they began farming on our native soil.

Early settlers soon cultivated corn

The first successful attempt of the English to cultivate corn in North America was in 1608, along the James river in Virginia. A year or two later it is said that as much as thirty acres of corn were cultivated there. It is recorded that as early as 1650 corn to the extent of 600 bushels was exported from Savannah, and by 1770 the amount exported from this same place had reached 13,598 bushels. However, during the period intervening numerous exportations are recorded ranging from 10,000 to 250,000 bushels, so we know that even at this early date more corn was raised than was needed for home consumption. In 1770 the total amount exported from the colonies was 578,349 bushels, and in 1800, 2,032,435 bushels were exported. By this we see that the development during this period was very rapid, at least considering the fact that agricultural implements were little known, and that there were no transportation facilities to speak of. The main increase in production was the result of increased acreage.

Teosinte

As to the origin of the corn plant itself, some botanists have endeavored to show that Teosinte, a rank-growing forage plant, is its progenitor. Teosinte is a native Mexican plant and is called by Watson "Zea canina." Recently Montgomery has expressed a similar theory. He states that corn and Teosinte may have had a common origin, and he intimates that in the process of evolution it is probable that the pistillate spikes in Teosinte were developed from the lateral branches of a tassel-like structure, while corn was developed from the central spike. Further, he suggests that the progenitor of these plants was a large, much branched grass, each branch being terminated by a tassel-like structure.

Bailey also expresses an opinion that Zea canina may not be a distinct species from our common corn. He mentions the tendency of some varieties of sweet corn to occasionally produce multiple rudimentary ears, and of the canina to lose them under cultivation, as a point in favor of the theory of the relation. The tendency of cultivation in all plants is to develop some parts and organs rather than all parts and all organs. The tendency to sucker, to produce tassels on the ends of the ears, the profuse drooping tassels of the flint corn and kindred varieties, or pointed kernels, and the occurrence of these peculiarities in the aboriginal corn in the Aztec region tends to emphasize the relation that exists between the varieties. Zea canina

From the natural characteristics of the corn plant we may safely conclude that the distribution of the species was necessarily of an artificial nature, for the seed has no wing or appendage which would permit it to be blown about by the wind. Furthermore, the perishable nature of the seed was directly opposed to Nature's methods of scattering the species. It seems safe to assume that the species that exist today have either been developed by man and perpetuated by this same agency, or that man came upon the plant soon after its useful development and at once began to cultivate it. There are at present eight species of the genus Zeas.

In 1814 there were only five varieties of corn (Zea Mays) known, i. e., Big Yellow, Big White, Little Yellow, Little White and Gourd-seed. Both the large and small varieties were flinty, corresponding to the old type of flint corn. The gourd-seed corn represents perhaps the first step in the development of the dent corn of today. It was characterized by a deep, pointed, soft kernel of either white or yellow color. By 1840 nearly forty varieties were known. These were based primarily upon color, size of ear, and density of kernel. At least one of our present standard breeds had its origin previous to that time and others soon followed.

CHAPTER II

ACREAGE, DISTRIBUTION, PRODUCTION AND VALUATION

ACREAGE DEVOTED TO CORN GROWING

The total area of land devoted to corn growing in the United States in 1907 amounted to 99.931,000 acres. If combined into a single field it would cover the entire land surface of the three states, Iowa, Illinois, and Ohio. Since 1870 nearly 12 per cent of all land classed as farm land and over 20 per cent of all improved farm land has been planted with corn each year. This would be equivalent to an 80-acre field in every section of farm land, or a 130-acre field in every section of improved farm land.

The increase in the acreage of corn has been for the past 40 years uniformly parallel to the increase in the area of farm land. The following chart illustrates this increase from the year 1866 to 1908:

CHART NO. 1.

Acreage of corn in the United States from 1866-1907.

Millions of Acres.

NOTE.—The acreage designated in the above chart represents the average acreage for the periods indicated in the margin to the left.

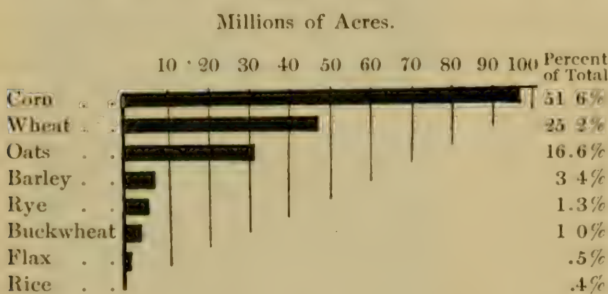
From the foregoing it is seen that the period of greatest increase was from 1880 to 1890, being 61.2 per cent, and the period of slightest variation was from 1890 to 1900, being only 7.2 per cent. Climatic conditions and the state of the general market have been perhaps the most important factors in this increase.

For the past 40 years the acreage devoted to corn growing has been slightly greater than that of all other cereals combined. In fact, 52 per cent of the entire area devoted to cereal crops, including corn itself, has been devoted to this crop. So constant has been this proportion that it has not varied 1 per cent either way during the entire period mentioned above.

The following chart will show the relative acreage of the cereal crops of the United States in 1906:

CHART NO. 2.

Comparative acreage of all cereals in the United States for 1906.



In considering briefly the acreage devoted to corn growing in each ot the ten states which have been leading in the production of this great cereal during the past few years, note the following table:

TABLE I.

ACREAGE OF CORN AS COMPARED WITH TOTAL ACREAGE OF ALL FARM LAND IN EACH OF THE TEN STATES LEADING IN ITS PRODUCTION IN 1900.

State	Acres of Farm Land	Acres in Corn	Per cent
Illinois	32,794,728	7,139,898	21.8
Iowa	34,574,337	8,048,946	23.3
Missouri	33,997,873	6,453,943	18.9
Nebraska	29,911,779	8,093,464	27.1
Indiana	21,619,623	4,031,600	19.1
Texas	125,807,017	4,553,495	3.6
Kansas	41,662,970	8,624,770	20.7
Ohio	24,501,985	2,888,924	11.8
Oklahoma	15,719,258	544,000	3.5
Kentucky	21,979,422	2,664,124	12.1
Total		53,043,164	

Taken from Census Report of 1900.

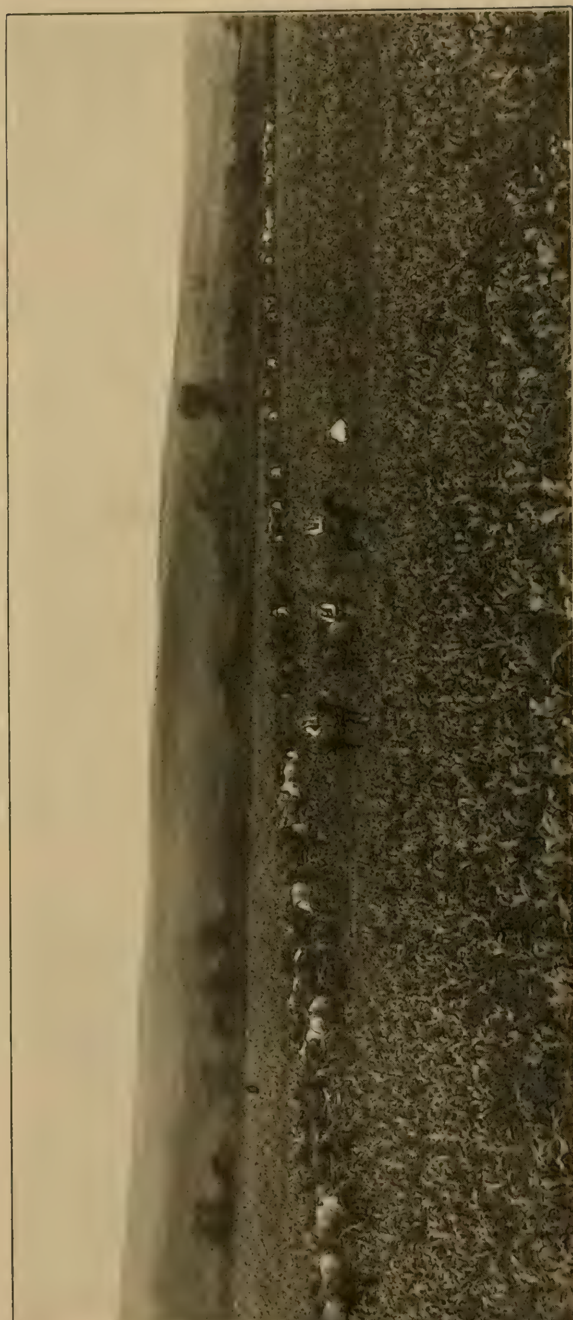


Fig. 2.
(Courtesy Midland Mfg. Co.)
David Rankin, of Tarkio, Missouri, Directing the Cultivation of a Thousand Acre Field.

These ten states represent nearly 56 per cent of the total acreage of corn grown in the United States. It is seen that Kansas led in 1900, with Nebraska second. In Nebraska we find the highest percent of all farm land devoted to the production of corn. While no doubt most of these states have reached their maximum acreage limit, the rapid strides made by Oklahoma in the past, and the low percentage of available land at present utilized in corn growing, bespeak for this state a more prominent place in the future. However, this country has now reached a point where increased acreage will play a minor role in the increased production of this great cereal in the future.

PRODUCTION AND DISTRIBUTION

The world's corn crop in 1906 amounted to 3,886,207,000 bushels. In one year there was produced enough corn to fill a double crib 16 feet wide to a uniform depth of eight feet for a length of 7,200 miles. This crib would extend from New York City to San Francisco, or if all of this corn were to be piled on a square mile of ground the pile would be 175 feet high.

There were concerned in this production five continents, including 22 different nations. A careful study of the following table will show the amount of corn produced by each country from 1899 to 1908; also which countries have been the heaviest producers.

PRODUCTION OF CORN BY COUNTRIES, 1899-1908.

TABLE NO. 2.

Country	1899	1900	1901	1902
United States	2,078,144,000	2,105,103,000	1,522,520,000	2,523,648,000
Canada (Ontario)	22,356,000	27,947,000	25,621,000	21,159,000
Mexico	93,438,000	92,204,000	93,459,000	78,099,000
Total North America	2,193,938,000	2,225,254,000	1,641,600,000	2,622,906,000
Argentine	66,185,000	56,612,000	98,842,000	84,018,000
Chile	9,000,000	1,500,000	1,500,000	866,000
Uruguay	6,000,000	3,035,000	5,576,000	5,060,000
Total South America	81,185,000	60,147,000	105,918,000	89,944,000
Austria-Hungary—Austria	14,583,000	15,446,000	17,535,000	13,462,000
Hungary proper	115,981,000	127,656,000	127,389,000	104,546,000
Croatia Slavonia	14,068,000	18,691,000	20,469,000	15,255,000
Bosnia Herzegovina				
Total Austria-Hungary	144,632,000	161,793,000	165,393,000	133,263,000
Bulgaria	20,462,000	18,000,000	25,000,000	18,109,000
France	25,548,000	22,232,000	26,393,000	24,928,000
Italy	88,536,000	87,969,000	100,455,000	71,028,000
Portugal	16,000,000	16,000,000	15,000,000	16,000,000
Roumania	27,721,000	85,047,000	116,945,000	68,447,000
Russia	30,912,000	34,256,000	68,400,000	48,647,000
Servia	15,000,000	18,472,000	18,849,000	18,396,000
Spain	24,667,000	26,016,000	25,759,000	25,272,000
Total Europe	394,090,000	469,785,000	562,194,000	424,090,000
Algeria	349,000	350,000	529,000	556,000
Cape of Good Hope	2,858,000	2,000,000	2,000,000	2,000,000
Egypt	30,000,000	25,000,000	30,000,000	30,000,000
Natal				
Sudan				
Total Africa				
Australia				
New Zealand				
Total Australasia	9,780,000	10,025,000	10,168,000	7,847,000
Grand Total	2,711,200,000	2,792,561,000	2,352,309,000	3,177,343,000

America first

At a glance it is seen that North America and particularly the United States has been far in the lead. Europe follows in second place, but there is a very wide margin between the two continents.

Europe second

The highest total world's production occurred in 1906, and the lowest during the period recorded, in 1901. The report for 1907 is not as yet completed, but a marked decrease is noted in practically every country. The season was extremely unfavorable throughout the corn belt.

Basing our conclusions on the crop of 1906 we find that 16 countries show an increase in production during the past nine years, two countries show neither an increase nor a decrease, and seven show an actual decrease.

PRODUCTION OF CORN BY COUNTRIES. 1899-1908.

TABLE NO. 2. (con.)

Country	1903	1904	1905	1906	1907
United States	2,244,177,000	2,467,481,000	2,707,994,000	2,927,416,000	2,592,320,000
Canada (Ontario)	30,211,000	20,880,000	21,582,000	24,745,000	22,949,000
Mexico	90,000,000	90,000,00	89,000,000	70,000,000	85,714,000
Total North America	2,364,388,000	2,578,361,000	2,818,576,000	3,022,161,000	2,700,983,000
Argentine	148,422,000	175,189,000	140,708,000	194,912,000	89,193,000
Chile	1,118,000	1,477,000	1,000,000	846,000	
Uruguay	5,289,000	3,035,000	4,417,000	3,226,000	5,359,000
Total South America	154,829,000	179,701,000	146,125,000		
Austria-Hungary,					
Austria	16,056,000	12,529,000	17,293,000	18,177,000	16,914,000
Hungary proper	135,751,000	59,400,000	94,042,000	162,923,000	155,617,000
Croatia Slavonia	23,918,000	11,434,000	18,385,000	25,600,000	27,600,000
Bosnia Herzegovina			9,584,000	8,936,000	7,748,000
Total Austria-Hungary	175,725,000	83,363,000	139,304,000	215,636,000	207,879,000
Bulgaria	22,836,000	18,000,000	19,649,000	20,000,000	12,000,000
France	25,360,000	23,000,000	24,032,000	14,581,000	
Italy	88,990,000	87,000,000	97,859,000	93,007,000	59,429,000
Portugal	14,000,000	15,000,000	16,000,000	16,000,000	
Roumania	80,272,000	19,598,000	59,275,000	130,546,000	57,576,000
Russia	50,732,000	26,032,000	33,551,000	59,320,000	41,903,000
Servia	19,479,000	9,498,000	21,431,000	27,786,000	17,691,000
Spain	18,759,000	21,300,000	31,900,000	30,000,000	25,372,000
Total Europe	496,153,000	302,791,000	442,999,000	618,057,000	
Algeria	435,000	410,000	400,000	544,000	
Cape of Good Hope	3,502,000	3,000,000	3,000,000	3,000,000	
Egypt	30,000,000	30,000,000	30,000,000	30,000,000	34,286,000
Natal			4,822,000	4,000,000	
Sudan			232,000	300,000	
Total Africa	33,937,000	33,410,000	38,454,000	37,844,000	
Australia			8,374,000	8,608,000	10,505,000
New Zealand			506,000	653,000	419,000
Total Australasia	5,615,000	10,519,000	8,884,000	9,261,000	10,924,000
Grand Total	3,054,922,000	3,104,782,000	3,455,038,000	3,886,207,000	

The only countries which have made any phenomenal progress are Roumania and Argentine Republic. The former has multiplied its production of 1899 nearly five times, and the latter has trebled its production. The United States shows an increase of nearly 50 per cent. **Roumania**

While it is not likely that Roumania will become a dangerous competitor to our own country, owing to limited area, yet with Argentine it is a different matter. In 1899 Argentine's production only amounted to 3.1 per cent that of the United States, while in 1906 it reached 6.6 per cent. The United States has practically reached its acreage limit, while Argentine's agriculture is still in its infancy. With an almost unlimited area, a remarkably adaptable climate and **Argentine** virgin soil fertility, Argentine's hope of at least approaching the cereal production of our country is by no means a vain one.

A more comprehensive view of the relative production and distribution of corn may be found by studying the following tables:

PERCENTAGE OF WORLD'S PRODUCTION OF CORN BY CONTINENTS FROM 1899-1908.

TABLE 3.

Continent	1899	1900	1901	1902	1903	1904	1905	1906	1907	Av.
North America	80.0	79.7	67.7	82.5	77.4	83.0	81.5	77.8	82.4	79.2
Europe	14.5	16.7	23.8	13.3	16.2	9.7	12.8	15.9	13.1	15.1
South America	2.9	2.1	4.5	2.8	5.0	5.7	4.2	5.1	2.9	3.9
Africa	1.2	.9	1.3	1.0	1.1	1.0	1.1	.9	1.0	1.0
Australia	.3	.3	.4	.2	.1	.3	.2	.2	.3	2.5
New Zealand	....	....	....	....	....	....	.01	....	....	....

Figures taken from special report from U. S. Department of Agriculture.

RANK, PERCENTAGE OF WORLD'S PRODUCTION AND DISTRIBUTION OF CORN BY COUNTRIES, 1899-1908.

TABLE NO. 4.

Country	R'k	1907	R'k	1906	R'k	1905	R'k	1904
United States	1	73.3	1	75.3	1	78.3	1	79.4
Austria Hungary	2	6.3	2	5.5	3	3.6	5	2.6
Argentine	3	2.7	3	5.0	2	4.0	2	5.6
Mexico	4	2.6	6	1.9	5	2.5	3	2.8
Italy	5	1.8	5	2.4	4	2.8	4	2.8
Roumania	6	1.8	4	3.5	6	1.7	11	.6
Russia	7	1.6	7	1.8	7	.9	7	.9
Egypt	8	1.0	10	.7	9	.8	6	.9
Spain	9	.8	8	.8	8	.9	10	.6
Ontario	10	.7	11	.6	10	.6	9	.6
Servia	11	.5	9	.7	12	.6	14	.3
Bulgaria	12	.3	12	.5	13	.5	12	.5
Uruguay	13	.2	17	.1	16	.1	16	.1
Australia	14	.3	15	.3	15	.2	15	.3
New Zealand	15	*	20	*	20	*	20	*
Chili	16	**	19	*	19	*	17	*
France	17	**	14	.3	11	.6	8	.8
Portugal	18	**	13	.4	14	.4	13	.4
Algeria	19	**	21	*	21	*	18	*
Cape Colony	20	**	18	.1	18	.1	19	*
Natal	21	**	16	.1	17	.1	21	*
Sudan	22	**	22	*	22	*	22	*

*Less than one-tenth per cent.

**Countries not reported in 1907.

RANK, PERCENTAGE OF WORLD'S PRODUCTION AND DISTRIBUTION OF CORN BY COUNTRIES, 1899-1908.

TABLE NO. 4. (con.)

Country	R'k	1903	R'k	1902	R'k	1901	R'k	1900	R'k	1899
United States	1	73.4	1	79.4	1	64.7	1	75.3	1	76.6
Austria Hungary	2	5.8	2	4.0	2	6.9	2	5.7	2	5.2
Argentine	3	4.8	3	2.6	5	4.2	6	1.9	5	2.4
Mexico	4	2.9	4	2.4	6	3.9	4	3.3	3	3.4
Italy	5	2.9	5	2.2	4	4.2	5	3.1	4	3.2
Roumania	6	2.6	6	2.1	3	4.9	3	3.4	8	1.0
Russia	7	1.6	7	1.5	7	3.0	7	1.2	6	1.2
Egypt	8	.9	8	.9	8	1.2	10	.8	7	1.1
Spain	12	.6	10	.7	11	1.0	9	.9	10	.9
Ontario	9	.9	11	.6	10	1.0	8	1.0	11	.8
Servia	13	.6	14	.5	13	.8	13	.6	13	.5
Bulgaria	11	.7	13	.5	12	1.0	12	.6	12	.7
Uruguay	16	.1	16	.1	16	.2	16	.1	17	.2
Australia	17	.1	15	.2	15	.4	15	.3	14	.3
New Zealand	20	*	18	*	20	*	20	*	20	*
Chili	15	.3	20	*	18	.1	18	.1	16	.3
France	10	.8	9	.7	9	1.1	11	.7	9	.9
Portugal	14	.4	12	.5	14	.6	14	.5	15	.5
Algeria	19	*	19	*	17	.1	19	*	19	*
Cape Colony	18	.1	17	.1	19	*	17	.1	18	.1
Natal	21	*	21	*	21	*	21	*	21	*
Sudan	22	*	22	*	22	*	22	*	22	*

*Less than one-tenth per cent.

In table No. 3, showing relative production by continents, it is seen that North America produces four times as much corn as all other continents combined. The second table, No. 4, goes still further and shows that the United States alone annually produces nearly four-fifths of the entire world's crop. Foremost of the remaining countries stand Austria Hungary, Argentine Republic, Mexico, Italy, and Roumania, but the production of these five countries together is only about one-sixth of the production of the United States.

PRODUCTION OF CORN IN THE UNITED STATES

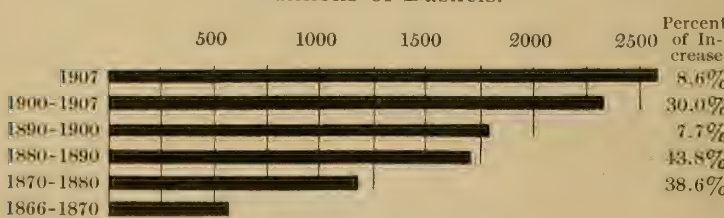
It has been stated previously that the United States produce annually four-fifths of the world's corn crop. In 1906, which was the year of our greatest production, this amounted to 2,927,416,000 bushels.

The production of this important cereal has from the earliest times kept pace with the wide spread of civilization and agriculture. The progress made during the past half century is best illustrated by the following chart:

CHART NO. 3.

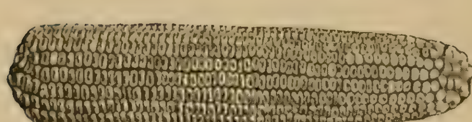
Increase in the Production of Corn in the United States from 1866-1907.

Millions of Bushels.



Note—The percentage of increase is figured on the average production designated on the chart for the periods indicated in the left margin.

The period of greatest increase was from 1880 to 1890, and the following decade shows the least increase of any period recorded.



A more thorough knowledge of the progress made during the past half century may be gained from the following table:

PRODUCTION OF CORN IN THE UNITED STATES FROM 1866-1907.

TABLE NO. 5.

Year	Acreage	Yield Bushels		Value	
		Total	Per Acre	Total	Per Bu. Cents
1866	34,306,538	867,946,295	25.3	$411,450,830	47.4
1867	32,520,249	768,320,000	23.6	437,769,763	57.0
1868	24,887,246	906,527,000	26.0	424,056,649	46.8
1869	37,103,245	874,320,000	23.6	522,550,509	59.8
1870	38,646,977	1,094,255,000	28.3	540,520,456	49.4
1871	34,091,137	991,898,000	29.1	430,355,910	43.4
1872	35,526,836	1,092,719,000	30.8	385,736,210	35.3
1873	39,197,148	932,274,000	23.8	411,961,151	44.2
1874	41,036,918	850,148,500	20.7	496,271,255	58.4
1875	44,841,371	1,321,069,000	29.5	484,674,804	36.7
1876	49,033,364	1,283,827,500	26.2	436,108,521	34.0
1877	50,369,113	1,342,558,000	26.7	467,635,230	34.8
1878	51,585,000	1,388,218,750	26.9	440,280,517	31.7
1879	53,085,450	1,547,901,790	29.2	580,486,217	37.5
1880	62,317,842	1,717,434,543	27.6	679,714,499	39.6
1881	64,262,025	1,194,916,000	18.6	759,482,170	63.6
1882	65,659,545	1,617,025,100	24.6	783,867,175	48.5
1883	68,301,889	1,551,066,895	22.7	658,051,485	42.4
1884	69,683,780	1,795,528,432	25.8	640,735,859	35.7
1885	73,130,150	1,936,176,000	26.5	635,674,630	32.8
1886	75,694,208	1,665,441,000	22.0	610,311,000	36.6
1887	72,392,720	1,456,161,000	20.1	646,106,770	44.4
1888	75,672,763	1,987,790,000	26.3	677,561,580	34.1
1889	78,319,651	2,112,892,000	27.0	597,918,829	28.3
1890	71,970,763	1,489,970,000	20.7	754,433,451	50.6
1891	76,204,515	2,060,154,000	27.0	836,439,228	40.6
1892	70,626,658	1,628,464,000	23.1	642,146,630	39.4
1893	72,036,465	1,619,496,131	22.5	591,625,627	36.5
1894	62,582,269	1,212,770,052	19.4	554,719,162	45.7
1895	82,075,830	2,151,138,580	26.2	544,985,534	25.3
1896	81,027,156	2,283,875,165	28.2	491,006,967	21.5
1897	80,095,051	1,902,967,933	23.8	501,072,952	26.3
1898	77,721,781	1,924,184,660	24.8	552,023,428	28.7
1899	82,108,587	2,078,143,933	25.3	629,210,110	30.3
1900	83,320,872	2,105,102,516	25.3	751,220,034	35.7
1901	91,349,928	1,522,519,891	16.7	921,535,768	60.5
1902	94,043,613	2,523,648,312	26.8	1,017,013,349	40.3
1903	88,091,993	2,244,176,925	25.5	952,868,801	42.5
1904	92,231,581	2,467,480,934	26.8	1,087,461,440	44.1
1905	94,011,369	2,707,993,540	28.8	1,116,696,738	41.2
1906	96,737,581	2,927,416,091	30.3	1,166,626,479	39.9
1907	99,931,000	2,592,320,000	25.9	1,336,901,000	51.0

This shows the annual increase in acreage and production, the average yield per acre, total value of corn crop and price per bushel. A little study will show the relation that exists between acreage and production, and the relation between average yield per acre and price per bushel.

It has been stated by some authorities that the corn grown per capita has been rapidly decreasing, but the census report, together with the annual report from the United States Department of Agriculture, reveals facts to the contrary. Note the following table:

TABLE NO. 6.

Year	Population	Total Production in United States (Bushels)	Corn per Capita (Bus.)
1850	23,191,876	592,071,104	25.5
1860	31,443,321	838,792,742	26.6
1870	38,558,471	760,944,549	19.7
1880	50,155,783	1,754,591,676	34.9
1890	62,622,190	2,122,327,547	33.8
1900	75,997,873	2,666,440,279	35.0

By referring to table No. 5 we find that the average yield per acre has remained practically constant since the early history of our country. Indeed, back as early as 1790 an average yield of 30 bushels was recorded. It was possible to raise 100 per acre before 1830, and old Agricultural Society Reports show that such yields were about as common then as they are today.

(Courtesy Denning Fence Company)

Fig. 3.

A Western Corn Field Full to Overflowing.

The highest yield per acre ever recorded was produced by Z. J. Drake, of Marlboro county, South Carolina, in 1889. On a single acre he grew 255 bushels of corn, shelled. However, much fertilizer, previous care, and subsequent cultivation, were found to be necessary. Nevertheless, Mr. Drake has shown what can be done, and he has given to every corn grower a goal to strive for.

Highest yield ever recorded

The lowest average yield occurred in 1901. It amounted to 16.1 bushels. It will be remembered that that year was extremely unfavorable to corn growing from nearly every standpoint. The spring was cold and damp and the summer exceedingly warm with little rainfall.

Lowest average yield

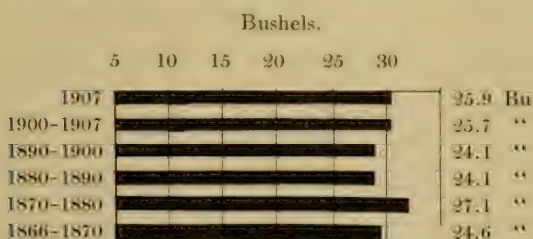
The highest average yield recorded was produced in 1872. In that year 30.8 bushels of corn were produced for every acre of ground planted. The climatological report shows only an average season. The spring was backward, but July showers and sunshine gave the needed encouragement.

Highest average yield

The following chart shows the average yield from 1866 to 1907:

CHART NO. 4.

Yield per Acre in United States from 1866-1907.



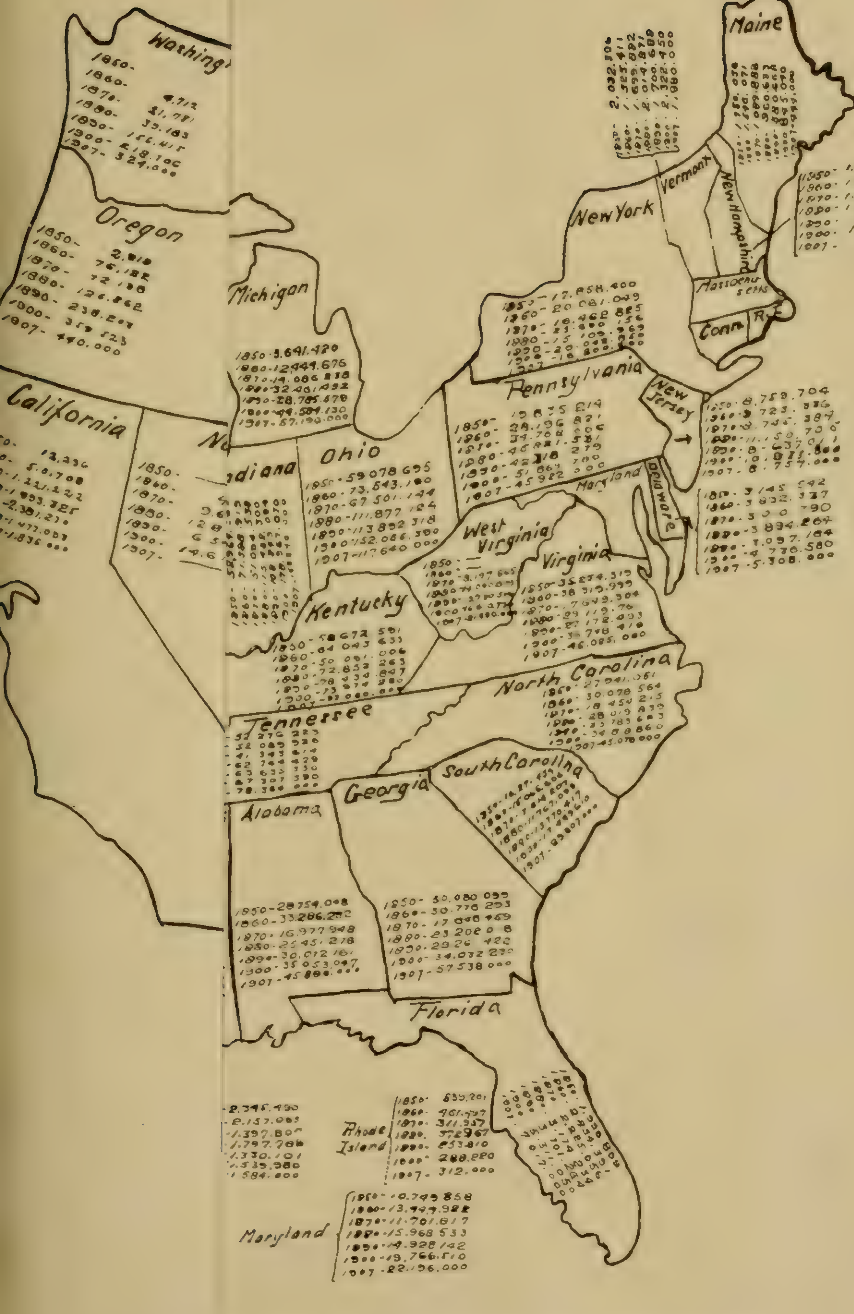
Note—The yields designated represent the average yield for the periods indicated to the left of chart.

In order that we may have some idea in regard to the rate of production among the several states of the Union it will be well to give some attention to the following table:

AVERAGE YIELD PER ACRE. 1879-1908.

Rank		Bushels	Rank		Bushels
1	New Hampshire	38.9	26	Nevada	25.2
2	Ohio	38.0	27	West Virginia	24.8
3	Iowa	37.9	29	Oklahoma	23.7
4	Vermont	37 9	29	South Dakota	23.3
5	Massaceusetts	37.2	30	Arizona	23.3
6	Illinois	36 9	31	Oregon	22.7
7	Connecticut	35.9	32	Tennessee	22 6
8	Maine	35.3	33	Delaware	22.3
9	Indiana	34.4	34	Montana	22.1
10	Pennsylvania	33.7	35	Washington	20.7
11	New Jersey	33.4	36	New Mexico	20.3
12	Nebraska	33 1	37	Virginia	19.4
13	Wisconsin	32 9	38	North Dakota	19.4
14	Rhode Island	32 6	39	Texas	19.3
15	Missouri	31.9	40	Arkansas	18.9
16	Michigan	31.0	41	Utah	18.9
17	California	30.8	42	Wyoming	18.9
18	District of Columbia	30.7	43	Colorado	17 8
19	Minnesota	30.3	44	Mississippi	15.7
20	New York	30.3	45	Louisana	15.7
21	Kansas	29.1	46	Alabama	13.7
22	Maryland	28.4	47	North Carolina	13.1
24	Indian Territory	26.0	48	South Carolina	11 0
24	Idaho	25.3	49	Georgia	10.8
25	Kentucky	25.3	50	Florida	9.8

NOTE—In the above table Oklahoma, South Dakota, Wyoming, Nevada, and District of Columbia, show and average yield only for 20 years, and Indian Territory for 10 years. Other states were figured on the 30 year basis.



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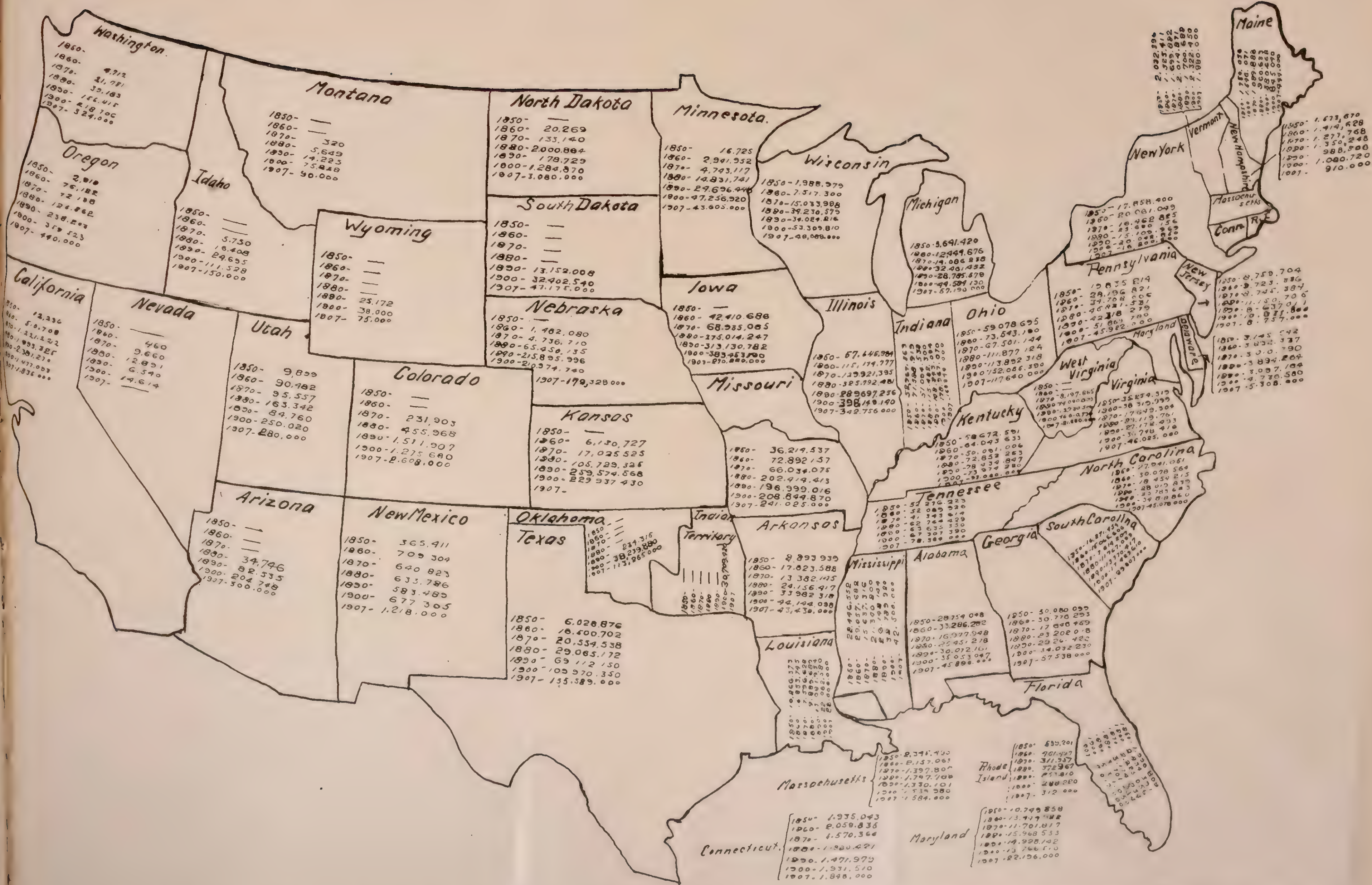
It will 60 years, and to that end the accompaning map was prepared.



It will be of some interest to know just what each state has been doing in the production of maize during the past 60 years, and to that end the accompaning map was prepared. This shows the total production in bushels of each state from 1850, or from time first reported until 1907.

In the preceding table we find the states listed in the order of their average yield per acre, covering a 30-year period. New Hampshire stands first with 39.8 bushels to its credit for every acre planted in corn, and Florida takes last place with only 9.8 bushels. Thus we see that in order to have a creditable average it is necessary for a large number of the states to stand well to make up for those which tend to pull down the average. New Hampshire stands first in average yield

If any definite conclusion may be taken from the table to which we have just been referred, we might say that the district of largest average yield extends from Maine south to Maryland, west, taking in a strip of corresponding width running gently southward to California. As we go south or north from this belt we find the average yield per acre gradually decreasing. However, this statement cannot be said to be absolute. Iowa third

Dividing the United States into the following five districts, North Atlantic, South Atlantic, North Central, South Central, and Western, the following table shows the relative average production as found in the last census report: Illinois sixth

PERCENTAGE OF PRODUCTION OF CORN IN THE UNITED STATES BY DISTRICTS, 1850 TO 1900.

TABLE NO. 7.

	1900	1890	1880	1870	1860	1850
North Atlantic	3.4	3.4	5.2	8.8	8.0	9.6
South Atlantic	6.3	6.2	7.4	11.4	16.0	21.2
North Central	72.8	75.3	73.2	57.7	48.4	37.5
South Central	17.3	14.8	14.0	21.8	27.4	31.6
Western	0.2	0.3	0.2	0.3	0.2	0.1

At present the North Central district produces nearly three-fourths of the entire annual yield of our country. The South Central district follows with a trifle over one-sixth of the total yield. Thus it is seen that the North Atlantic, South Atlantic and Western sections combined produce barely one-tenth of our annual crop. Centers of production

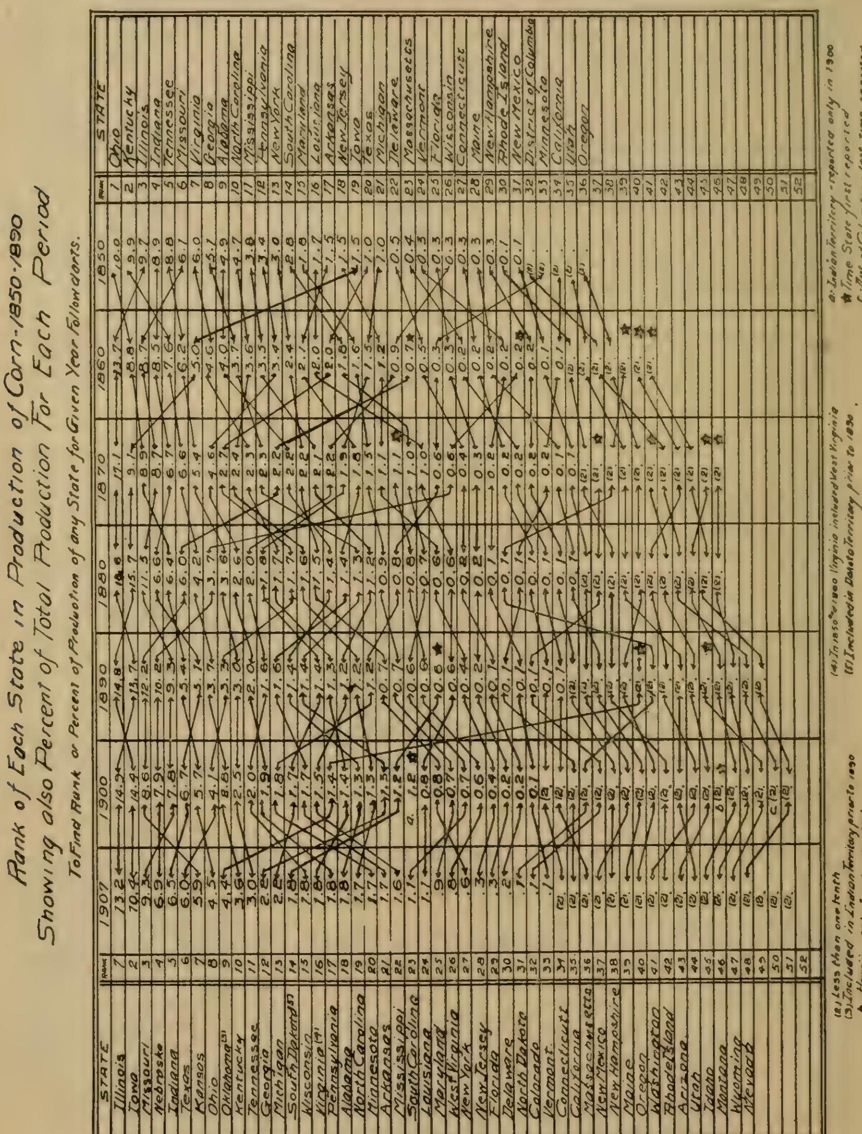
The center of production of the corn crop has been moving slowly westward. It s position since 1850 is shown in the following table:

TABLE NO. 8.

	North Latitude	West Longitude	
1900	39°–19′—33″	90°–27′— 6″	54 miles southwest of Springfield, Illinois.
1890	39—16—57	90—26—49	55 miles southwest of Springfield, Illinois.
1880	39—28—12	89— 7—43	36 miles southwest of Springfield, Illinois.
1870	38—47—13	87—14—15	90 miles southwest of Indianapolis, Indiana.
1860	38— 1—54	86—29— 4	47 miles southwest of New Albany, Indiana.
1850	39—14—54	81—43—38	86 miles southeast of Columbus, Ohio .

Figures taken from Twelfth Census Report.

As we leave the map on production we are now prepared for a closer study of the progress made by each state during a corresponding period. The following diagram shows the rank of each state by consecutive decades from 1850 to 1900, and for 1907. It further shows the percentage of total crop produced by each state for a given period.



Illinois first in 1907

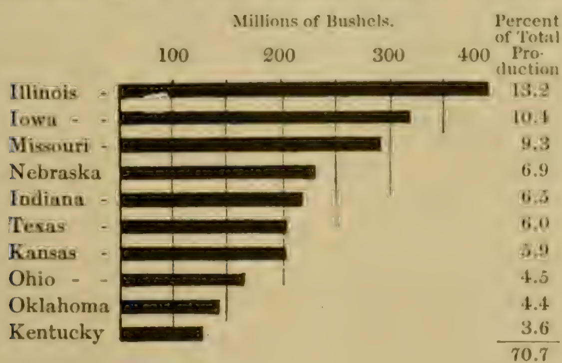
Iowa seventeenth in 1850 and second in 1907

Taking the states ranking from one to five inclusive, in 1907 we find Illinois first. Following the darts to the right we disclose the fact that only in 1890 and 1850 did this state fall below first place in production. In 1850, at which time it ranked third, it produced 9.7 per cent of the total production of the United States, and in 1907, 13.2 per cent. Iowa stood seventeenth place in rank in 1850, first in 1890 and second in 1907. Missouri ranked sixth in 1850 and third in 1907. Nebraska, when first reported in 1860, ranked thirty-first, and in 1907 ranked fourth. Indiana, however, fell from fourth place in 1850 to fifth place in 1907.

Considering now just the ten states leading in production in 1907, let us first note the following chart for a comparative study:

CHART NO. 5.

Production of Corn in the Ten Leading States in 1907.



Together these ten states produced 70.7 per cent or nearly three-fourths of the entire crop of 1907. Illinois, which was the heaviest producer, furnished 13.2 per cent of the entire crop, or 342,756,000 bushels. Iowa stood second with 10.4 per cent of the entire crop, or 270,220,000 bushels. The crop of this state was severely damaged and diminished by extremely unfavorable weather throughout the entire season. Missouri ranked third, with 9.3 per cent of the entire production, or 241,025,000 bushels. Nebraska followed in fourth place with 6.9 per cent of the entire crop, or 179,328,000 bushels. Indiana in fifth place produced 6.5 per cent of the entire crop, or 168,840,000 bushels. Texas ranked sixth with 6 per cent of the entire crop, or

155,589,000 bushels. Kansas ranked seventh with 5.9 per cent of the entire crop, or 155,142,000 bushels. Ohio stood eighth with 4.5 per cent of the entire crop, or 117,640,000 bushels. Oklahoma stood in ninth place with 4.4 per cent of entire crop, or 93,000,000 bushels. And last came Kentucky with 3.6 per cent of entire crop, or 78,364,000 bushels. The standing of other states may be taken from the preceding charts.

As has been stated before, the future increase in the production of corn in this country depends upon something more than increased acreage. We must now look to our seed selection, cultivation and crop rotation.

VALUATION OF THE CORN CROP

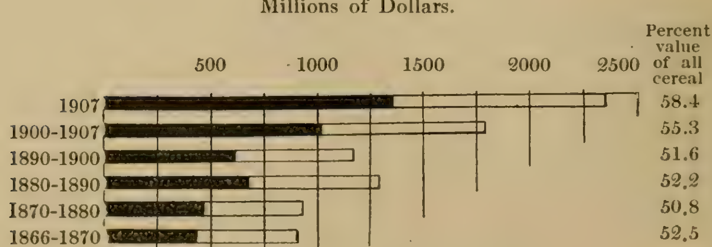
p of corn one year will pay ional debt

The proceeds from a single year's production of corn in the United States, considering only the raw product, would pay off our national debt. If the entire annual crop were to be moved at one time the transaction would take over one-third of all the money in circulation in this country. In 1907 the crop was valued at $1,336,901,000.

The value of the annual corn crop as compared with all other cereals for consecutive periods beginning with 1866 is shown in the following chart:

CHART NO. 6.

Value of the Corn Crop as Related to Entire Value of All Cereal Crops. 1866-1907.



Black portion of bar represents value of corn.
Entire length of bar represents value of all cereals.
NOTE. The valuations designated in above chart represent an average covering entire periods indicated to the left of chart.

From the preceding chart we find that the value of the corn crop is greater than that of all other cereals combined. For the past fifty years it has aggregated approximately 54 per cent of the entire value of all cereals including corn itself.

Supply and demand

The value of the annual corn crop from 1866 to 1907 may be ascertained by referring to table No. 5 on page 15. It is governed largely by production, varying slightly with the demand.

Prices increase as you move away from center of production and vice versa

The highest average price paid for corn in this country is recorded for 1901, and corresponds to the year of the lowest average yield. An average taken over any number of years for yield per acre and price per bushel shows a marked co-relation between the two. Yet this statement must necessarily be qualified slightly to meet the changing conditions of the times. For instance, the average price during the last seven years has been higher than for any previous decade following 1870. We find that as our system of farming becomes more intensive, and less of the raw product is exchanged, the law of increasing demand enters into the problem to affect price more prominently than ever before.

By referring to the annual report of the Department of Agriculture for 1907, we find that the average price in different states varies greatly. The highest average price is recorded in Arizona and amounted to 90 cents per bushel, while the lowest of only 41 cents is found in Nebraska. A close study of this table shows that the prices increase as you move away from the center of production and vice versa, depending considerably, too, upon density of population and shipping facilities.

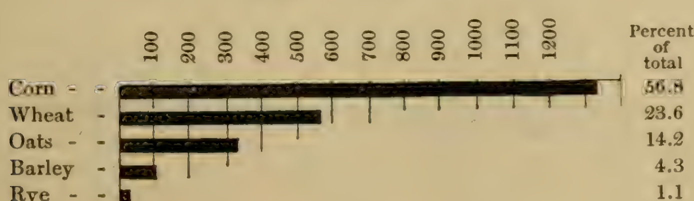
In comparing the value of the corn crop of the United States with that of each of the other cereal crops for 1907, we find it even above the average.

Note the following chart:

CHART NO. 7.

Valuation of the Corn Crop as Compared With Other Cereal Crops in the United States for 1907.

Millions of Dollars



Let us now consider from a similar standpoint the ten states topping the list in the production of corn in 1907. We will note first the comparative value of this crop as related to that of other cereal crops, and second as related to the total value of all farm products, including live stock, dairy products, etc. These states will be considered separately in descending order of production. Note accompanying charts for comparative value of cereals.

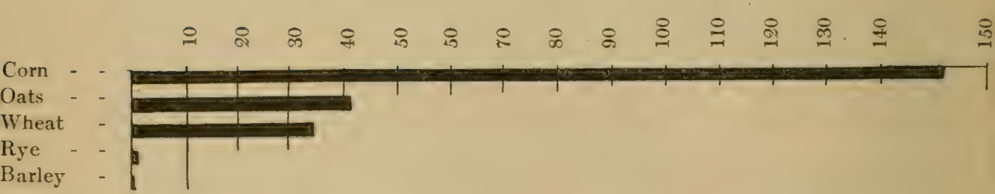
ILLINOIS.

Value of corn crop in 1907	$150,813,000
Per cent of total value of all cereals in 1907	51.3
Per cent of total value of all farm products in 1900	24.5

CHART NO. 8.

Value of Corn Crop as Compared With Other Cereal Crops in Illinois, in 1907.

Millions of Dollars.



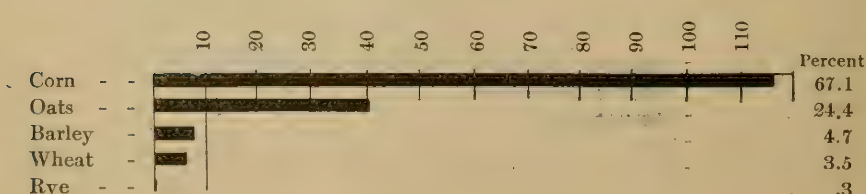
IOWA.

Value of corn crop of 1907	$82,582,186
Per cent of total value of all cereal crops in 1907	55.8
Per cent of total value of all farm products in 1900	22.6

CHART NO. 9.

Valuation of the Corn Crop in Iowa as Compared With Other Cereal Crops in 1907.

Millions of Dollars.



PERCENTAGE OF CROPPING AREA DEVOTED TO CROPS MENTIONED.

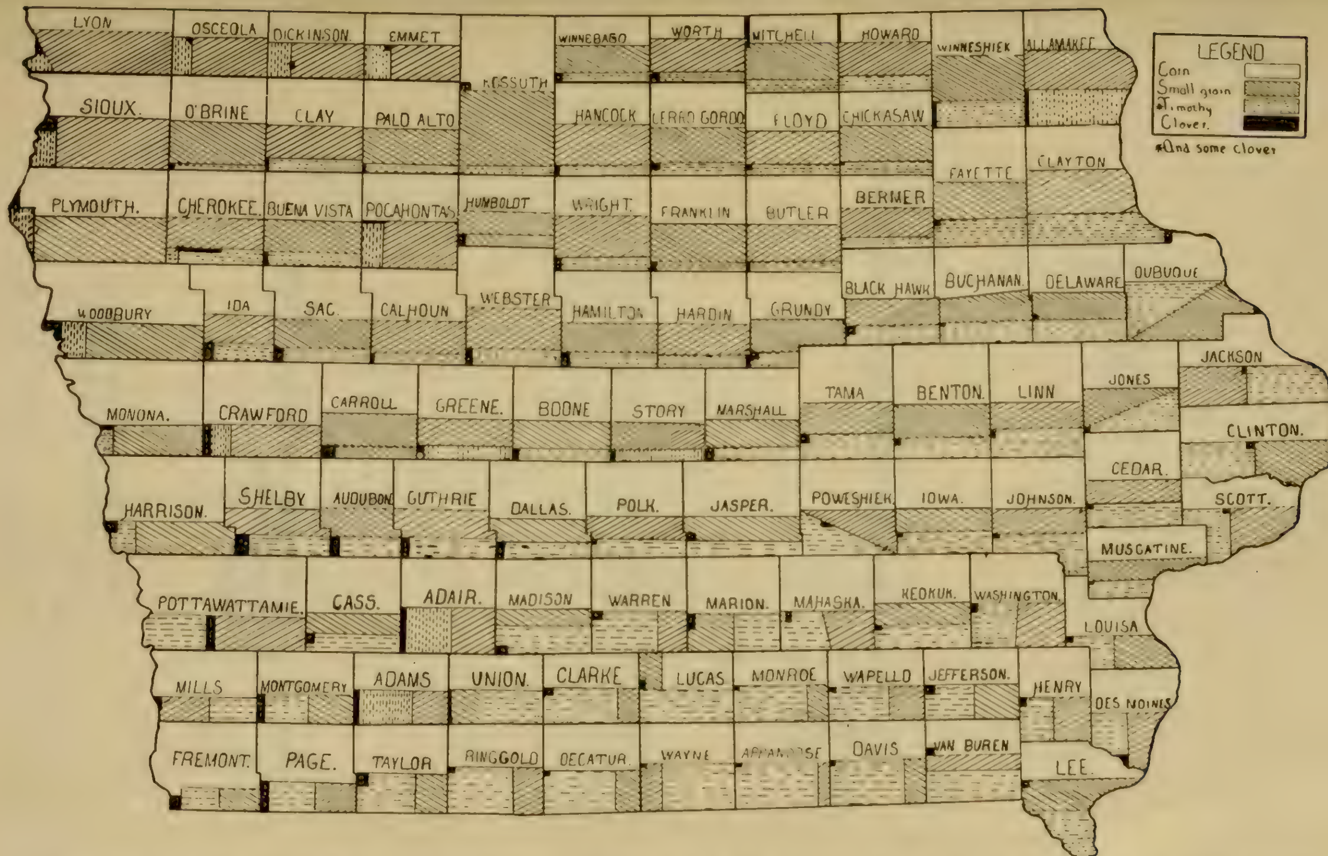
The following table should be studied in connection with map on page 25. Per cent is in proportion to the area devoted to the production of the crops mentioned, not the total area of the county.

	Corn		Small Grain		Timothy*		Clover	
Adair	54	Percent.	22	Percent.	22	Percent.	2.	Percent.
Adams	57	"	16	"	25	"	2.	"
Allamakee	32	"	38	"	29	"	1.	"
Appanoose	44	"	9	"	46	"	.5	"
Audubon	53	"	29	"	15	"	2.6	"
Benton	50	"	32	"	17	"	.8	"
Black Hawk	53	"	29	"	17	"	1.	"
Boone	59	"	27	"	13	"	1.	"
Bremer	43	"	41	"	15	"	.2	"
Buchanan	48	"	28	"	23	"	.1	"
Buena Vista	52	"	36	"	11	"	.9	"
Butler	51	"	37	"	12	"	.3	"
Calhoun	55	"	35	"	11	"	.3	"
Carroll	53	"	34	"	11	"	2.	"
Cass	57	"	23	"	18	"	2.7	"
Cedar	51	"	25	"	23	"	.6	"
Cerro Gordo	46	"	39	"	14	"	.8	"
Cherokee	53	"	33	"	12	"	2.	"
Chickasaw	40	"	44	"	16	"	.1	"
Clarke	45	"	13	"	40	"	1.3	"
Clay	49	"	38	"	14	"	.5	"
Clayton	36	"	39	"	24	"	.6	"
Clinton	54	"	23	"	22	"	.9	"
Crawford	54	"	31	"	14	"	1.8	"
Dallas	62	"	22	"	13	"	2.2	"
Davis	45	"	14	"	41	"	.9	"
Decatur	52	"	12	"	36	"	.4	"
Delaware	48	"	28	"	24	"	.5	"
Des Moines	52	"	26	"	21	"	1.5	"
Dickinson	43	"	46	"	11	"	.2	"
Dubuque	39	"	32	"	29	"	.4	"
Emmet	45	"	40	"	14	"	.5	"
Fayette	41	"	34	"	25	"	.2	"
Floyd	45	"	40	"	14	"	.4	"
Franklin	50	"	37	"	13	"	.8	"
Fremont	78	"	11	"	10	"	1.5	"
Greene	59	"	26	"	13	"	1.4	"
Grundy	51	"	37	"	11	"	1.1	"
Guthrie	53	"	28	"	18	"	2 3	"
Hamilton	55	"	30	"	13	"	1.5	"
Hancock	44	"	44	"	12	"	.4	"
Hardin	55	"	32	"	13	"	.6	"
Harrison	71	"	22	"	6	"	1.3	"
Henry	52	"	25	"	21	"	1.7	"
Howard	34	"	44	"	22	"	.2	"
Humboldt	50	"	35	"	14	"	1.2	"
Ida	56	"	30	"	11	"	2.7	"
Iowa	52	"	25	"	23	"	.6	"
Jackson	43	"	23	"	34	"	.5	"
Jasper	60	"	23	"	17	"	1.3	"
Jefferson	50	"	24	"	24	"	1.3	"
Johnson	50	"	25	"	24	"	.4	"
Jones	50	"	21	"	29	"	.7	"

	Corn	Small Grain	Timothy*	Clover
Keokuk	54 Percent.	22 Percent	23 Percent.	.8 Percent.
Kossuth	47 "	42 "	11 "	.3 "
Lee	44 "	27 "	29 "	.9 "
Linn	50 "	25 "	25 "	.6 "
Louisa	61 "	24 ”	15 "	.7 "
Lucas	46 "	14 "	40 "	.5 "
Lyon	33 "	62 "	5 "	.7 "
Madison	56 "	17 "	25 "	2.2 "
Mahaska	58 "	21 "	19 "	1.7 "
Marion	59 "	19 "	20 "	2.2 "
Marshall	55 "	29 "	14 "	2.3 "
Mills	69 "	16 "	14 "	1.6 "
Mitchell	34 "	50 "	16 "	.4 "
Monona	72 "	24 "	3 "	.4 "
Monroe	46 "	12 "	41 "	.6 "
Montgomery	59 "	19 "	19 "	2.7 "
Muscatine	57 "	25 "	19 "	.2 "
O'Brien	47 "	42 "	11 "	.5 "
Osceola	38 "	51 "	11 "	.5 "
Page	64 "	16 "	17 "	3.8 "
Palo Alto	51 "	40 "	9 "	.4 "
Plymouth	52 "	41 "	6 "	.9 "
Pocahontas	51 "	40 "	10 "	.3 "
Pottawattamie	65 "	21 "	11 "	2.4 "
Poweshiek	54 "	23 "	21 "	1.4 "
Polk	60 "	23 "	16 "	.2 "
Ringgold	49 "	15 "	36 "	.7 "
Sac	55 "	29 "	14 "	1.9 "
Scott	47 "	35 "	17 "	.5 "
Shelby	56 "	28 "	13 "	3.7 "
Sioux	47 "	46 "	5 "	1.4 "
Story	59 "	27 "	13 "	.7 "
Tama	47 "	30 "	22 "	1.5 "
Taylor	57 "	14 "	28 "	1.7 "
Union	50 "	15 "	34 "	1.0 "
Van Buren	40 "	18 "	40 "	1.5 "
Wayne	45 "	11 "	44 "	.3 "
Wapello	52 "	18 "	30 "	.8 "
Warren	57 "	16 "	25 "	1.7 "
Washington	54 "	24 "	21 "	1.6 "
Webster	52 "	36 "	11 "	.8 "
Winnebago	44 "	43 "	13 "	.8 "
Winneshiek	35 "	43 "	22 "	.5 "
Woodbury	65 "	29 "	5 "	1.4 "
Worth	32 "	51 "	15 "	1.3 "
Wright	43 "	46 "	10 "	1.1 "

*Including clover and timothy mixed.

Showing Areas Devoted to Different Crops in State of Iowa *



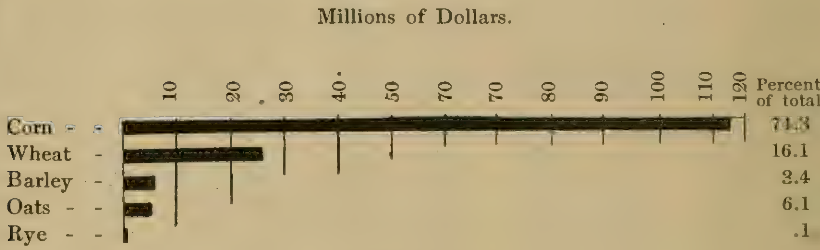
These percentages are not given with reference to the total area of each county, but the percentage of the total area devoted to the growing of the crops mentioned. Note the large acreage in corn. * Iowa year book 1905.

MISSOURI.

Value of the corn crop of 1907	$113,282,000
Per cent of total value of all cereal crops in 1907	74.3
Per cent of total value of all farm products in 1900	26.9

CHART NO. 10.

Value of the Corn Crop as Compared With Other Cereal Crops in Missouri in 1907.

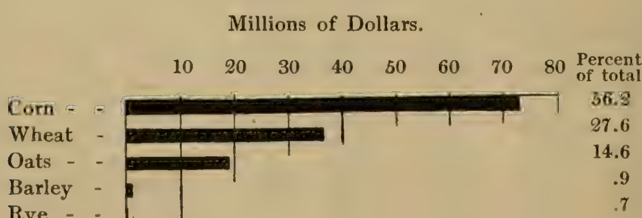


NEBRASKA.

Value of corn crop of 1907	$ 73,524,000
Per cent of total value of all cereal crops in 1907	56.2
Per cent of total value of all farm products in 1900	40.1

CHART NO. 11.

Value of the Corn Crop as Compared With Other Cereal Crops in Nebraska in 1907.



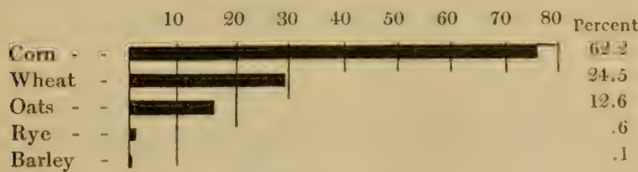
INDIANA.

Value of the corn crop of 1907	$ 75,978,000
Per cent of total value of all cereal crops in 1907	62.2
Per cent of total value of all farm products in 1900	24.1

CHART NO. 12.

Valuation of Corn Crop as Compared With Other Cereal Crops in Indiana in 1907.

Millions of Dollars.



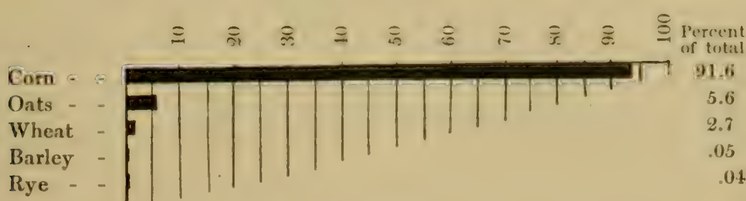
TEXAS.

Value of corn crop in 1907	$ 93,353,000
Per cent of total value of all cereals in 1907	91.6
Per cent of total value of all farm products in 1900	16.1

CHART NO. 13.

Valuation of the Corn Crop as Compared With Other Cereal Crops in Texas in 1907.

Millions of Dollars.



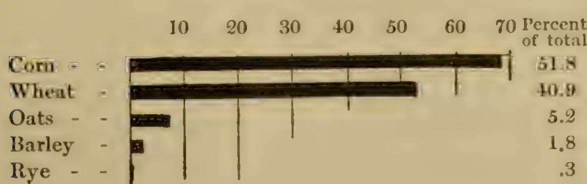
KANSAS.

Value of corn crop of 1907	$ 68,262,000
Per cent of total value of all cereals in 1907	51.8
Per cent of total value of all farm products in 1900	24.9

CHART NO. 14.

Value of the Corn Crop as Compared With Other Cereal Crops in Kansas in 1907.

Millions of Dollars.



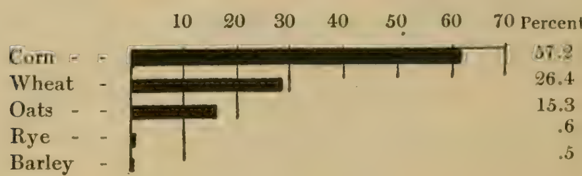
OHIO.

Value of the corn crop of 1907	$ 61,173,000
Per cent of total value of all cereal crops in 1907	57.2
Per cent of total value of all farm products in 1900	14.1

CHART NO. 15.

Valuation of the Corn Crop in Ohio as Compared With Other Cereal Crops in 1907.

Millions of Dollars.



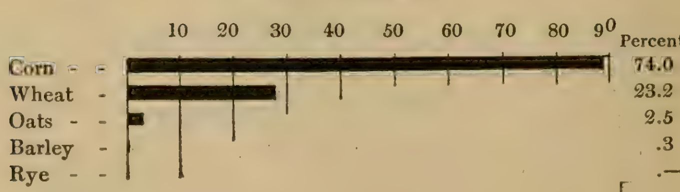
OKLAHOMA.

Value of the corn crop of 1907	$ 89,837,000
Per cent of total value of all cereal crops in 1907	74.0
Per cent of total value of all farm products in 1900	8.1

CHART NO. 16.

Valuation of Corn Crop in Oklahoma as Compared With Other Cereal Crops in 1907.

Millions of Dollars.

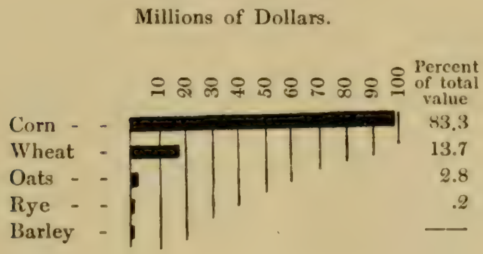


KENTUCKY.

Value of the corn of 1907	$ 49,322,000
Per cent of total value of all cereal crops in 1907	83.3
Per cent of total value of all farm products in 1900	22.5

CHART NO. 17.

Valuation of the Corn Crop in Kentucky as Compared With All Other Cereal Crops in 1907.



ACKNOWLEDGEMENTS

In securing data relating to the history of corn we have drawn largely from the botanical works of such authors as DeCandolle, Sturtevant, Watson and Bailey. The local coloring given had largely for its inception the reports of Agricultural Societies which existed early in the past century and during the closing decade of the century preceding. Besides these sources, the agricultural journals on file in the State Library at Des Moines presented a very complete record of the progress made in corn growing since the early days of our country.

The figures quoted in the chapter on Acreage, Production, Distribution and Valuation, were taken largely from the annual reports of the National Secretary of Agriculture, and from the decennary census reports. For the figures quoted for 1907 we are debtors to the courtesy of J. C. Simpson, Secretary of the Iowa State Board of Agriculture, and to the United States Department of Agriculture.

COLLATERAL READING

In extending the research relative to the history and past production of corn, most excellent references may be found in the old files of the Iowa State Library at Des Moines, in the Historical Building. A complete file of old Agricultural Reports and farm journals, with a splendid botanical library, furnish an abundance of material for further work. Anyone who is not located within range of this library, however, may do well in other state or national libraries or in any private library where special efforts have been made in securing and cataloging data bearing on farm problems.

THE PRINCIPAL CORN GROWING COUNTRIES OTHER THAN THE UNITED STATES

MEXICO

The Awakening in Agriculture in Mexico

Corn trains in Mexico

Dr. Pehr Olsson-Seffer was commissioned in 1906 to investigate Mexican Agricultural conditions. In his recent report (spring of 1908), he recommended the establishment of a Department of Agriculture for the nation. The Mexican National Railroad, in the summer of 1908, made plans to put on special corn trains as was done in Iowa several years ago.

Educated leaders in Mexico

A great many ranchers in Chihuahua and Durango have for some time employed improved methods and selected their seed corn. President Diaz has always been interested in the farmers. A leader in the greater movement is Mr. Zeferino Dominguez, a Mexican owner of owners furnish each peon family with an adobe house, a yoke of large haciendas in the Northeast Mexico. His trips to the United States have resulted in the introduction of better seed. A great many students from the northern states of Mexico have graduated from the Agricultural Colleges of the United States. Jose Mora, Bishop of the State of Leon, has arranged a course of lectures to be given to farmers throughout Mexico. The greatest good will come with increased facilities for irrigation.

The Peonage System

Mexican labor

All work of an agricultural nature is done by the peon or native. The landlords own very large tracts of land. Many ranches contain one million acres. Ten thousand acre haciendas are common. These owners furnish each peon family with an adobe house, a yoke of oxen, seed, and such rude agricultural implements as are considered necessary. The peon is charged with one-half the seed, and the renting price of the oxen. Any food bought is charged against him at the store which appears on the larger ranches. At the end of the year settlements are made after the landlord has deducted all advances made to the peon during the season. Farm laborers who are paid directly receive certain daily rations and ten dollars Mexican (five dollars gold), a total of fifteen dollars Mexican, per year.

The Tortilla. (The Bread of the Natives of Mexico.)

The "tortilla" or "corn cake" of Mexico is the "staff of life" of 90 per cent of the native Mexican people. The total annual consumption of tortillas is valued at $76,560,000 gold.

The tortilla is made from shelled corn which has been put in an earthenware jar and covered with rather strong lime water and allowed to soak over night. The swollen grains are then ground between mill stones. The hull, being very tender because of soaking, is ground with the kernel. Every town of one thousand inhabitants has a mill of this kind. The ground mass comes out as a doughy "massa." During the grinding, cold water is slowly poured on the meal through the mill. Hence the ground material is about three-fourths greater in bulk than the original swelled kernels. Tortilla made from corn

The regulation size of the tortillas is from four to five inches in diameter. They are served with strips of mutton or beef and seasoned with salt and "salsa," or "sauce." The baking which requires but three minutes is done over charcoal burners. Size

The tortilla has come to be a specialized product in the larger cities. In Mexico City alone there are one thousand tortilla makers. Baking

The Production of Corn in Mexico

Because the climatic and soil conditions vary so much in different parts of Mexico the discussion will here be taken up by states.

SONORA*. Sonora is a large state in the northwest corner of Mexico. It is bounded on the North by Arizona, and on the West by the Gulf of California. The maximum temperature in July, 1906, was 99 degrees Fahrenheit, and the minimum 81 degrees Fahrenheit. During the months of July and August the temperature is very consistently high. In February, 1908, the maximum rose to 76 degrees F., while the minimum dropped to 53 degrees F. Fifty degrees F. recorded on December 22, 1907, at Hermosillo, was the coldest day during the fiscal year of 1907. There were produced in this state in 1907, as far as reports could be obtained, 1,872,419.2 bushels, with an average production of 25 bushels per acre, or a total of 78,096.8 acres. Climate

The price per bushel in American gold was about 1 cent per pound. Improved methods and American machinery are being used. The prospects are quite favorable for this state becoming a corn growing region. The flint type is mostly grown at present. Price of corn

*American Consul Hermosillo, Sonora.

LOWER CALIFORNIA.* The northern part of this peninsula is in a valley adapted to corn growing. The soil is a sandy loam, being very fertile and productive when irrigated. The rainfall has not in twenty-two years exceeded an average of 10½ inches. Some growers

Rainfall

are introducing the dent varieties, but the flint corn is usually grown. The limited supply and large demand for human consumption has raised the price to 56 cents per bushel.

The extreme southern part of this narrow strip of land is mostly a mining district.** Corn is imported to La Paz, B. C., from across the Gulf of California in Sinaloa. The price is approximately 64 cents per bushel.

CHIHUAHUA.*** Chihuahua is a very large state, being a mining district in the north, grazing in the central, and farming in the south. South of the capital city, Chihuahua, the acreage of corn is large and increasing. The corn on the irrigated lands is planted 2 or 3

Planting

inches deep and yields 30 to 50 bushels. As there are 19 inches of rainfall annually in this district, fair yields are obtained from the dry farming fields. The precipitation occurs in July, August and September, and usually falls in torrents. On this land the corn is planted

Varieties

four to five inches deep. The varieties are largely dent corn at present, and improved methods are gradually being adopted by the farming classes. Chihuahua is one of the states of Mexico which will in the near future grasp agricultural opportunities. An Agricultural

Agricultural College

College has been established at Cuidad Juarez, which is just across the river from El Paso, Texas.

COAHUILA.**** Coahuila is just east of Chihuahua and extends to the Rio Grande on the north. A large area of this state is in corn. The

Seed companies of U. S. y June corn here

fact that laborers secure higher wages in the mines has a tendency to check the development of new areas. Although crude methods of cultivating and harvesting are used, yields of 30 bushels are common. Prices range from 60 to 90 cents per bushel. Some of the seed companies of the United States secure seed for what is termed "June Corn" from this state. It is a short season crop, maturing in three months. The crop of this state is mostly all flint corn. Development depends upon the increased facilities for irrigation.

SINALOA.***** Sinaloa is a long, narrow state on the west coast of the mainland just east of the southern point of Lower California. Al-

On a plateau

though a comparatively undeveloped district, this state is now a large

*American Consul Ensenda, L. C.
**American Consul La Paz. B. C.
***American Consul, Cuidad Juarez.
****American Consul, Cuidad Porfirio Diaz.
*****American Consul Mazatalan.

producer of corn and bids fair to increase rapidly in the future. Already some corn is being exported.

DURANGO.* The state of Durango, situated in the North Central plateau of Mexico, has a mean altitude of about 5,000 feet, with climatic conditions varying with the altitudes. These range from 2,000 feet in the valleys of the eastern portion of the state to 12,000 feet in the Sierra Madre mountains.

Corn is, and ever has been, one of the principal crops where the elevation is 5,000 feet or more. Compared with the whole state, the acreage devoted to corn is small, it being confined to the table-lands near the mountains, where rainfall is frequent; and to other lands which can be irrigated.

Roughly, it is estimated that last year 300,000 acres were planted to corn and that the average yield per acre was 15 bushels, making a total crop of 4,500,000 bushels. The price, on account of the drought, has been exceptionally high; in fact, the highest ever known in the history of this part of Mexico. Corn has sold as high as $1.25 gold per bushel, and not less than 80 cents. No corn is exported from the country, and but little from the state. It is, with beans, the principal article of food for the people of the country, and in times of abundance the surplus finds a ready sale in the numerous nearby mining camps. At all times the local demand far exceeds the supply. The corn of this part of Mexico is a species of the flint, but of a mixed mongrel breed.

High price for corn

The climate naturally varies with the altitude, but in the parts of Durango where corn is raised, it is temperate with fairly abundant rainfall near the mountains during the so-called rainy season, which lasts from May until October. This so-called rainy season is not to be depended upon to insure moisture sufficient for the crops, as was seen in 1907, when but little rain fell and the only full harvests were secured by those aided by irrigation.

Temperature

The mean annual temperature of the corn lands is about 60 degrees F. December is the coldest month of the year. At that time the thermometer often drops during the night to 28 degrees F. May is the hot month during which 90 degrees F. is frequently registered. In the low lands and mountains the variation is much greater.

Cultivation

The soil, in general, is a light loam with a tendency to a clay formation which packs hard after rains, but in working pulverizes easily. For corn, no fertilizer is or ever has been used, irrigation being the only auxiliary. Corn was raised in this state before the advent of the

*American Consul, Durango.

Spaniards, and the methods as practiced by the farmers in general have not been changed in the last two hundred years. The land to-day, as then, is plowed with a crooked stick or wooden plow, and the plowing, where there is no irrigation, commences with the first rains. The corn is dropped and covered by hand. The only cultivation it receives is with the same plow that was used to break up the soil. Such a thing as a harrow or cultivator is to be found only among the most progressive. When the corn is well along in the milk, it is topped to hasten the ripening. The tops are saved for fodder, taking the place of hay, of which none is raised.

Brighter future

The prospect for the future of corn growing is for improvement in every way. Nevertheless, the change for the better will be slow for various reasons. Already many of the progressive ranchers are, in a limited way, introducing improved implements and using approved methods, but the majority are more than conservative. Here labor is cheap and the style of farming too well established to be easily changed.

Experiments

No experiments in corn raising, as it is understood in the United States, are being carried on in this state, but Americans who have invested in farming and ranch lands are cautiously, carefully, and gradually introducing new imported seed, up-to-date implements and approved methods. New tools and new methods are introduced only by asking the most intelligent laborers, as a favor, to use them for a season, and guaranteeing them against loss. Should the result be an increased harvest it gives the owner a chance, by the object lesson, to equip others.

Farmers coming in from South America

NUEVO LEON.* Nuevo Leon, which lies in the northeastern part of Mexico, next to the Rio Grande, is not an agricultural state, being mostly mining and manufacturing. It is estimated that 15,000 acres were planted in 1907. Much of the soil is fertile and adapted to corn, but except for irrigation the crop is very light. Where sufficient water is at hand for irrigation two crops annually are not uncommon. Thirty bushels of corn of the flint type is good yield. The present price per bushel (June, 1908) is $1.20 in American currency. The methods of cultivating are crude. The whole stalk is usually harvested, the corn being husked out afterward by hand. In the southeastern part of this state American farmers are moving in and developing large areas of the more fertile lands. With irrigation the alluvial soils along the Rio Grande will produce heavy yields of corn. The rainfall here is 18 to 20 inches annually.

*American Consul General, Monterey.

TAMAULIPAS.* Because of the slight rainfall and the lack of irrigation on this side of the Rio Grande, there is at present very little agricultural activity in this consular district. However, corn may be said to be one of the staple crops. Although conditions seem to warrant the claim that three crops per year can be grown, yet the farmers only attempt to raise two. The average yield per acre of each crop is said to be about 35 or 40 bushels, but it is believed that this could be greatly increased by irrigation and proper care and cultivation.

New corn is worth at the present time (June 23, 1908) about $12.00, Mexican money, per cargo of 312 pounds, or between $1.00 and $1.10, American money, per bushel. Old corn which is coming from Monterey sells for $14.00, Mexican money, per cargo, or about $1.25 American money, per bushel. During the year the price of corn ranges from $8.00 to $16.00 per cargo, or from 70 cents to $1.40 per bushel, American money. **Prices in 1908**

There is not sufficient corn raised in the district to supply the demand, consequently there is no corn exported. A great deal of corn is shipped into this city from the interior and some is brought over from Brownsville, Texas.

The corn planted is a dent variety known here as the "Mexican Creole." No particular care has been given in the past to the selection of corn for planting. This year, however, Senor Jorge Webber of this city, sent to Mexico City to obtain a better variety of corn and obtained a "starch corn." The grains were large, but were not uniform. It was very soft and seemed to be very full of starch or flour. **Methods of planting**

Statistics showing the average rainfall and temperature in this district are not obtainable, but it is reasonable to state that they cannot be very different from those for Brownsville, Texas, which is just across the Rio Grande.

The following table of statistics was secured from Mr. Charles M. Barnes, Secretary of the Lower Rio Grande Commercial Club of Brownsville. This table was made up from statistics and observations taken by the medical department and weather observers at Fort Brown before the abandonment of that post, and cover a period of seventeen years, from which the average is made.

	Mean Average Temperature	Mean Av. Rainfall
January	56.6	1.59
February	63.3	1.51
March	68.3	1.32
April	73.6	.93
May	78.5	2.42
June	82.3	2.01
July	83.4	2.04
August	83.3	3.36
September	79.8	7.30
October	74.2	4.35
November	67.1	2.00
December	61.6	1.64
Annual mean	72.8	30.52

American Consul, Nuevo Laredo.
American Consul, Matamoras.

In order that this table will not be misleading, it is well to state that summer weather begins about March 1st and continues into October, and that from June 1st until September 1st the temperature in the sun ranges from 90 degrees upward. During the winter months there are generally two or three light frosts and once in a long while there will be a heavy frost.

AGUASCALIENTES.* The district of Aguascalientes is in Central Mexico just north of the capital city.

In the district of Aguascalientes, corn is the chief product of agriculture, varying every year according to the amount of rain. The rainy season commences about June 15th and lasts until the end of September. It is impossible to estimate the number of inches as no official data is kept of the fall. The character of the climate is subtropical, tempered by the high altitude, the average temperature being from 75 to 85 degrees F.

Season

The prevailing soil is poor and sandy, but in the lowlands, which are scarce, it is of a loamy quality. No fertilizer is used to enrich it, and agricultural products are allowed to grow under natural conditions.

Planting

Planting is done almost entirely by wooden plows, a few disc plows being used on the large farms and ranches. One man plows the soil, then makes a furrow in which a boy alternately drops three grains of corn and two of beans. When the corn is a few inches high, it is banked up, and two or three cultivations given with the plow. The corn when ripe is topped, over the ear, and the toppings used for fodder. After the first frosts, the ears are stripped by hand and thrown into a basket carried upon the back of the peon. Cattle are then turned into the field to pick up what is left.

Cultivating

Classes of corn

There are three kinds of corn grown in the state of Aguascalientes which are similar to the pod and dent corn of the United States. The first one is called "mais de riego" or irrigated corn, which is planted after the frost when the soil is warm, that is to say, during the month of March. The growing period is of seven months and produces as a rule from 300 to 500 bushels of corn for each bushel sowed. The "mais poblano," sowed during the early rains in May, needs four months to grow and produces as much as 200 bushels of corn for each bushel planted. The "mais temporal," or "pepitills," is seeded during the regular rains of June and July and is harvested three months afterward, producing from 50 to 100 bushels for each bushel sowed.

There is no data as to the cultivation by acres. As a rule the peons receive all the land that they can take care of, one man generally taking care of two fanegas, about 17½ acres, which he cultivates with two oxen.

The retail price of corn is very high, selling at from $4.00 to $4.50, Mexican ($2.00 to $2.25, United States) per hectolitro (2.8378 bushels). For this reason none is used for feeding cattle, and none is exported. The total output being consumed by the people in the form of bread and "tortillas," a kind of corn pancake.

There are no experiments being made at the present time to place agriculture on a scientific basis.

COLIMA.* Colima is a small state on the west coast just due west of Mexico City. "Relating to corn growing in the state of Colima, Mexico, I have to state that corn is one of the principal crops of this section. The exact acreage is not known, no statistics being compiled. However, from what information I can obtain I would report about 25,000 acres being planted with corn annually in the state. The average yield per acre is from 25 to 30 bushels, which could probably be almost doubled by irrigation. The price of corn here is from 30 cents to $1.00 United States gold per bushel. Last year the price was higher than it had been for many years, in some few instances selling for as much as $1.10 per bushel. The average price was about 45 to 50 cents per bushel. At the present time it is selling for 40 cents. Very little corn is exported at present. In former years a fair amount was exported to Central America; none was exported last year, however. When the price justifies, considerable corn is shipped to Mazatlan in the state of Sinaloa.

Yield 30 bushels

"The corn raised here is the dent and flint corn and is used by the natives for making their corn cakes (tortillas) which with beans (Frijoles) make up the menu of their daily fare. The leaves are also stripped from the stalks and with the corn are used for fodder. Hogs are fattened with corn for the purpose of making lard to be used in soap making, only about 23 per cent of the lard made being used for cooking purposes.

"The climate is hot and divided into two seasons, wet and dry, the wet season beginning in June and the dry in December or January. The amount of rainfall varies in different years, that of 1906 being especially heavy, 45 inches of rain falling during a three days' storm in the latter part of September of that year. A conservative estimate of the average annual rainfall, however, would be from 50 to 55 inches. The average temperature is 88 degrees F.

Climate

*American Consul, Manzanillo.

"The character of the soil in the valleys is rich alluvial, and with improved methods of cultivation would yield large returns. No fertilizer is used. The method of planting is still rather primitive except on a few of the up-to-date ranches. The Indians select a place on the hilltops or mountains of their lands to get abundant rainfall and be free from the depredations of cattle, and begin clearing the brush and cutting the timber, letting it dry where it falls and then setting fire to it, burning over the cleared ground. The stumps and trunks of trees are left as they are, no effort being made to remove them. When the first rains come the corn is planted by taking a sharp stick, making a hole in the ground and dropping three or four kernels of corn into it, then covering it with dirt by hand or foot.

Rich alluvial soil

"No further attention is paid to it until it is ready for gathering in the fall. The ears are then picked from the stalks and carried in baskets to the houses or shacks of the owners. The leaves are then gathered from the stalks for fodder and the cattle allowed to go into the fields to feed. If the same field is utilized the next year for corn, the weeds and brush that may have grown up are burned off again and the corn planted as before, but on account of the rapidly growing weeds it will be necessary once during the season to go over the ground with a hoe to cut down the weeds. The land is not used again for corn, as the weeds would necessitate too much attention and a new piece of land is selected for the next year's crop and cleared and burned over in like manner. Where land is used after the second year for corn it is plowed over, the trunks of the trees then being cleared out somewhat, but the stumps remain. The plows used are the curious Mexican wooden plows called 'bull tongues.' They have one handle and are drawn by oxen. They have a small cross-piece near the point to turn the soil to one side.

"There are now two large ranches in the state owned by Americans and several by Mexicans where corn is raised and cultivated by modern methods, which are meeting with success. The future for corn here seems to be good, as the Mexican Central railroad now building to Guadalajara, and to be completed before the end of the present year, will give new markets in a good mining region.

Railroad extension

(There are no experiment stations in this state at the present time.)

VERA CRUZ.* Vera Cruz extends along the eastern or Gulf coast of Mexico for considerable distance. The altitude is very high because of the mountains being so near the coast. The soil is quite fertile, and the rainfall is abundant, being about 132 inches. The corn

Price

*American Consul, Vera Cruz.

is planted in hills 30 inches apart, two kernels in the hill. Yields of 20 to 50 bushels are common. The price here varies from 50 cents to $1.00 per bushel (gold).

YUCATAN.* Yucatan forms the eastern and northern part of the peninsula of Yucatan. It has an area of 33,108 square miles, and a population of about 300,000. The surface is mostly low. The soil is of the rocky lime-stone variety. The climate is sub-tropical, averaging 81 degrees in summer and 69 degrees in winter. Rainfall is generally irregular and scant. The type of corn grown there is white and yellow tropical Indian corn. It is used for making tortillas and for fattening cattle. The average yield per acre is 20 bushels, and the present price per bushel is 75 cents. The ancient method of planting is employed, A clearing is burned and the corn planted in stake holes. The only cultivation is the weeding of the land. It is probable that more corn will be grown in the future.

Argentine Republic

Argentine Republic extends over 2,300 miles of latitude. Of the four provinces, Buenos Aires, Santa Fe, Cordoba, and Entre Rios, the first two are the largest corn producers.

These areas lie within the limits of 35 and 30 degrees south latitude. However, some good corn is grown as far north as 24 degrees south latitude.

Mean annual temperature

The average annual temperature at Buenos Aires from 1856 to 1875 was 62.9 degrees, from 1876 to 1896, 61.5 degrees, and from 1897 to 1900, 63.1 degrees. These represent quite fairly the averages of the principal corn regions. The temperature in this part of the corn belt seldom rises above 95 degrees, but seems much higher because of the excessive humidity of the atmosphere.

The corn district of Argentine has an average annual rainfall of 31.52 to 39.40 inches, which is quite evenly divided between the two seasons. The number of days during which some rain falls varies from 39.2 to 82.2 in different parts of the corn growing region.

The corn land, being owned by wealthy landlords, is farmed by renters or "colonists" who have no serious ideas of home-building. The different ranches are specialized in different crops. Alfalfa or wheat may be grown entirely for a series of years. Rents range from $1.25 to $4.50 per acre. Usually one-half of this must be paid in advance.

*American Vice Consul Progress, Yucatan.

Time of planting

Corn planting begins August 15th and may continue as late as January 15th. The safest time, however, is September 15th to December 31st. The early planted corn usually yields more heavily. The rows range from 10 to 36 inches apart. During the last few years a number of American corn planters are being introduced, but all of them are used simply for drilling, no checking being done. When the plants are two or three inches in height the land is harrowed. Nothing more is done until the corn is 12 inches high, when an implement with a double mold-board like a lister is run through and the rows hilled up.

Varieties

Ninety per cent of the corn grown in Argentina is of the flint type. This corn yields heavily, an average of 50 and 60 bushels being common in the better districts. This corn is less absorbent of moisture and consequently less liable to heating when passing the equatorial zone enroute to Europe. North American varieties like the Hickory King, a white corn, and Queen, a yellow variety, have been tried with success.

No fear of frost presses the farmers in regard to selecting the seed corn early, because the ears often remain on the stalk for two months after matured. However, the farmers are very anxious to get the corn gathered and shelled in order to reach the seaboard before the wet season begins. Hence, some years a great deal of immature corn is shipped out. In 1902 Argentina exported 55.75 per cent of the corn produced. With development in the packing and slaughtering methods more corn will be fed at home.

Exporting

The export corn is often shipped as ballast in the mail and line steam ships. Most all the corn is shipped in bags. The ocean rates vary from 8 shillings per ton (4.95 cents per bushel) to 20 shillings per ton (12.38 cents per bushel). The only inspection of export corn is that made in a private way by the companies doing a large business. In May, 1908, the prices of corn varied from 61 to 67 cents per bushel for white and 55 to 61 for yellow.

Brazil*

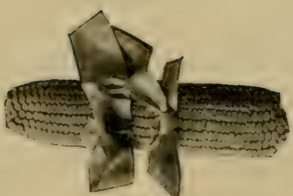
Brazil is a republic of South America. The southeastern portion is mountainous. The central northeastern and western parts are occupied by a great plateau with the low plains of the Amazon to the north and those of Paraguay to the west. This country is awakening to the need of diversified agriculture, and it is certain that more corn will be grown there in the future. In many parts of Brazil two crops

*Consul General, Rio de Janeiro.

can be grown and high yields are easily obtained. The average yield of corn grown per acre is larger than that of the United States. The average yield of corn grown per acre is larger than that of the United States. The average price is about 75 cents per bushel. The flint type is almost universally grown. The temperature and rainfall is quite variable and cultivation pratices rather crude. There are several experimental farms in operation, however, and it is certain that corn growing will receive a stimulating impetus in the future.

Austria-Hungary

The total production of corn in Austria-Hungary in 1890 exceeded that of 1880 by 40 per cent. Hungary produces the greater part of the total crop, the soil in the western part of this latter country being exceedingly fertile. The climate is typically continental; cold in winter and hot in summer. The mean annual temperature at Budapest varies from 0.7 degrees C. in January to 20.4 degrees C. in July. In Hungary 75.1 per cent of the population is engaged in agriculture, while in Austria the percentage is 55. In Austria proper 34.45 per cent of the land is arable.



CHAPTER III.

CLASSIFICATION AND BOTANICAL CHARACTERISTICS

CLASSIFICATION

The Polymorphic species *(Zea mays)* is divided into six distinct sub-groups by Dr. E. L. Sturtevant.* His classification is based upon an extended examination of almost 800 varieties. This grouping is founded on the internal structure of the kernels of the cultivated varieties and the presence of a husk on each kernel in the so-called aboriginal form.

The following species-groups are established:

Pod Corn

I. **ZEA TUNICATA.—The Pod Corn.** This is also known as primitive corn. In this group each kernel is enclosed in a pod or husk, and the ear thus formed is also enclosed in husks. The seed is supplied by our seedsmen for growing as a curiosity. Instances are on record where seemingly the dent corn has reverted to this type. The kernel itself is rather hard and flinty.

Pop Corn

II. **ZEA EVERTA.—The Pop Corns.** This species-group is characterized by the excessive proportion of the corneous endosperm and the small size of the germs, kernels and ears. The best varieties have a corneous endosperm throughout. This gives the property of popping, which is the complete eversion or turning inside out of the kernel, through the explosion of the contained moisture on the application of heat. This type is very hardy and the embryo has wonderful germinative vitality. Its culture is an important industry in certain districts near the larger cities.

Flint Corn

III. **ZEA INDURATA.—The Flint Corns.** A species-group readily recognized by the occurrence of a starchy endosperm enclosed in a corneous endosperm, as shown in a split seed. This corneous endosperm varies in thickness with varieties. It is grown farther north than any of the other types. The kernel is therefore usually

*Bulletin No. 57 of the U. S. Department of Agriculture.

very shallow, containing very little white starch and maturing in a short time. There are generally eight rows to the cob, though some varieties have twelve. The stover is more valuable than that of dent corn because it lacks woodiness.

IV. **ZEA INDENTATA.—The Dent Corns.** A species-group recognized by the presence of corneous endosperm at the sides of the kernel, the starchy endosperm reaching to the summit. By the drying and shrinkage of the starchy matter, the summit of the kernel is drawn in, or together, and indented in various forms. The ears are much larger and have more rows than flint corn. The kernels are deeper, less glassy, with sharper corners, and more angular in shape. The dent corn is the corn of the corn belt, and the corn of commerce. **Dent Corn**

V. **ZEA AMYLACEA.—The Soft Corns.** This species-group is at once recognized by the absence of corneous endosperm. Through the uniformity of the shrinkage in ripening there is usually no indentation, although this occasionally occurs. In the southern regions this corn is grown almost exclusively. This is the mummy corn of Chile and Peru. **Starch Corn**

VI. **ZEA SACCHARATA.—The Sweet Corns.** A well defined species-group characterized by the translucent, horny appearance of the kernels and their more crinkled, wrinkled, or shriveled condition. The first sweet corn cultivated in America was secured from the Susquehanna Indians in 1779, by Captain Richard Begnall, who accompanied General Sullivan on his trip to subdue the Six Nations. **Sweet Corn**

VII. **ZEA AMYLEA SACCHARATA.—The Starchy Sweet Corns.** The upper half of kernel is horny and transparent, the lower part, starchy. It is of little importance.

Zea canina (Watson) sometimes known as *Maiz de Coyoto,* or a wild corn, is a hybrid form from fourth or fifth generation of a cross between Teosinte and Black Mexican Corn.

BOTANICAL CHARACTERISTICS OF CORN

Indian Corn is an annual, herbaceous plant, belonging to the family of grasses *(Gramineae).* The botanical name *(Zea mays)* is derived from the Greek word, *"Zao,"* meaning "to live," while *"mays"* is believed to come from the Livonic word *"Mayse,"* meaning "bread, staff of life." **Zea Mays**

PLANT STRUCTURE. Many minute cells compose the body of a plant. These cells vary in shape and size in different parts of the same plant and in different plants. The cell is filled with a living material called *protoplasm*. The greater part of protoplasm is *cytoplasm*, a colorless material of granular character. In addition to the cytoplasm, the *nucleus*, or governing portion of the protoplasm, is generally located in the center of the cell. *Nucleoplasm* forms the major part of the nucleus, although the vital principle contained therein is the *chromatin*. Cells multiply, that is, development takes place at the growing point, by the process of cell division. A corresponding segmentation of the nucleus takes place simultaneously, whereby the new cell has all the essential cell elements. *Cellulose*, a firmer material, constitutes the cell wall, which is usually very thin.

Protoplasm and its parts

Cellulose

NATURE OF ROOT GROWTH. Root growth takes place at a point just back of the cap, known as the growing point. The tip, which is pushed through the soil by the constant addition of cells at the growing point, is made up of harder sells and acts as a protection to that portion. As it wears away, new cells are supplied from behind by the growing point.

Root cap

(Courtesy Iowa State College) Fig. 6.

THE FIBROUS ROOT SYSTEM OF CORN.

Many of the finer cross roots were lost in removing the plant from the soil.

Corn, which is merely a giant form of grass, has a fine, fibrous root system, like all members of the grass family. The root system is not characterized by any tap root such as is found in clover.

In the early stages the roots develop laterally. The North Dakota Experiment Station found that *30 days after planting the roots from adjacent stalks had met and interlaced, and that most of the roots were within the first eight inches of the surface of the soil and that few had penetrated to a depth of 12 inches. Six inches from the hill the main roots laid 2½ inches below the surface, while midway between the hills, they were 4½ inches below the surface. The latter point should be especially noted, for it is a strong argument in favor of shallow cultivation.

Root development thirty days after planting

An examination 55 days after planting, at the last cultivation, when the plants were 4½ feet high, showed that the main roots had reached a depth of 2½ feet. Many of the lateral roots extended the entire distance from hill to hill (three feet eight inches), inclining most of the way, and when about 3 to 3½ feet from the hill dropping almost vertically downward. The lateral and vertical roots gave off numerous branches which rebranched again and again, filling the soil to a depth of two feet with a perfect network of roots. The lateral roots sent up numerous vertical feeders to within two inches of the surface.

Fifty-five days after planting

At 90 days from planting, or soon after the frost had killed the corn, another sample showed that the ground to a depth of 3½ feet was fully occupied by roots. The conclusions were that after corn is ten inches high, it should not be cultivated deep because of injury to surface roots.

Ninety days after planting

PRIMARY AND SECONDARY ROOTS. The roots which arise from the base of the stalk are called "primary" roots. Often in this same class are also placed those springing from the first two or three nodes. The "secondary" root system appears in checked corn during the time of "laying by;" that is, when the winds of summer begin to "jostle" the corn plants. In trying to support themselves these roots are sent out. They may appear on nodes as high up as the seventh, and in listed corn, even higher. These roots do not usually appear on more than two nodes above the ground. They act both as guys and stays. Before entering the soil a small enlargement forms at the end. On entering a moist soil this thickened portion becomes mucilaginous and may be an aid in holding the root in the soil until it forms a little bunch of roots of its own. The brace roots aid in the support of the plant and absorb small quantities of plant

Brace roots are necessary

*Bulletin 43, N. D. Experiment Station.

food. From 22 to 28 brace roots usually appear at each node. If the weather is stormy and the corn has a tendency to blow over, these brace roots grow very rapidly.

(Courtesy Iowa State College)

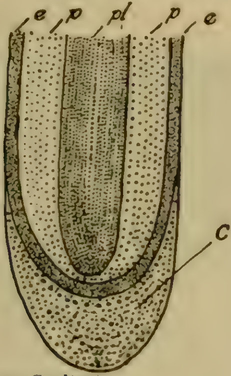
Fig. 7.

Stalk showing brace roots at nodes above the ground. Note also the rudimentary roots just appearing at the two upper nodes.

STRUCTURE. The outermost layer of a young root is a single cylinder of cells termed the "piliferous layer." This layer, when near the newly formed tip of the root, is the absorbing surface for soil moisture and plant food. The root hairs are merely projecting portions of the individual cells of this layer. The fact that this layer is absorptive differentiates it from the epidermis of the stem.

Formation of root hairs

Immediately beneath the piliferous layer is the "cortex" which is thick and consists chiefly of parenchymatous or thin-walled cells. The office of these cells is merely to give the root strength and form, while through them and between them the moisture absorbed by the outer layer reaches the central cylinder within.



(Courtesy Coulter)

Fig. 8.

A longitudinal section through the root tip of shepherd's purse, showing the central vascular axis (p), surrounded by the cortex (p), outside of the cortex the epidermis (e) which disappears in the older parts of the root, and the prominent root-cap (c).

The innermost layer of cells of the cortex forms a very complete and very rigid cylinder, enclosing the *central cylinder.* This *endodermis* consists of regularly formed, closely-fitting cells which prevent the escape of plant food on its course upward through the central cylinder of older roots. In younger plants, however, the passage of moisture from the surface to the cylinder is not hindered. **Central cylinder**

The *pericycle,* though not very distinct in many roots, is the outer cell layer of the central cylinder. From single cells within it, arise all secondary roots. By pushing their way outward through the cortexand surface layer, and by repeated cell divisions they soon elongate and become tributary feeders. This internal origin of the branch roots can be readily seen by peeling off the cortex, which lays bare the attachment.

The central cylinder consists for the most part of tubes which are of use in carrying the plant food upward into the stem and leaves.

CONDITIONS AFFECTING ROOT GROWTH. The factors affecting root growth are the factors which affect the yield of the crop.

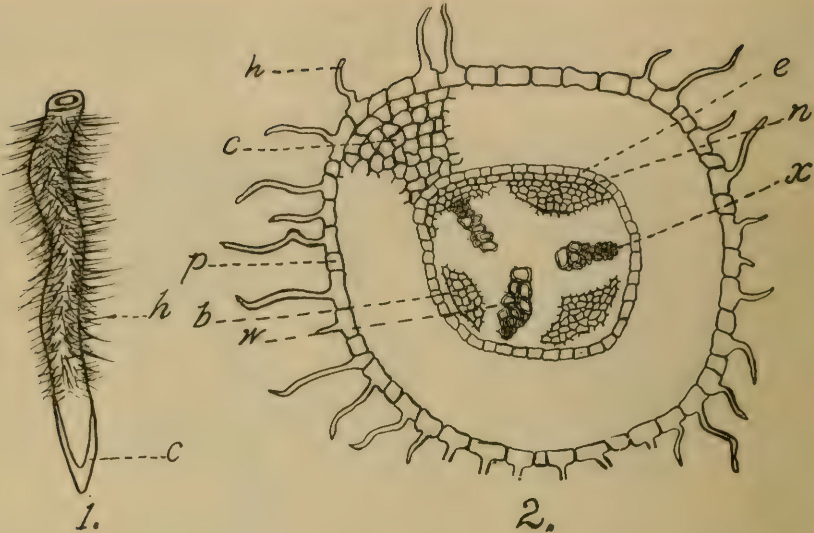
(1) In order that the younger and more tender rootlets may push through the soil, its texture must be quite fine. A root will not cross a large interspace between lumps of earth.

(2) Corn roots draw almost entirely upon the *capillary* water of the soil. In case of extreme drought they use the *hydroscopic* moisture. Very little, if any of the *gravity* water, that which is drained from the soil in tiling, is utilized by the plant.

(3) Roots avoid a cold soil and if the ground is of a low temperature will feed near the surface.

(4) The entrance of oxygen into the soil is necessary to insure the spread of root growth.

(5) Roots seek and require the presence of plant food in the soil.



(Courtesy Percival) Fig. 9.

1. Young root of a pea. h Root-hairs of the piliferous layer; c root-cap. (Twice natural size.)
2. Transverse section through a young root of a pea near h in 1. h Root-hairs; c cortex; p piliferous layer; e endodermis; n pericycle; w wood strand; x its protoxylem; b bast strand. (Enlarged 48 diameters.)

STALK.—Structure of Stem. The stem varies in height from 18 inches to 24 feet, according to variety and conditions influencing growth, as climate and soil. It is made up of a series of sections known as *internodes,* which vary in length from a few inches at the base to more than a foot at the top. They are separated from each other by short, thick joints or *nodes.* The length of internodes is less at the base for the purpose of strengthening the stalk. Being longer at the upper end, the stalk has more chance to flex in the breeze without breaking. The average circumference of the nodes measured on ten stalks was about as follows: Second internode above root crown, 3.7 inches; first internode below the ear, 3.3 inches; first internode above the ear, 2.875 inches.

Form of stem

The stem of the corn plant consists structurally of

(1) A very thin layer, the *epidermis,* on the outside. This consists of a one layered cylinder of cells. The surface is very smooth and glossy, being impervious to moisture. The idea that a corn stalk "drinks in" the showers is erroneous, as shown by this impenetrable coat. On the other hand, this covering lessens the evaporation of

Epidermis

moisture from within. Being smooth, it affords no place for the lodgment of smut spores. Insects find difficulty in inserting their sucking mouth into these parts.

(2) The woody wall, which is really a layer consisting of a close union of a great number of *fibro-vascular* bundles. In the small grains and grasses, this woody wall is the only supporting structure in the stem. From each node, where a leaf grows out, a number of these bundles leave the wall to extend into the leaf to feed it. The more rank the growth, the greater is the number of these bundles in the wall. **Woody wall**

(By courtesy of Iowa State College)

Fig. 10.

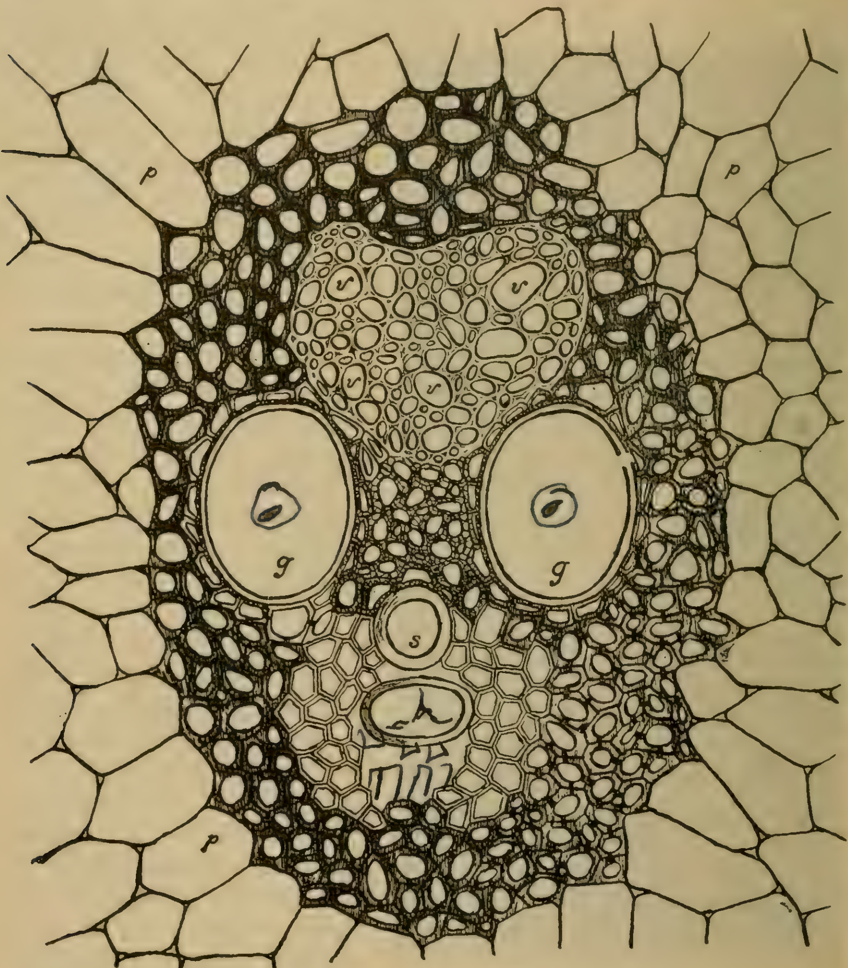
Section of corn-stalk showing pith, fibro-vascular bundles, and epidermis.

(3) The pith is composed of *parenchyma* cells and fills the center of a corn stem. With a given weight of material, a hollow column is stronger than a solid one in withstanding pressure, as heavy winds in summer, although when excessive weight is borne by such a column the sides are liable to collapse. To meet the former condition, the stems of cereals are hollow, while in the latter case the stalk of corn has a light filler. The cells of the pith are very large and loosely arranged, and although they do not transport moisture, they do act as reservoirs in time of drought. During the final stages of maturity, after frost has killed the leaves and the stalk loses its color, the kernels on the ear are fed for some time from the plant food stored here. The pith has one other function, to hold in place the fibro-vascular bundles. **Pith**

(4) The fibro-vascular bundles are the circulatory ducts for the

Fibro-vascular bundles

raw plant food drawn from the roots, and the distributing canals for the cell sap which has been manufactured therefrom in the leaves. These bundles are quite woody and fibrous and can be seen in an old corn stalk, appearing very much like threads. These tubes, of which



(Courtesy Coulter)

Fig. 11.

Fibro Vascular Bundle. Cross-section of a closed collateral bundle from the stem of corn, showing the xylem with annular (r), spiral (s), and pitted (g) vessels; the phloem containing sieve vessels (v), and separated from the xylem by no intervening cambium; both xylem and phloem surrounded by a mass of sclerenchyma (fibers); and investing vessles and fibers the parenchyma (p) of the pith-like tissue through which the bundles are distributed.—After Sachs.

these bundles are composed, are large and numerous. This helps to account for the rapidity of growth of corn under favorable conditions.

Growth of Stems. An examination of a longitudinal section of a growing corn stem will show that above each node the pith and fibro-vascular bundles are of a darker green color. The pith in the upper part of the internodes shows a pure white color and is often rather dry, while at the base of the internodes the cells are full of sap. These cells, as well as the extreme tip of the stem, constitute the growing points of the cornstalk. The possession of 14 to 20 such points enables a corn stalk to lengthen rapidly during the growing season. As the stems come out of the ground, their upward course is like the unfolding of a telescope. Such rapid extension gives corn a chance to outdo its competitors, the weeds, in the race for supremacy in the field. Corn has an *endogenous* stem. Growth in diameter takes place on the inside, rather than by adding layers on the outside, as in the case of *exogenous* plants, such as the oak.

Growing points on corn stalk

LEAVES.—Arrangement. The leaves arise from the nodes and for some distance from one node, almost to the next above, surround the stem in the form of a sheath. The edges of this sheath meet on the side opposite the blade, which spreads out from the stem above the next node in the same manner, but exactly on the opposite side. The leaves are arranged alternately and arise on, and conceal, the grooved side of the stem. The leaf sheath is movable on the internode. This allows the leaf to swing back and forth upon the stem without breaking loose at its base. The leaves appearing at the lower nodes are usually abortive, hence there is not a full leaf for each node on the stem. There are, however, usually 12 to 18 leaves upon a stalk, the number varying with the variety, the season, and the soil. Corn which is thinly planted will have a greater number of leaves than that which is closely planted.

Leaf sheath movable

Structure. At the point where the leaf blade spreads away from the leaf sheath and changes its vertical course for one more horizontal, there appears a hinge. At this point, the fibro-vascular bundles in the blade are closer together and a light colored triangular spot appears. The blade is especially full near its base for several inches along the edge. This waviness is due to the edge growing more rapidly than the mid rib. This extra amount of surface allows flexibility, both in lateral and vertical movements. This *ligule* is very prominent in corn and its need is demonstrated especially well in the western part of the corn belt.

Wavy edges of leaf allow flexibility

Just inside and springing from the ligule is a short, thin, yet rigid prolongation or fringe which clasps the internode of the stem very closely. This is the *rainguard,* which, contrary to common opinion, instead of catching the rainfall and collecting it inside the leaf sheath, transfers it to the opposite side of the stalk and allows it to drip on the rainguard and ligule below. This rainguard in turn does the same thing. The water is carried in a zigzag manner until it reaches the ground. The fact that, after a light shower in August, a wet spot is noted at the base of each hill of corn can be accounted for because of this process.

Rainguard

The midrib and the veins, which are only larger gatherings of fibro-vascular bundles, serve to hold the green surface spread out to the sunlight. They are also circulatory ducts. The epidermis of the leaf is not very thick nor tough. This is shown by the tendency of the point of the blade to split in a heavy, whipping wind. The green, cellular structure between the veins of the leaf of corn is, in the plant's early growth, very turgid and of a dark color. The curious openings on the surfaces of the leaf, known as *stomata,* are very active in the corn plant. Guarding each opening will be found two crescent-shaped cells known as *guard cells.* The stomata act as passage ways for the transpiration of moisture and for the inlet and outlet of carbon dioxide and oxygen. They cannot properly be spoken of simply as breathing pores.

Midrib

FIGURING THE LEAF SURFACE OF A CORN STALK. As the corn plant requires over 500 tons of water for the formation of one ton of dry matter, the leaf surface must necessarily be large to accommodate this enormous transpiration. In figuring the surface area of a leaf, measure the width three inches from the ligule, also at a point six inches from the tip of the leaf. Add these two widths, divide by two to get the average. Multiply this average width by the length of the leaf from the ligule to that point, six inches from the tip. To the area of this rectangle, add the area of the isosceles triangle at the tip of the leaf, which is six inches in altitude and as wide as the leaf is at that point. The sum of the two areas gives the leaf surface on one side of a single leaf. Multiply this sum by two and the entire surface of leaf will be ascertained. For approximate calculations, the surface area of one leaf multiplied by the number of leaves on the stem will give the entire leaf surface of the stalk.

Five hundred tons water to one of dry matter

An Example. Leaf 36 inches in total length,
4 inches wide at lower measurement (3 inches from ligule),
3 inches wide at upper measurement (6 inches from tip of blade),
3½ inches average width.

Three and one-half inches multiplied by 30 inches (36-6 inches) equals 105, square inches, area of rectangle.

The isosceles triangle with 3 in. base and 6 in. altitude has an area of 9 square inches. 105 sq. in. plus 9 sq. in. equals 114 sq. in., one surface. 114 sq. in. multiplied by 2 equals 228 sq. in., the area of both sides of the leaf. With 12 leaves on the stem, there would be a total of 2,736 square inches, or 19 square feet of leaf surface for that one stalk.

Figuring leaf surface

DROUGHT RESISTING CHARACTERS. While necessary for the transpiration of so much moisture, the larger surface area of the leaves of a corn stalk, must, of course, be equipped with means of preventing undue loss. Nature is not extravagant. This is especially true in the case of corn. As the water level slowly settles, when the summer season advances, the roots of the corn plant begin going down, following the strata of moisture. When the spring season has been very wet and the summer turns dry suddenly, causing the surface soil to bake and evaporation to go on very rapidly, the water table often sinks so quickly that the plant, which had before fed near the surface, cannot change its root system in time to prevent its being stunted from want of moisture.

Root extension in dry weather

When the root system fails in its attempt to keep in contact with the water table, the foliage exhibits certain adaptations for reducing evaporation. The leaves of a very young corn plant are always tubular, partly because of their being wrapped about each other and partly because if their surface were open moisture would be lost by transpiration faster than it could be supplied by the small root system. The leaves are built up of many cells of delicate nature, hence they depend upon moisture for the maintenance of rigidity. As excessive evaporation from the surface continues and the supply from below slackens, the leaves fold in halves on the mid rib. The edges also curl in on each other. This "curling" of corn in July is a bad omen to corn growers in the drier districts. Through July and August, during the formation of the ear, is the critical period in the life of a corn plant. A lack of moisture at this time means curtailment of yield.

"Curling" of corn

THE FLOWER. The corn plant is *monecious;* that is, the staminate and pistillate flowers are borne on the same plant, but at different places. They will be spoken of here as male and female flowers, respectively, as they are commonly known as such, but from a strict botanical point of view the terms male and female are incorrect when so applied. The time of blossoming depends upon:

(1) The time of planting. Early corn usually comes out in bloom and ripens before the late planted corn.

(2) Varieties, whether early or late.

(3) Seasonal influences. Often in a growing season of plenty rainfall, the early corn will remain green and continue growing late in the summer before blossoming. A sudden drouth at the time of rapid growth forces the date of blossoming upon the corn.

(4) Soil conditions. A soil which is lacking in plant food and not retentive of moisture, dwarfs the plants and they prematurely put out flowers.

MALE OR STAMINATE FLOWERS.—Tassels. The male or staminate flowers are found in the tassel, arranged in the form of a *panicle,* the branches of which are shorter nearer the base. There are two single flowers in each spikelet. Each single flower has its own set of inner

Bracts

bracts, and the two together are enclosed by thicker, darker green, outer bracts. Each flower has three stamens, mounted at first upon short, stock *filaments,* but which as the pollen matures, lengthen and push the pollen sacks or *anthers* out to be caught in the breezes. The anthers are two-celled and instead of opening at the tip end, split just above and along one side. This allows the pollen grain to be wafted to greater distances. At the base of each set of these filaments, there is

Pollen sacs

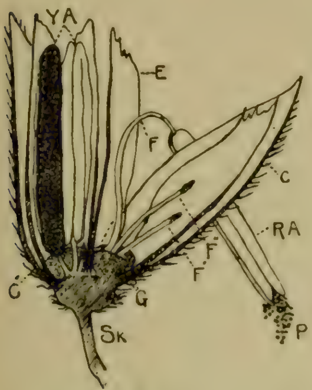
present a greenish, grandular, turgid body, called the *lodicule,* which swells as maturity advances, thus spreading open the bracts to allow the stamens to be pushed out. Each pollen grain is very small, having in its center a nucleus, while the remainder of the cell is light, and serves as a buoy in its course through the air. It has been estimated that each anther or pollen sac produces about 2,700 pollen grains. A single tassel con-

(By courtesy of Iowa State College)

Fig. 13.

Section of branch of tassel showing pollen sacs suspended on the elongated filaments. Note the openings of the cells of the pollen sacs (anthers).

tains 7,500 pollen sacks, making a total of 30,250,000 pollen grains per plant in the corn field. This excess of pollen is necessary because of the loss of so many grains which are lodged about the stalk and which fall to the ground. If every grain were to reach a silk there would be 30,250 grains for each ovary, if each stalk produced but one ear, or 15,125 in case of two ears, counting 1,000 ovaries per ear.



(Courtesy Sargent)

Fig. 14.

A spikelet from the tassel cut lengthwise to show its two flowers, the one on the right fully open, the other not yet mature. Sk, stalklet; C, C', outer bracts; D, E, inner bracts of the open flower; G, lodicules, which by swelling spread the bracts apart; F', F'', filaments cut across; F, filament bearing ripe anther (RA) shedding pollen (P); YA, young anthers, the left hand one cut to show the pollen. Enlarged. (Original.)

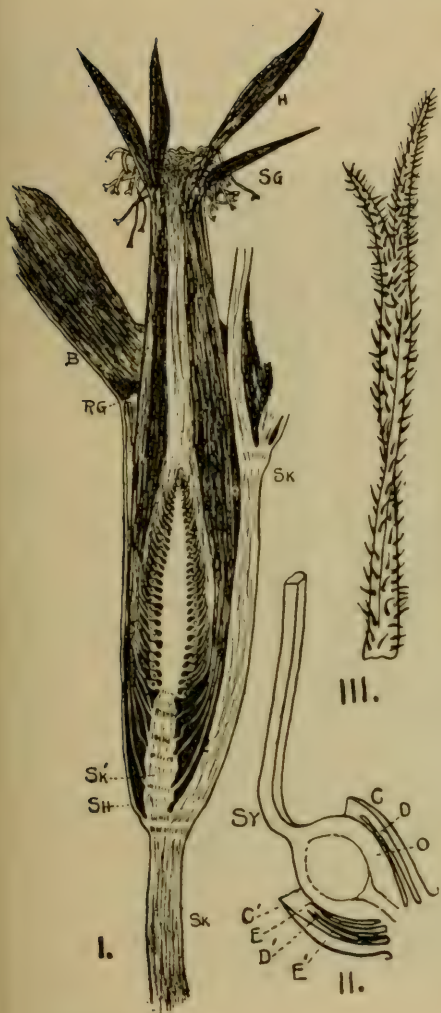
FEMALE OR PISTILLATE FLOWERS. The female flowers are borne on a hardened spike (cob), which is produced on a branch or shank coming from a node on the main stem. At first, the leaf sheath covers and protects this outgrowth, but it soon appears above the sheath and the corn is said to be "shooting." In a short time, the husks, which are modified leaves, open at the tip end and silks appear. The outer end of each silk, a portion of the *stigma*, is often split, and is covered with very short hanrs which, together with a sticky or mucilaginous secretion present, aids in collecting pollen grains. **Stigma**

The remainder of the silk to its attachment is the *style*, which is slightly angular and i stubular. The style is attached to the summit of the *ovary* (kernel), which is held in two sets of bracts and encloses within its walls a single *ovule*. There is but one silk for each ovary and there are 800 or more ovaries on the spike. **Style** **Ovary** **Ovule**

DEVELOPMENT OF THE EAR. Corn is a cross-pollinated plant. Nature, in her effort to accomplish this, sends out the tassel as many as seven days before the silks appear on the shoot below. This character is taken advantage of in mating ears in the breeding block. When a pollen grain falls upon the stigma of a silk, the moisture there present, and the heat of the summer causes it to germinate. The external evidence of germination of a pollen grain is the production of a long pollen tube which penetrates the stigmatic surface and passes down through the hollow style to the tip of the ovule within the kernel. The internal evidence of germination consists in several divisions of the pollen grain nucleus. Two of the resultant nuclei pass down through the pollen tube, out through its ruptured tip and one **Corn is cross-pollinated**

(Courtesy Iowa State College) Fig. 15a.

EAR IN SILK.
(Entire Tassel.)



(Courtesy Sargent)

Fig. 15b.

Maize. 1. A young ear cut through the middle lengthwise. Sk, Sk, the main stalk; Sk, the branch silk which bears the ear· Sh, sheath of the leaf enfolding the whole ear; RG, rain guard; B, blade of the same leaf; H, husks; Sg, stigmas ("Silk") protruding beyond the jusks.

II. A single spikelet of the ear, showing the bracts (C, C', D, E, D', E') and the ovary (O) and the lower part of the style (Sy) of the single pistil. Enlarged.

III. Upper part of stigma, showing the delicate hairs that cover it. Enlarged. (Original.)

unites with the egg cell, which has been formed within the ovule. This constitutes the act of fertilization. But one grain is required for the fertilization of each ovule. The fertilized ovule immediately begins to grow and together with the surrounding ovary, forms the kernel of corn. The silks at the butt of the ear are the first to appear and the first, as a rule, to be pollinated. The middle kernels are next. The complete fertilization of the tip kernels of the ear depends upon the continuance of good weather and the late tasseling of other nearby stalks in the same field. Warm, balmy weather, with a slight breeze, is ideal for the transfer of corn pollen. Dashing rains at this season of tne year wash the pollen from the tassel, and a moist atmosphere prevents the grains from floating about.

Conditions for pollinating well

The developing kernel is fed from within the cob by a single fibro-vascular bundle which extends directly to the stalk. This duct, in its course through the cob, passes between the soft white cellular pith and the woody portion and enters a passage way through this woody portion to the base of the kernels. The bracts about the base of the ovary become the colored chaff of the matured cob.

Each ear is borne upon a shank which at first holds the shoot upright along the side of the stalk, but, which, as a rule, later allows the matured ear to droop and even to hang, because of increased weight of the ear and lack of rigidity in the shank itself. The shank

(By Courtesy of Iowa State College)

Fig. 16.

EAR IN NATURAL POSITION ON STALK.
Note That Its Shank Lies in the Groove. The Outer Husks are Shorter Than the Inner Ones.

fits in the groove of the internode and appears jointed just as does the stalk itself. As many as ten or more internodes are present. At each node a husk is produced, those from the lower nodes overlapping those above. The number of husks and their coarseness depends upon the season, the soil and the variety. The place of appearance of this shank varies. In rank growing corn it will be higher than on plants produced on poor soil. In a wet season, when the fibro-vascular bundles are constantly supplying plant food from below, "shoots," so-called, may appear at seven or more nodes, beginning quite near the ground. The position of the shoot which finally matures is an inherited character and it has been shown that it may be largely controlled by selection. As a rule, it develops at a point between four and six feet from the base of the stalk. Some varieties produce two or more ears on each stalk. In favorable years, two ears per stalk are not uncommon in many fields.

THE KERNEL, DEVELOPMENT OF. In the study of the development of the kernel, the first period of growth includes what is commonly referred to as the milk stage. Kernels in the milk are very sweet, due to the presence of sugar which has not yet been transformed into storage starch. The protein, ash, and oil are deposited in the *germ* (embryo plant) before the endosperm or body of the kernel is filled out. Later, the cellular structure (endosperm) surrounding the germ is packed full of starch. Much of this material has been held in readiness in the stalk and is now deposited in the grain. A seed such as corn in which the reserve food is stored outside of the embryo is said to be *endospermous;* one in which the food is stored entirely within the embryo is said to be *exendospermous.* The storage of all this readily available food material takes place during the development of the seed. Man has taken advantage of these facts and developed in certain grains an increased storage of one or all these constituents. The matured grain-fruit (kernel) is called *caryopsis.* It is the ripened ovule surrounded by the ovary walls.

Protein and oil deposited first

Starch deposited later

Immediately covering the food supply of the seed and enveloping the entire caryopsis, is a thin membranous layer called the *tegmen* (seed coat), overlain by a tough coat or *testa* (ovary wall). The *integument* formed by the union of these two constituents is the *bran* of wheat and the *hull* of corn. It may be removed after soaking the kernel in warm water for about twenty minutes.

Covering and formation of caryopsis

Germination is the resumption of growth of the young plant which lies within the seed. This young plant is the embryo or germ.* It is made up, first, of a large shield-shaped portion (scutellum) which lies next the endosperm and which does not appear above ground, and second, a portion which develops into the roots, stem, and leaves of the

Radicle

*The term embryo is sometimes loosely applied to that portion of the germ which produces the roots, stem and leaves. This is incorrect, the terms germs and embryo are strictly synonymous.

corn plant. The portion which is to produce the stem and leaves lies toward the crown of the kernel and is called the plumule. The portion which is the first root lies toward the tip of the kernel, and is called the radicle.

Plumule

At the time of germination the radicle becomes the root sprout. It appears enveloped for a time in a sheath, the "coleorhiza." This root sprout is usually temporary. The permanent roots spring from the first node of the stem sometimes before it has pushed its way out from under the hull of the kernel.

Monocotyledonous

Dicotyledonous

The "stem sprout" is the awakened plumule. It is believed by some good authorities that the scutellum corresponds to the single *seed leaf* or *cotyledon* in such plants as the lily. The corn is therefore said to be "monocotyledonous." A representation of the "dicotyledons" is the bean which has two such seed leaves. The first leaves are tightly rolled together, the younger ones being enclosed within the older. Just as soon as the stem sprout reaches the light, it turns green owing to the formation of *chlorophyll.*

ACKNOWLEDGMENTS. In the classification of the types of corn the facts were drawn from Dr. Sturtevant's investigations.

In gathering the facts for the description of the botanical characteristics, we drew freely from "Agricultural Botany," Percival, who presents the details of plant structure very plainly. "Corn Plants, their Uses and Ways of Life," by Carpenter, was used as a guide in discussing the peculiarities of the parts of the stalk. "Plants," a text book of Botany, by Coulter, and the text book of Botany by Wood, were also used as references.

COLLATERAL READING.

Flint Varieties of Corn,
Farmers' Bulletin No. 225.

Varieties of Corn, by Sturtevant,
U. S. Department No. 57.

Pop Corn,
Farmers' Bulletin No. 202.

A Study of Corn,
Maine No. 139.

Sweet Corn,
Maryland No. 96.

Corn, Roots of:
Kansas No. 127.

CHAPTER IV.

GERMINATION AND THE GROWTH OF PLANTS

GERMINATION

Germination is the awakening of the dormant embryo. Its immediate subsequent continuation is dependent upon available nutriment contained in the seed.

THE CONDITIONS OF GERMINATION ARE

- A. VITALITY.
- B. MOISTURE.
- C. PROPER TEMPERATURE.
- D. OXYGEN.

Take away any one of these first four factors and life will not awake from its slumber. The successful storage of grains is dependent upon the elimination of as many of these favorable conditions as possible. The exclusion of oxygen is a physical impossibility, while the regulation of temperature is limited, but by preventing the access of moisture to stored seeds, germination is prevented.

VITALITY. The vital principle in a live seed is known only by its effects. The organic life evidenced by germination is a phenomenon due to the presence of living cells in the germ of the matured seed. **Organic life**

Kernels which have been subjected to continued freezing or to excessively high temperatures have this life extinguished. Embryos which are not full of water are not so suddenly or injuriously affected by these extremes. The cells of a swollen plumule or radicle are destroyed when the temperature is lowered below freezing. **Old corn**

By experimentation, De Candolle was able to germinate seeds of a few species after a storage of fifteen years. Other plants require immediate favorable environment or the vitality of the seeds is weakened or lost. Seeds of Mountain Potentilla were known to germinate at Meriden, New Hampshire, when 60 years old.

"Well matured corn two years old is very slightly weakened if kept in cool dry storage. Corn four years old shows very weak germination, much of it failing to grow at all."*

MOISTURE. A dry seed is usually hardy. It withstands the extremes of heat and cold. The structure of a matured corn kernel is conducive to the absorption of water, the first process in the awakening of the embryo. Water has four distinct functions in germination.

(1) It softens the covering of the seed. It penetrates the minute cells of the seed coat, enters the larger cells within, and by swelling them causes the entire seed to increase in size and ruptures the softened covering.

Absorption of moisture

Kernels of corn placed in water at a temperature of 70 degrees Fahrenheit will absorb 15 per cent of their original weight in 52 hours. The rapidity of absorption depends upon the maturity of the corn and temperature of water. Kernels with a large amount of flinty starch and covered with a thick coating of horny gluten, which acts as a sealing wax, require considerable time and a higher temperature to induce penetration of moisture. Starchy kernels of an open cellular structure admit the soil moisture very readily. This accounts for the rotting of immature kernels when placed in the ground early in the spring, at which time it is cold and wet.

Immature kernels germinate rapidly

(2) It dissolves the plant food. The parent bequeaths to the ripened ovule a store of starch, fat, sugar, and protein before the seed is cast off. Of these substances the sugar and allied compounds are soluble in water; before the remainder can be utilized they must be digested or rendered soluble. This digestion takes place, however, only in the presence of water. This fact is well illustrated by the rapid germination of immature kernels of corn. The sugar which would later have been changed to starch and stored in the kernel, is readily soluble in the water which first enters. Tests have shown that corn which was picked early, germinated in a shorter time than that gathered in the husking season. However, it must be borne in mind that there is a smaller reserve of plant food in such a kernel to continue the germination. Therefore, the soil must be warm and rich in order that the young rootlets may begin immediately to draw from outside sources.

Water as a carrier

(3) It carries the plant food to the growing embryo. A continual supply of available nutriment is demanded by the young plant. The presence of water insures its transportation to every growing point. The scutellum acts as an absorbing organ for the plant food

*Classbook of Botany. wood.

stored in the endosperm. The food so absorbed, together with that stored in the scutellum, passes over a sort of bridge to the sprouting plumule and radicle.

(4) It aids in the chemical and biological changes. The two classes of food materials present in the largest amounts in the mature seeds are the albuminoids and carbohydrates. The albuminoids in cereals appear in aleurone grains. Starch represents the larger part of the carbohydrates. The aleurone cells are thought to secrete diastatic ferments. These ferments or "enzymes" begin immediately to corrode the starch cells lying beneath. The epithelium of the scutellum has similar secretive cells which become active very early. The resultant product after the diastatic action on the starch is an invert sugar which is readily soluble in water and is quickly absorbed by the growing plant. Some soluble cane sugar enters the embryo as food also.

Enzymes and their action

In the spoiling of stored grain the same process occurs. Bacteria, yeasts, and moulds, which are universally present, change the sugars to alcohol and acids, making the grain sour. In the case of the germinating plant in the field, the sugar is used before the latter steps have time to take place.

Spoiling of stored grain

PROPER TEMPERATURE. Many experiments have been made with the seeds of cereals and grasses to determine the effect of heat upon germination. The highest temperature at which a certain kind of seed will germinate is termed the "maximum." The "minimum" temperature refers to the lowest point at which the seed will germinate. The most favorable temperature—the degree of heat which produces the most rapid substantial growth—is the "optimum" temperature.

The following are the maximum, optimum, and minimum temperatures as given by Sachs for some of our most common farm seeds:

	Minimum.	Optimum.	Maximum.
Wheat	41	84	104
Barley	41	84	104
Maize	48	93	115

Professor Gerald McCarthy, of the North Carolina Experiment Station, gives:

	Minimum.	Optimum.	Maximum.
Oats	55	70	90
Rye	55	75	90

The Department of Agriculture in seed investigations has tried to imitate nature in the germination of seeds. A temperature of 64 degrees to 68 degrees F. is maintained, but during six hours out of each twenty-four, the temperature is raised to 86 degrees F. *Pammel gives the minimum degree for the germination of corn as 49.9 degrees F., the optimum 91.4 degrees F., and the maximum as 134.8 degrees F. The lowest temperature at which maize will germinate, according to Sturtevant, is 43.7 degrees F. for all varieties. Corn seems to do much better under a constant rather than a changing temperature, which is not the case with more northern native plants.

Optimum temperature 91 to 93

Some heat is generated in the process of germination, but where the seeds are planted in hills by themselves this radiates so rapidly as to be unnoticeable. Low temperature at the time of germination retards growth. Cold, wet, mucky soil which excludes the warmer surface air, produces a weak plant and feeble advancement. Seed beds in the best tilth are conducive to increased activity of the roots and a higher coloring of the stem sprout, showing greater strength and vigor.

OXYGEN. Oxygen is present in the seed, both in a free and a combined state, but this supply is insufficient for germination. Germination will not take place in water which has been boiled to drive off oxygen. The inhalation of this vital element is followed by the oxidation of the constituents stored in the seed and a consequent evolution of energy. With the intaking of oxygen, there is a comparable outgoing of carbon dioxide gas. This process, which is slow and imperceptible, except by direct and careful experimentation, is called *respiration.*

Oxidation

The principle upon which the tilling of the soil lies, is in the assistance of nature. A soil impenetrable to the air, resists the processes which bring about rapid and substantial growth. It is not alone to eliminate weeds that the seed bed is prepared so carefully. The more delicate operations of vegetation are facilitated.

Air in the soil

The unhealthy appearance of corn on poorly drained soil is usually considered to be due to too much water, when it is really the lack of oxygen. When corn, which has been planted very deeply, is slow in germinating in the spring, especially when continual rains come on, it is due largely to a reduction of temperature and an exclusion of oxygen.

TIME REQUIRED FOR GERMINATION. The time required for germination depends upon the presence of the conditions just men-

*Grasses of Iowa. Vol. 1, Page 91.

tioned. In germination box tests in the green house, at a temperature of 80 degrees F., corn has sprouted distinctly in four days.

Early planted corn on ground which has been well prepared, in order to admit the surface air, will appear in 10 to 12 days or sooner. Listed corn on low ground sometimes requires two weeks or more before it can be seen in the furrow.

Corn germinates in 4 to 6 days

THE GROWTH OF PLANTS

The growth of plants is a natural process. It is a cellular development which usually results in increase of volume and weight. This activity is the expression of life. During the early period of existence of a plant, this development takes place in all the parts at the same time. Later, centers of growth are formed, usually near the tips of roots, stalks, and branches. In cereals and grasses, growth takes place at the base of each internode and also at the tip of the stem.

THE ESSENTIALS FOR THE GROWTH OF GREEN PLANTS ARE:

1. Constitution.
2. Water.
   - A. The absorption of water.
   - B. Its uses.
     - (1) An essential constituent of the plant.
     - (2) Regulates temperature of plant.
     - (3) Maintains turgidity.
     - (4) Aids in the physical changes in plant food.
     - (5) Enters into the chemical processes within the plant.
     - (6) Transports plant food.
3. Proper Temperature.
4. Light.
5. Plant Food.
   - A. From the air.
     - (1) Oxygen.
     - (2) Nitrogen.
     - (3) Carbon.
   - B. From the soil.
     - (1) Carbon.
     - (2) Nitrogen.
     - (3) Phosphorus.
     - (4) Potassium.
     - (5) Calcium.
     - (6) Others.

CONSTITUTION. This term is often confused with vitality. A plant or animal may have vitality, that is, there may be life present, but it may lack strength and vigor. Many corn plants that come through the ground in the spring never attain any size.

In-breeding leads to a lack of constitution

In-breeding in corn tends, as in live stock, to weaken the constitution of the plants. The blades become narrow and of a light green color, the root system shallower and the stalk itself more slender. The weakness is often inherited, although it may result from improper care of the seed. The offspring of an ear of corn or spike of wheat may, from germination to maturity, show certain characters of strength which stand out distinctly. The breeder takes advantage of this fact, especially in the production of plants of economic importance. New varieties are evolved in this manner. The importance of knowing the ancestry of one of these plants with marked constitution cannot be overestimated. The environment has much to do with the highest development of virile characters.

WATER. The presence of water in a plant is necessary for the activity of its cells. The protoplasm, which is the most important part of the cell, is a more or less slimy or jelly-like substance containing a considerable proportion of water. The peculiar phenomenon which is called "life," is associated with this watery substance. The amount present is influenced by the kind of plant and the environment. Fresh red clover hay contains 70 per cent of water; green timothy hay, 62 per cent; mangel beet roots, 91 per cent; potatoes, 79 per cent; corn silage, 79 per cent; corn from the crib, 11 per cent.

THE ABSORPTION OF WATER. The adequate absorption of water goes on only when the following conditions are present:

(1) A degree of temperature suitable to the nature of the plant. The oat plant will absorb moisture from a much colder soil than will the corn plant. The millets require an even higher temperature. A corn plant is slow to use moisture early in the spring, although requiring a great deal for the most rapid growth during the summer months. Well water poured into pots of tropical plants in a greenhouse often checks their growth.

(2) A supply of fresh air. Imperfect respiration occurs in the roots of plants which are growing in soil which is so full of moisture as to exclude oxygen. Undrained portions of corn fields, where the water stands on the surface or very near it, always grow weakly stalks. Even in July, when this water is warmed, the plant cannot use it because of the exclusion of air.

(3) The condition of the water. Plants differ in their demands for water. Plants with a very fine, fibrous root system, draw almost entirely upon the slight films of moisture surrounding each soil particle. Plants with few roots require that the moisture be present more abundantly. Corn seems to take a place rather between these extremes. The root system is not fine enough to absorb moisture from a dry soil, and yet the plant will not thrive in a saturated stratum.

In Plant Growth, Water has six distinct functions.

(1) Water is an essential constituent of the plant.

The most abundant constituent of growing farm crops is water. In chemical combination with carbon, it enters into almost every compound stored or used by the plant.

(2) Water regulates the temperature of the plant.

When there is danger of excessive heat injuring the plant, the rapid evaporation of water from the leaves reduces the temperature. This is proved in the corn field in July. The temperature may rise very rapidly to extreme heat, but the moisture which is taken up by the roots is continually evaporating from the leaves; this keeps the whole plant cool. If the moisture supply be deficient, evaporation is diminished and the temperature of the plant rises.

(3) Water maintains turgidity.

A cell which has absorbed water until it is exerting considerable stretching force upon the cell walls is said to be turgid. The moisture necessary to maintain the turgidity of the plant is obtained from the soil by the root hairs. These hairs draw upon the capillary and "hydroscopic" water within their reach. The root system receives this moisture and passes it from cell to cell into the tubes of the central cylinder.

Transpiration

The moisture continues its upward course as sap. Just why sap rises has never been entirely satisfactorily explained. It is probably due to a combination of physical phenomena; among them *root pressure*, capillarity, the "pumping" action of certain cells of the stem and the higher concentration of the cell sap where transpiration is rapid. The passage of moisture from these tubes to the cells is affected by *osmosis*. This is the diffusion of liquids through a membrane in which no openings are visible.

Root pressure

Osmosis

Vapor is *transpired*, or evaporated through minute openings on the surfaces of the leaves of a plant. These pores or *stomata* are surrounded by guard cells which open or close according to the amount of water stored in the plant. They help to regulate the degree of turgidity of the entire plant. When every cell is full of water these guard cells dilate the stomata and evaporation is increased. In contrast, if the roots fail to furnish a sufficient supply of moisture, the wilting of the leaves relaxes the guard cells and the opening of the stoma closes and transpiration is diminished. The curling of corn leaves in July indicates that the roots are securing insufficient moisture. When the atmosphere is clear, dry and hot, and the wind is blowing briskly, transpiration is increased even though the stomata are practically closed. Coolness and dampness of the air tends to reduce the passage of moisture from the stomata.

Turgidity

*The following was found to be true regarding the amount in tons of water per ton of dry matter lost by transpiration through the plant and evaporation of the soil:

Dent corn	used	309.8	tons	of	water	per	ton	of	dry	matter.
Flint corn	"	239.9	"	"	"	"	"	"	"	"
Red clover	"	452.8	"	"	"	"	"	"	"	"
Barley	"	392.9	"	"	"	"	"	"	"	"
Oats	"	522.4	"	"	"	"	"	"	"	"
Field peas	"	477.4	"	"	"	"	"	"	"	"
Potatoes	"	422.7	"	"	"	"	"	"	"	"

(4) Aids in the physical change of plant food.

The nitrates, the form in which all nitrogen enters the plant, are soluble in water. This compound is drawn in with the soil moisture by the root hairs. Other soil constituents are also soluble in water. "The weight of evidence supports the conclusion that water is capable of dissolving from the soil all the substances that it contains which serve as the food of plants."** A few analists assert that phosphoric acid is not soluble in water alone. Yet experiments have proved its presence in water solutions of ten days standing. It must be kept in mind, however, that only weak solutions of plant food are readily absorbed and assimilated. Care should be taken then that manure containing a large amount of available and soluble elements is not applied heavily to the corn crop. In case of excess, the plant is injured. The presence of carbon dioxide in water renders it more effective in dissolving the food materials in the soil.

(5) Water enters into the chemical processes within the plant.

In all probability, carbonic acid and water are decomposed at the same time by the action of the sun's rays through the chlorophyll, in the leaves of the plant.*** "It is probable that formaldehyde is first

*"The Soil," King, Page 155.
**Johnson's "How Plants Feed," Page 316.
***Warrington's "Chemistry of the Farm," Page 6.

produced according to the following equation. CO_2 plus H_2O equals CH_2O plus O_2. Cane sugar ($C_{12}H_{22}O_{11}$) and starch ($C_6H_{10}O_5$) are among the earliest products. These are converted respectively into glucose ($C_6H_{12}O_6$) and maltose ($C_{12}H_{22}O_{11}$) for the nourishment of distant parts of the plant, to which they are conveyed by the movement of the sap. In parts where growth is taking place and new cells are being formed, the sugar of the sap is converted into 'cellulose,' the substance which forms the cell walls, and of which the skeleton of the plant primarily consists."

Chemical processes

The fatty matter of the plant is thought to come from the carbohydrates. Albuminoids are probably formed from the carbohydrates and the nitrates and then changed to proteids.

(6) Transports plant food.

The activity of water in plant growth is incessant and vital. The growing regions depend upon this carrier of plant food in physical solution for their maintenance and continued development. This is a very important function of water in plant life. Water acts as a carrier of waste materials.

PROPER TEMPERATURE. The average temperature of the native habitat of a plant is an important factor in determining its maximum growth. Yet adaptability to environment has enabled many plants to move far away from their original abode. Corn now grows north of the Minnesota-Canadian line. South Dakota is yearly increasing its production of this cereal. The optimum temperature for the development for different plants varies greatly. A cool month of May is detrimental to growth of corn, but small grain thrives luxuriantly. A hot, wet July is ideal for corn, but means destruction to spring wheat.

Hot, wet July best for corn

The following table shows the growth of 25 stalks of corn from June 21 until August 20, 1907. The measurements were in most cases taken every three days. The highest point of the stalk was used as the basis. When the corn was small the highest point was in the crotch where the upper leaves spread away from the central stem.

RATE OF GROWTH OF CORN PLANT

NO. HILLS	June 21st	June 24th	June 27th	July 1st	July 4th	July 8th	July 11th	July 15th	July 18th
1	3.5	5.0	7.0	9.2	13.5	18.0	24.0	27.5	35.0
2	3.5	4.0	6.2	9.0	12.0	16.0	24.0	26.0	35.0
3	3.7	4.5	6.0	9.2	14.0	18.0	24.0	29.0	35.5
4	2.5	3.5	4.5	8.5	11.2	24.0	20.5	27.0	35.5
5	3.7	3.5	5.5	9.0	11.5	17.0	20.0	26.5	34.0
6	4.0	4.2	7.0	9.5	12.5	16.0	21.5	27.5	33.5
7	3.2	4.5	7.5	9.5	12.5	17.5	22.5	26.0	36.0
8	4.0	5.5	8.5	10.7	15.0	19.0	22.5	30.0	40.0
9	3.7	5.0	7.0	10.0	14.5	18.0	21.5	28.0	35.0
10	4.5	6.5	8.5	10.5	16.0	19.0	24.0	26.5	32.0
11	5.0	6.0	8.5	11.0	20.0	21.5	26.0	36.0	39.0
12	3.0	5.5	6.7	8.0	14.5	19.0	22.0	27.0	36.0
13	3.5	5.0	7.0	9.5	17.0	18.5	25.0	32.0	37.0
14	6.0	7.0	11.0	13.5	19.5	23.0	28.5	38.0	44.0
15	6.5	8.5	12.0	14.0	20.5	26.0	34.0	45.0	50.0
16	5.5	8.0	9.0	12.5	18.0	19.0	28.0	39.0	47.0
17	4.5	5.5	9.0	11.0	17.0	20.0	27.0	33.0	44.0
18	5.0	5.5	9.3	11.0	15.0	20.5	25.0	28.5	36.0
19	4.5	5.5	9.5	11.5	16.0	22.0	27.0	36.0	47.0
20	4.2	6.0	9.0	11.5	18.5	23.0	26.0	40.0	47.0
21	5.5	7.0	8.0	10.0	15.5	22.0	26.0	31.0	37.5
22	5.7	6.0	8.2	10.5	15.5	20.0	25.5	33.0	42.0
23	4.5	5.5	7.5	10.5	15.0	19.0	24.5	31.0	37.0
24	6.2	8.3	10.5	14.0	20.5	25.5	34.5	43.0	49.5
25	6.4	8.0	10.5	14.5	19.5	26.0	35.5	36.0	51.0
Average	4.5	5.7	8.1	10.7	15.5	20.3	24.8	32.1	39.8
Increase		1.2	2.3	2.6	4.8	4.8	4.5	7.3	7.7

NO. HILLS	July 22d	July 24th	July 26th	July 30th	Aug. 3d	Aug. 6th	Aug. 10th	Aug. 13th	Aug. 17th	Aug. 20th
1	48.0	52.0	64.0	72.0	85.0	95.0	104.0	109.0	115.0	114.0
2	46.0	49.5	59.5	68.0	75.5	76.5	96.0	106.0	113.5	114.0
3	48.5	48.5	57.5	70.0	83.5	92.0	101.0	101.0	101.5	101.0
4	46.0	49.0	60.0	68.0	80.5	90.0	111.0	119.5	125.0	124.0
5	52.0	57.0	62.0	73.5	85.5	96.0	112.5	116.0	117.0	115.0
6	48.0	52.0	64.0	75.5	81.0	95.0	109.0	115.0	120.0	121.5
7	49.0	54.0	64.0	66.0	79.0	90.0	111.5	118.5	129.0	131.5
8	46.5	55.5	67.5	80.0	84.0	105.0	113.5	128.0	133.0	135.5
9	46.0	50.0	62.5	72.0	82.0	92.0	115.0	121.0	128.0	128.0
10	44.5	50.0	60.0	71.0	79.0	86.0	102.0	105.5	111.0	111.0
11	54.0	48.0	69.0	75.0	89.0	102.0	106.0	110.0	106.0	106.5
12	50.0	49.0	61.0	77.5	98.0	106.5	109.5	116.0	124.0	125.5
13	50.0	55.0	60.5	77.5	93.0	102.0	109.5	113.5	113.5	115.0
14	58.0	62.0	72.0	81.0	94.5	104.5	115.0	119.0	120.5	118.0
15	62.0	65.0	77.0	82.0	93.0	105.0	113.0	113.5	114.5	114.5
16	64.0	68.0	78.0	91.0	110.0	116.5	119.0	122.0	120.0	122.0
17	57.5	58.0	65.0	74.0	89.0	97.0	106.0	106.0	106.5	106.5
18	47.0	56.0	68.0	86.5	101.0	103.0	103.5	103.5	104.0	103.5
19	61.5	64.0	72.0	87.0	106.0	116.0	130.5	131.0	130.0	131.5
20	58.0	60.0	69.5	77.5	96.0	114.0	116.5	123.0	127.0	118.0
21	51.5	52.0	64.5	71.5	84.0	93.5	117.5	123.0	129.0	124.0
22	54.0	57.0	68.0	81.0	97.0	107.0	116.5	120.0	122.0	121.5
23	48.0	51.5	62.0	75.5	88.5	97.0	106.5	114.5	120.0	119.0
24	54.0	70.0	80.0	95.0	112.0	119.5	127.5	130.0	130.5	130.0
25	58.0	65.0	79.0	94.0	112.0	116.0	131.0	130.5	131.5	131.5
Average	52.1	55.9	66.7	77.8	91.1	101.1	112.0	116.6	119.7	119.6
Increase	12.3	3.8	10.8	11.1	13.3	10.0	10.9	4.6	3.1	.1

TEMPERATURE AND PRECIPITATION COINCIDENT WITH THE RATE OF GROWTH AS SHOWN IN THE FOREGOING TABLE.

Time	Maximum	Minimum	Rainfall
June 21, 1907	82	50	
June 22, 1907	82	57	.10
June 23, 1907	85	65	.5
June 24, 1907	88	54	.23
June 25, 1907	74	55	.01
June 26, 1907	72	43	
June 27, 1907	75	38	.01
June 28, 1907	81	42	
June 29, 1907	85	48	
June 30, 1907	85	53	.04
July 1, 1907	82	47	.04
July 2, 1907		47	.05
July 3, 1907		52	Trace
July 4, 1907		62	Trace
July 5, 1907	96	64	
July 6, 1907	85	54	.41
July 7, 1907	87	56	.04
July 8, 1907	86	69	
July 9, 1907	84	57	1.0
July 10, 1907	81	57	.28
July 11, 1907	79	51	Trace
July 12, 1907	82	47	
July 13, 1907	84	51	
July 14, 1907	88	62	Trace
July 15, 1907	82	57	.76
July 16, 1907	85	57	.31
July 17, 1907	83	49	
July 18, 1907	88	55	.53
July 19, 1907	88	55	.02
July 20, 1907	84	58	.46
July 21, 1907	90	65	
July 22, 1907	86	57	
July 23, 1907	89	50	
July 24, 1907	86	59	1.05
July 25, 1907	90	60	.37
July 26, 1907	77	49	
July 27, 1907	76	44	
July 28, 1907	85	55	
July 29, 1907	82	50	
July 30, 1907	86	47	
July 31, 1907	84	54	
Aug. 1, 1907	77	54	
Aug. 2, 1907	73	41	
Aug. 3, 1907	75	37	

Time	Maximum	Minimum	Rainfall
Aug. 4, 1907	76	40	.33
Aug. 5, 1907	87	51	.01
Aug. 6, 1907	89	51	.03
Aug. 7, 1907	86	53	.36
Aug. 8, 1907	84	58	.67
Aug. 9, 1907	86	61	
Aug. 10, 1907	92	62	
Aug. 11, 1907	85	60	Trace
Aug. 12, 1907	83	44	
Aug. 13, 1907	83	49	
Aug. 14, 1907	82	50	
Aug. 15, 1907	86	50	.01
Aug. 16, 1907	86	46	Trace
Aug. 17, 1907	84	58	
Aug. 18, 1907	89	58	
Aug. 19, 1907	83	54	Trace
Aug. 20, 1907	71	38	

A close study of the two tables will reveal several very striking points. In the increase of growth there is a gradual rise in the number of inches per day as the plants near forty inches in height. That is, when the plants are smaller the root system has not developed sufficiently to secure an abundance of plant food which will push the plant along. It will be seen that this rapidity of growth is kept up until the tassel begins to appear in August; then a decided slackening occurs.

A relative study of the second table with the first shows more rapid growth during the days of the highest temperature. However, the greater factor is the amount of precipitation during these warmer days. The period from July 15th to 25th inclusive, the amount of rainfall was 3.5 inches. With the high temperature plants at that age utilized this excessive moisture and rapid increase in height ensued.

Light necessary for carbon fixation

LIGHT. In 1779, Ingenhouss discovered that oxygen gas is given off from foliage and carbon deposited in the structure and tissues of plant due to the influence of light upon the absorbed carbon dioxide. Partial darkness decreases to a certain extent the assimilation of carbon dioxide, beside eliminating the green chlorophyll entirely. Absolute darkness even causes the plant to lose in weight and deteriorate in structure. The yellow corn plant growing in a shaded place or under a clod is a practical example of a lack of sunlight. This is often seen also in the listed furrow. Corn which is drilled thickly for fodder purposes, shows long, slender internodes, and very often has short narrow leaves. The cells of the plant are elongated and require a large amount of moisture to maintain their turgidity. In cold, cloudy seasons, crops are always late in maturing.

PLANT FOOD FROM THE AIR. The term plant food is commonly used to designate all of the crude materials which are taken into the plant, and which are utilized by it. Strictly speaking, the term "plant food" is not analagous to the same term used in connection with animals. Plant foods are rather the raw mtaerials used in the manufacture of food. These materials are built into carbohydrates, fat, and proteids, and in this form are used as food by the plant. However, as we are here concerned with the source rather than with the finished product, the term plant food will be used in its more commonly accepted sense—that is, as meaning the crude materials.

Disregarding the other constituents, which are present only in very limited amounts, the atmosphere contains in one hundred parts:*

	By Weight.	By Volume.
Oxygen	23.17	20.95
Nitrogen	76.83	79.05

(1) Oxygen.

Free oxygen is utilized by plants in exactly the same way as in the body of an animal. Foods are required for the purpose of building up new tissues and to furnish energy by their decomposition for the growth and movement of a plant and its parts. Oxygen is necessary for the latter process, the evolution of energy from the food material being a process of oxidation. Carbon dioxide is given off as a result and may again be utilized in *photosynthesis*, which is discussed below. The liberation of energy from the food or tissue substance is known as respiration.

Respiration

Photosynthesis

(2) Nitrogen.

Free nitrogen as such cannot be assimilated by any green plant. Small quantities of ammonia and nitric acid are washed down by rains into the soil and are taken up by the roots. Certain bacteria, however, some living free in the soil and others in nodules of legumes fix the free nitrogen of the atmosphere and convert it into a form which can be utilized directly or indirectly by the plant.

Sources of nitrogen

(3) Carbon.

Just what is the source of the large amount of carbon used by the plants was at one time a subject of extensive investigation. Experiments show that plants flourish and increase in carbon content when their roots feed in a nutrient solution containing no carbon. This carbon must then, in such cases, be drawn from the air. But carbon,

*Air also contains between .03 and .05 per cent of carbon dioxide.

as a free element, well illustrated by pure charcoal, does not exist in the atmosphere. The compound carbon dioxide CO_2, however, is present to the extent of 3 parts in 10,000 parts of air. Experiments have further proved that the carbon dioxide gas is absorbed directly by the foliage in solar light. The stomata aid in this absorption. It has also been found that plants die in an atmosphere free from carbon dioxide. The carbon after entering the cells of the plant undergoes a chemical change by combining with water, as just previously described. This conversion of carbon dioxide and water into carbo-

CO_2 necessary also

(Courtesy of Iowa State College) Fig. 18.

FIELD WHICH HAS BEEN DROWNED OUT EARLY IN THE SPRING.

Notice the corn is in patches. The water logged soil prevented the permeation of air.

hydrates is known as "photosynthesis." The resulting solution of soluble carbohydrates accumulate rapidly in the tissues of the plant and oxygen is given off.

The corn plant, which is so dark green in color and bears a large foliage area, is a gross feeder upon carbon dioxide in the atmosphere.

PLANT FOOD FROM THE SOIL. Not all plants require the soil as a medium of growth, but those which do call upon the soil for organic and inorganic substances. The principal elements necessary for plant growth required from the soil are:

(1) **Carbon.** Although plants draw upon the atmosphere for their supply of carbon, yet the decaying organic matter or humus in the soil is also the source of a small amount. Air permeating the interstices of a soil rich in decaying organic matter has been found to contain as much as 5 per cent of carbon dioxide. This is a large amount compared with that usually found in the air—3 parts in 10,000.

(2) **Nitrogen.** Nitrogen is made available by the decay of organic matter in the soil. The ammoniacal form is changed by microscopic organisms present in the soil, into nitrous acid; other organisms in turn change this to nitric acid, which when in union with the mineral bases forms the nitrates which are the directly available forms of nitrogen. As the nitrogenous organic compounds, such as dung, urine, and green manure, as well as ammonium salts, are finally changed to nitrates, it is evident that the corn plant growing on a field which has been treated with manures of this character draws its nitrogen supply from the nitrates of calcium, magnesium, potassium and sodium, formed by the union of their decomposition products with the bases in the soil. Nitrogen gathering bacteria living in symbiotic relation with certain plants, namely, the legumes, draw upon the abundant supply of nitrogen in the air, transforming it into nitric acid, thus making it available for the plant. The element nitrogen enters largely into the formation of the grain. Sixteen per cent of the elementary composition of protein is nitrogen. Experiments have shown that corn grown on soils rich in nitrogen are higher in protein content.

Nitrogen gathering bacteria

(3) **Phosphorus.** Phosphorus constitutes a large proportion of the ash of seeds. The amount of phosphorus (calculated as phosphoric acid) in the ash of the wheat kernel is 45 to 50 per cent, while in the straw it is only 5 per cent.*

Phosphorus in kernels

Phosphorus is absorbed in the form of phosphates of calcium and potassium. It enters into the formation of the proteins and is also present in the inorganic compounds.

In live stock farming phosphorus is more largely sold from the farm than any other of the principal soil constituents necessary for plant growth. Being used in the formation of bone and muscle the per cent of phosphorus in a feed is of significance in feeding young animals.

(4) **Potassium.** Potassium, usually spoken of as potash, K_2O, the oxidized form, requires less serious consideration from the standpoint of its ultimate depletion in the soil than either nitrogen or phos-

*"Agricultural Botany," Percival.

phorus. In the first place, there is already in all soils, except some peaty-swamp soils, a large supply. Furthermore, the fact that it is present in the straw rather than the grain of plants, guarantees, under more modern methods of farming, its return to the soil each year.

Potassium in straw

Potassium is taken in largely as a nitrate, chloride, carbonate, sulphate and phosphate. In the assimilation of carbon dioxide the process is facilitated by the presence of potassium. Any plant containing a large percentage of carbohydrates usually shows a considerable amount of potassium in the ash. The fact that wheat straw loses its stiffness upon a soil which is so rich in nitrogen as to force the plant along without sufficient potash, proves this. The glazed surface and woody wall of the corn stalk are due to the strengthening power of potash.

Lime in straw

(5) **Calcium.** Calcium, usually known as CaO, or lime, is necessary to correct the acidity of soils which have been farmed continuously, and whose humus content has been almost exhausted. Although of less importance in the actual development of plants, the amount of lime in the ash of barley, oat, and wheat straw is generally about seven per cent.*

(6) **Other Plant Foods.** Sulphur enters into the composition of the protein. Magnesia is found in the ash of seeds, especially in small grains. Iron is an essential element of chlorophyll. Plants grown in nutrient solutions, free from iron, have no green color. Although silicon, sodium, and chlorine are present in the ash of plants, some authorities claim that they are unessential to the growth of plants.

The following table gives the amount of the three chief elements of plant food found in the principal farm crops by analyses.

	Amount	Nitrogen	Phosphorus	Potassium
Corn, grain	100 bushels	100 pounds	17 pounds	19 pounds
Corn, stover	6 tons	48 "	6 "	52 "
Entire crop		148 "	23 "	71 "
Oats, grain	75 bushels	45 "	7 "	9 "
Oat straw	2 tons	24 "	4 "	40 "
Entire crop		69 "	11 "	49 "
Wheat, grain	40 bushels	46 "	6 "	11 "
Wheat straw	2 tons	19 "	4 "	34 "
Entire crop		65 "	10 "	45 "
Timothy hay	2 tons	48 "	6 "	47 "
Clover hay	3 tons	120 "	15 "	90 "
Cowpea hay	3 tons	140 "	15 "	95 "
Alfalfa hay	8 tons	400 "	36 "	192 "

The table showing the amount of different elements taken from the soil by the principal crops is taken from circular No. 68 of the Illinois Experiment Station.

*"Agricultural Botany," Percival.

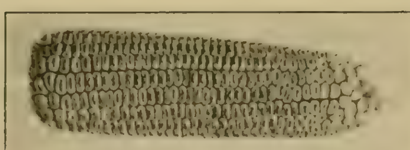
ACKNOWLEDGMENTS. The subject of germination as here treated was suggested largely by the outline appearing in the Agronomy Series written by Professor P. G. Holden, of the Iowa State College, for the Sioux City, Iowa, Correspondence School in Agriculture. Many ideas in regard to plant growth were secured from this source also.

The measurements of corn were made by Prof. H. G. Bell, of the Farm Crops Department, of the Iowa State College.

COLLATERAL READING:

Effect of Fungicides upon Germination,
Kansas Bulletin No. 41.

Water Requirements of Corn,
Utah Bulletin No. 86.



CHAPTER V.

CLIMATE AND SOIL IN ITS RELATION TO CORN

CORN AND CLIMATE

The factors which are absolutely essential to the production of a corn crop may be included under the following heads:

1. Seed used.
2. Cultivation (both before and after planting).
3. Climate (including temperature, sunshine, precipitation).
4. Topographical features (including nature and condition of soil).

Favorable influences essential

The final yield and character of the crop are determined by these factors. If, in any particular case, one of these is found to be unfavorable to the needs of the crop, that one factor may determine the character of the crop produced. It is usually impossible to ascertain definitely just how much influence on the final outcome has been exerted by any particular factor. However, much of both interest and profit may be learned by a study of that factor, even though it may be largely or wholly beyond human control, as is the case with temperature or precipitation.

Grown under varying conditions

EFFECT OF CLIMATE UPON DISTRIBUTION. Corn is grown under more widely varying conditions than almost any other cereal. It is raised in every state and territory except Alaska, and in both Mexico and Canada. Nevertheless, as is shown in another chapter, the great bulk of the production is centered in the seven principal states of the corn belt—Iowa, Illinois, Missouri, Kansas, Nebraska, Indiana and Ohio. The reason for the largely centralized production of a crop showing such wide adaptability, is found in the fact that on the area mentioned is found the most favorable combination of soil and climate. Other large areas may possess equally favorable soil conditions, but the climate is not so well suited to corn raising. Where the soil and temperature are all that could be asked, the rainfall is

We cannot control the elements

usually found to be either insuffcient or not properly distributed over the long growing season. *Such is found to be the case when the 70 to 80 degree July isotherm of the northern latitude is traced around the world.

EFFECT OF CLIMATE UPON CHARACTER OF GROWTH.

Corn displays a wonderfully variability in its habits of growth. It adjusts itself readily, though somewhat slowly, to changes in its environment. This adaptability of the plant has resulted in a very marked correlation between the manner of growth and the climatic conditions under which it has been grown for a term of years. This correlation is seen in

We should however know their effects

1. The time of maturity and hence length of growing season.
2. Size and nature of the stalks.
3. Yield and character of the grain.

The length of the growing season for corn varies from 90 to 160 days, and in different parts of the United States are found varieties which are adapted to this wide range. In Iowa** the average length of the growing season is 173.4 days. According to Hunt, the rate of shortening of the season as we go north of a given latitude is, in general, about one day for each ten miles. The reverse is true as we go south.

Long growing season necessary.

The length of the growing season is in general the most important factor in determining the size of the stalk produced. The long seasons of the south induce the growth of tall, massive stalks with large yields of both fodder and grain, while the shorter northern season induces a small, stunted stalk with a moderate yield of grain. The larger stalks are more coarse and woody in structure, while the smaller ones are much less so, and produce a better quality of fodder. Accompanying these differences in the stalk are corresponding differences in the grain. The southern corn has large ears with long, deep kernels, possessing a deep, pinched dent and a structure that is inclined to be starchy. On the other hand as we go north the opposite of these characters are seen. The dent grows shallower and smoother and the kernels shorter and more horny and flinty, until they merge into the characteristic Flint corn of the north. The differences seen in these respects between sections no further separated than the northern and southern parts of Iowa, are very marked, while beyond the borders of the state the differences are still more noticeable. The dependence of yield upon climate is seen when the average production per acre for the state for a term of years is considered. Under similar

Variation in yield in Iowa

*Hunt's "Cereals in America," Page 203.
**Report Iowa Weather and Crop Service, 1902.

conditions, aside from climate, the yield for Iowa has varied from 14.8 bushels to 41 bushels per acre. During two successive seasons, yields of 14.8 bushels and 38 bushels per acre, respectively, were produced. That all the differences mentioned are due largely to climate is indicated by the fact that they occur over a wide range of soils and correspond closely to difference in climate.

That other factors, such as crossing, natural selection or "survival of the fittest," and conscious and unconscious selection by man, are also partly responsible, is very probable.

Corn can be acclimated to new conditions

CLIMATE AND VARIETIES. Whatever caused the original form of varieties, it is evident that a slight change in climate will affect corn seriously; but after a few years it adjusts itself to the new conditions and becomes fully acclimated. It was by such a process that the cultivation of corn has been gradually extended northward in the United States. Today this cereal is grown successfully, where twenty-five years ago its cultivation was impossible. Although the corn plant is so sensitive to climatic changes, it adjusts itself to them so readily that new varieties can be successfully introduced if they are first grown on a small scale until fully acclimated. The sensitiveness of the plants, however, suggests that caution should be used about purchasing for field production in a large way, seed from a distant locality, particularly if that locality be in a different latitude.

Corn tends to maintain uniform composition

EFFECT OF CLIMATE UPON COMPOSITION. Unlike the wheat plant, the chemical composition of which is largely dependent upon climate, corn appears to be but slightly affected by such influences. Richardson *analyzed many samples of corn grown in the various parts of the United States, but from seed obtained from a common source. The variation in the ash content was found to be small; that of oil and crude fiber was proportionately the same as was found in wheat, fairly constant, but the content of albuminoids (protein) did not vary nearly so widely as did those of wheat. These results are supported by analyses of foreign corns by Koenig. "Our conclusion must be then, that corn can supply itself with nitrogen, under varied circumstances, but that it rarely is able to assimilate more than a certain amount. The bushels may vary, and the size of the grain, but the quantity of albuminoids is practically unchanged."* From these experiments Wiley concludes that "It is evident that Indian corn, growing as it does over the whole of the United States, is one of those crops which tends more than any other to maintain a uniform composition and to vary less under environment. It is this char-

*Yearbook U. S. Department of Agriculture, 1901.

acteristic of Indian corn which enables it to be grown with success under such widely varying conditions."* This, of course, is not taking selection into consideration.

RELATION OF CORN GROWING TO PRECIPITATION. In the production of a corn crop water is of the utmost importance. The yield obtained is more often decided or limited by this factor than by any other. Corn does not require so much water for each pound of dry matter produced as do many other crops, but the large total weight of this crop more than overbalances such a consideration. Whereas, the average amount of water transpired by plants is usually given as 500 pounds for each pound of dry matter, the amount for corn is 300 pounds.

300 to 500 Pounds Water transpired

The following table is inserted here as a basis for the discussions which are taken up. It shows the figures from which charts Nos. one, two, three, four and five were made.

CORN YIELD AVERAGE IN IOWA FOR 18 YEARS.

Year	Average	Year	Average
1890	28 bu.	1899	36.3 bu.
1891	38	1900	43.3
1892	29	1901	26.2
1893	35.7	1902	34.0
1894	14.8	1903	31
1895	38	1904	36
1896	39	1905	37.2
1897	29	1906	41
1898	34.5	1907	29.5

Average 33.2

MEAN ANNUAL TEMPERATURE AND RAINFALL OF IOWA FOR 18 YEARS

Year	Temperature	Rainfall
1890	47.7	31.28
1891	47.4	32.90
1892	47.5	36.58
1893	45.7	27.59
1894	49.7	21.91
1895	45.5	26.77
1896	48.5	37.23
1897	46.7	26.97
1898	47.6	31.34
1899	47.6	28.68
1900	49.5	34.15
1901	49.0	24.41
1902	47.8	43.82
1903	47.3	35.66
1904	46.3	28.74
1905	47.3	36.51
1906	48.7	31.23
1907	47.4	31.62

*Yearbook Dept. Agriculture, 1901.

MONTHLY MEAN PRECIPITATION IN IOWA FOR 18 YEARS.

Year	May	June	July	August	Average
1890	3.56in.	7.76in.	1.98in.	3.41 in.	4.18 in.
1891	3.18	5.39	4.22	4.24	4.26
1892	8.77	5.19	5.29	2.24	5.37
1893	3.45	3.90	3.33	2.32	3.25
1894	1.87	2.67	0.63	1.58	1.69
1895	3.19	4.32	3.40	4.43	3.84
1896	6.68	3.10	6.90	3.52	5.05
1897	1.92	3.81	3.26	1.86	2.71
1898	4.67	4.72	2.98	3.44	3.95
1899	6.23	5.04	3.07	3.68	4.50
1900	3.31	3.98	6.15	4.65	4.52
1901	2.35	3.71	2.34	1.29	2.42
1902	5.39	7.16	8.67	6.58	6.95
1903	8.55	2.86	4.83	6.64	5.72
1904	3.78	3.45	4.41	3.43	3.77
1905	5.95	5.53	2.91	4.05	4.61
1906	3.54	3.92	3.04	3.95	3.61
1907	3.48	5.35	7.27	4.33	5.11
Average	4.44	4.55	4.15	3.64	4.2

MONTHLY MEAN TEMPERATURE IN IOWA FOR 18 YEARS.

Year	May	June	July	August	Average
1890	57.7	72.7	75.6	68.4	68.6
1891	58.3	69.1	68.6	69.1	66.3
1892	54.0	69.2	73.0	71.4	66.9
1893	56.6	71.2	75.0	69.4	68.1
1894	61.1	73.2	76.4	74.6	71.3
1895	61.7	69.7	72.1	71.9	68.9
1896	65.5	69.1	73.6	71.7	70.0
1897	59.6	69.1	75.6	68.9	68.3
1898	59.6	71.4	73.4	71.2	68.9
1899	60.2	70.7	73.1	74.4	69.6
1900	63.2	69.7	73.4	77.4	70.9
1901	60.7	72.3	82.4	73.8	72.2
1902	63.8	65.2	73.1	69.1	67.8
1903	61.6	64.6	72.9	69.1	67.1
1904	59.6	67.1	70.6	69.1	66.6
1905	58.3	68.9	70.6	74.3	68.0
1906	60.8	67.9	70.9	74.1	68.4
1907	53.5	65.6	73.7	71.1	66.0
Average	59.8	69.3	73.6	71.6	68.3

Rainfall should be well distributed throughout the season

Of equal or greater importance than the total amount of rainfall is its distribution during the growing season. Corn makes its most rapid growth during the months of July and August, and, therefore, it is during these months, while the corn is tasseling and forming ears, that the greatest amount of rain is needed for the best growth of this crop. The so-called small grains require their moisture earlier in the season, since they make their growth and mature early. April is the critical month for winter wheat, from the standpoint of precipitation, and May and June are the important ones for oats. For these reasons, the small grains are to quite an extent dependent upon the winter precipitation for their moisture, while it is the later rains which benefit corn. While heavy May and June rains are needed for oats, they may be detrimental to corn, in that they favor development of a shallow root system which is ill-fitted to withstand the frequent dry weather of July and August. A very wet May or June means also a poorer stand, vigorous growth of weeds, ineffective and insufficient cultivation, and a puddling of the soils, which means baked and cloddy ground when a dry spell arrives. The plants also tend to grow on too large a scale, producing too great a proportion of stalks to roots. The resulting condition of both plant and soil are such as to unfit them for a dry summer.

The accompanying charts show concretely the importance of precipitation and illustrate the foregoing discussion. They are based upon the average yields of corn in Iowa for the past eighteen years and the mean monthly temperatures and precipitations for the same period. In each case, the heavy lines represent the normal yield, temperature, and rainfall. The first chart shows the relation of yield to the total rainfall of the growing season, or the months of May to August inclusive. With a few explainable exceptions, the yield and rainfall agree very closely. The years 1892, 1902 and 1903, show high precipitation, with yields not correspondingly large, but the other charts show that in each of these seasons there was an excessively wet May or June, or both, accompanied by a low average temperature. In 1893, the yield was higher than the rainfall for these months would account for, but it follows a very wet season and the April (1893) had an unusually large amount of rain, which is not included in the total which is plotted. In 1906, the largest average yield is shown with a rainfall slightly below normal. The May, June and July conditions of that year were nearly normal, while the critical month of August was exceptionally favorable. The low yield of 1907 is accounted for on the grounds of the very cold May and June, early frosts in the fall and erratic distribution of the rainfall.

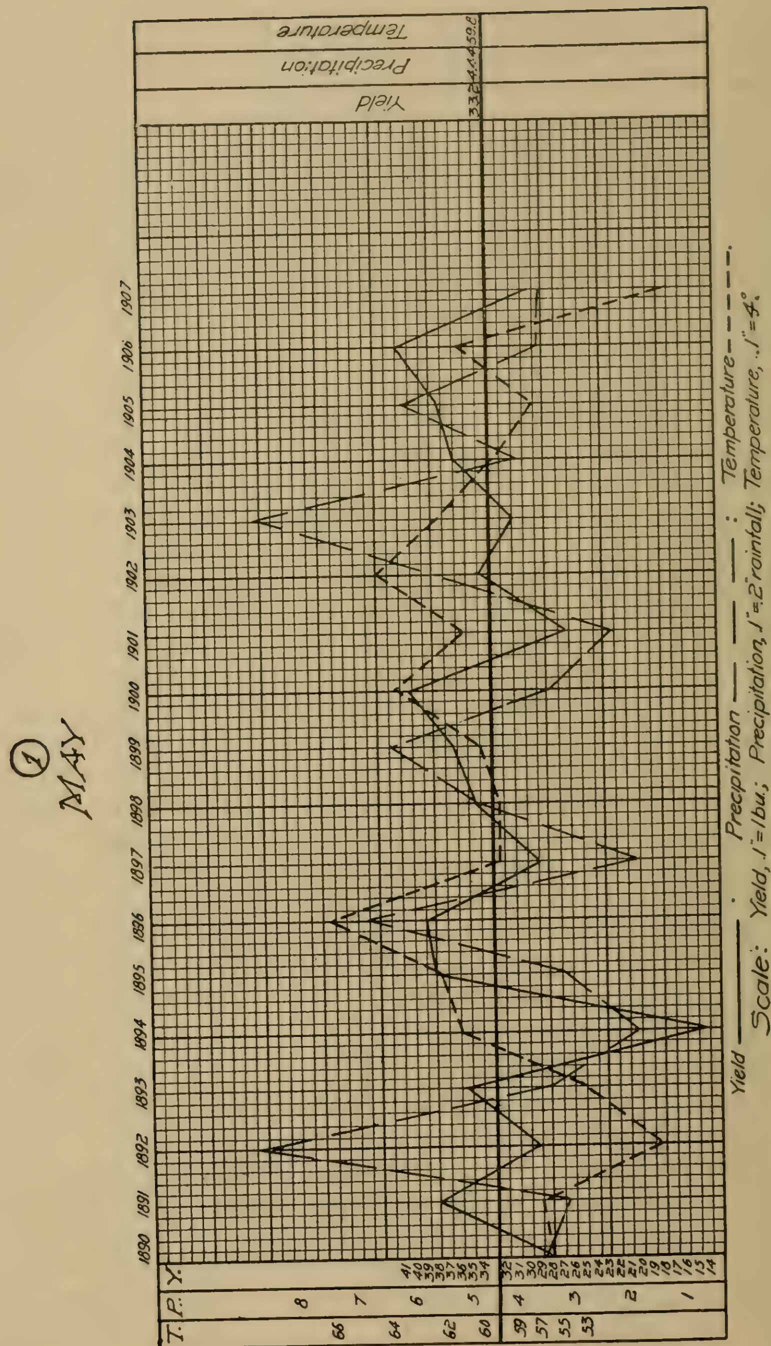
Previous season has something to do.

Charts 1 and 2 do not show close correlations between yields and precipitations for May and June. The explanations for these discrepencies have already been given.

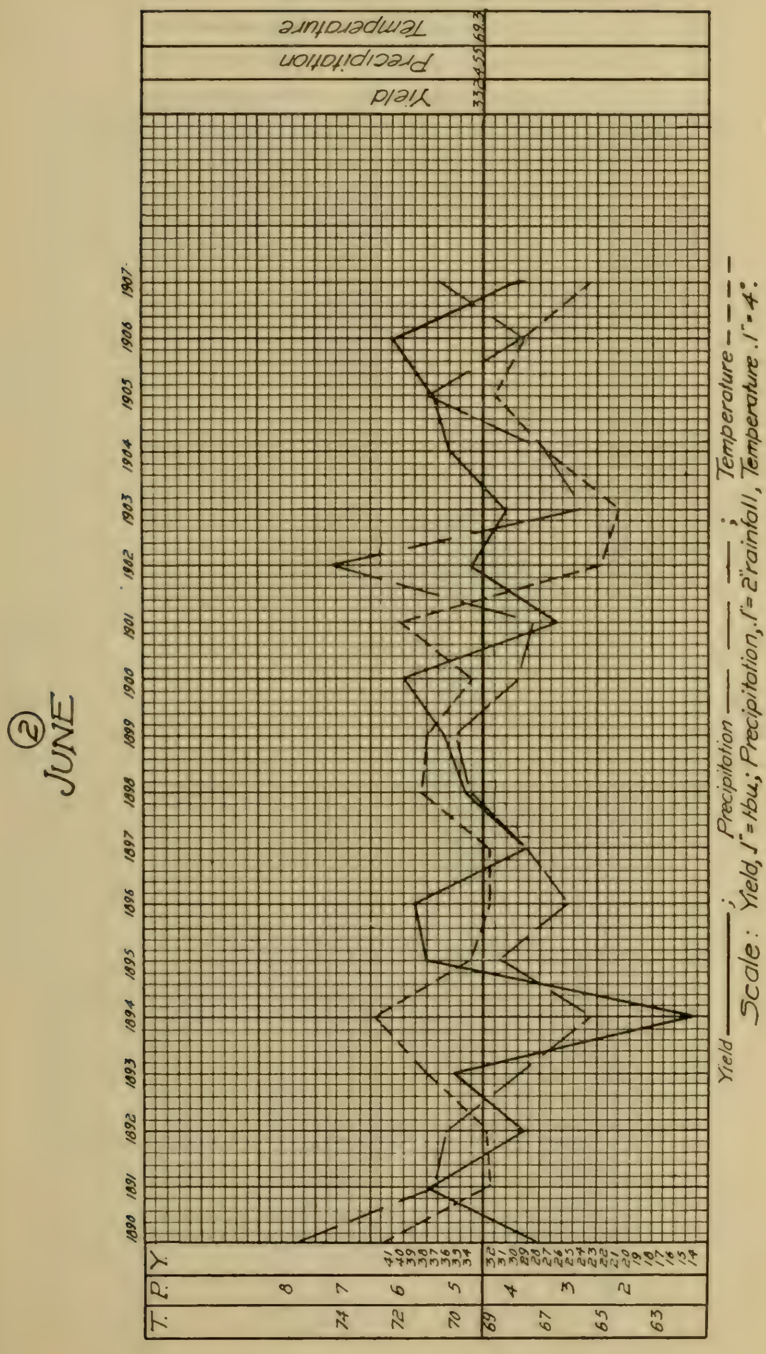
The correlations of yields and rainfall for July and August, especially the latter, shown by charts 3 and 4, illustrate the importance of rainfall to corn during these months. The August precipitation follows the yield, even more closely than does the total seasonal rainfall.

Rainfall affects habit of growth

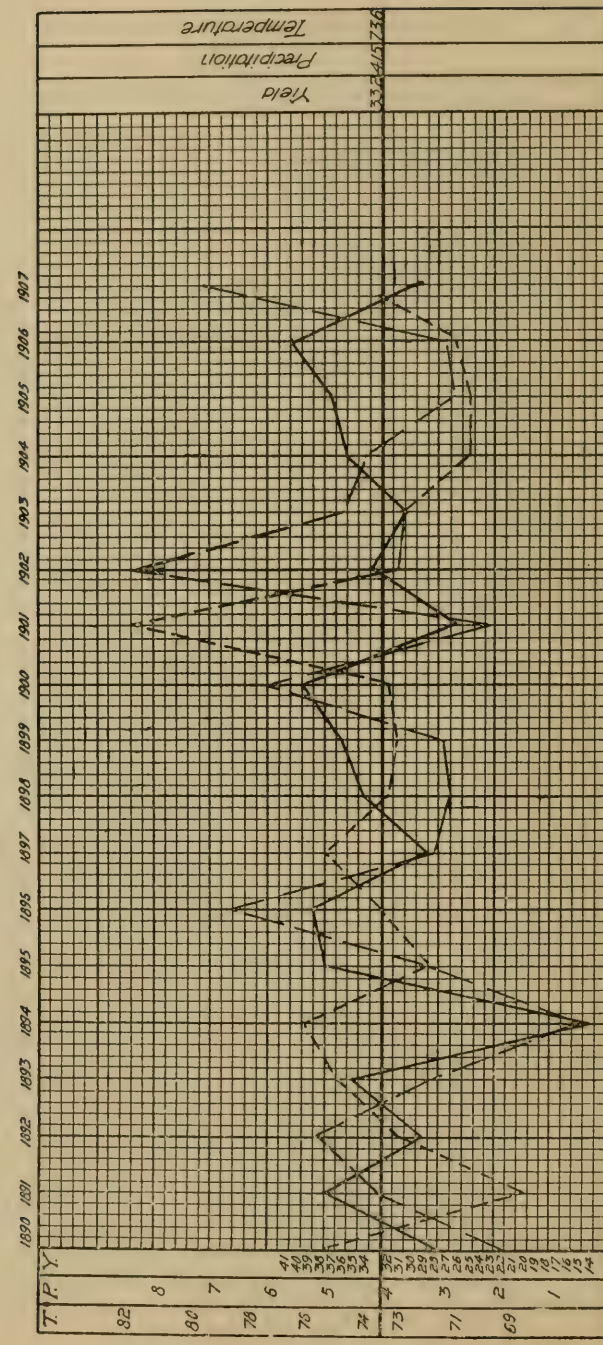
Rainfall affects not only yield, but habit of growth as well. A wet season favors larger and continued growth, while a dry one induces



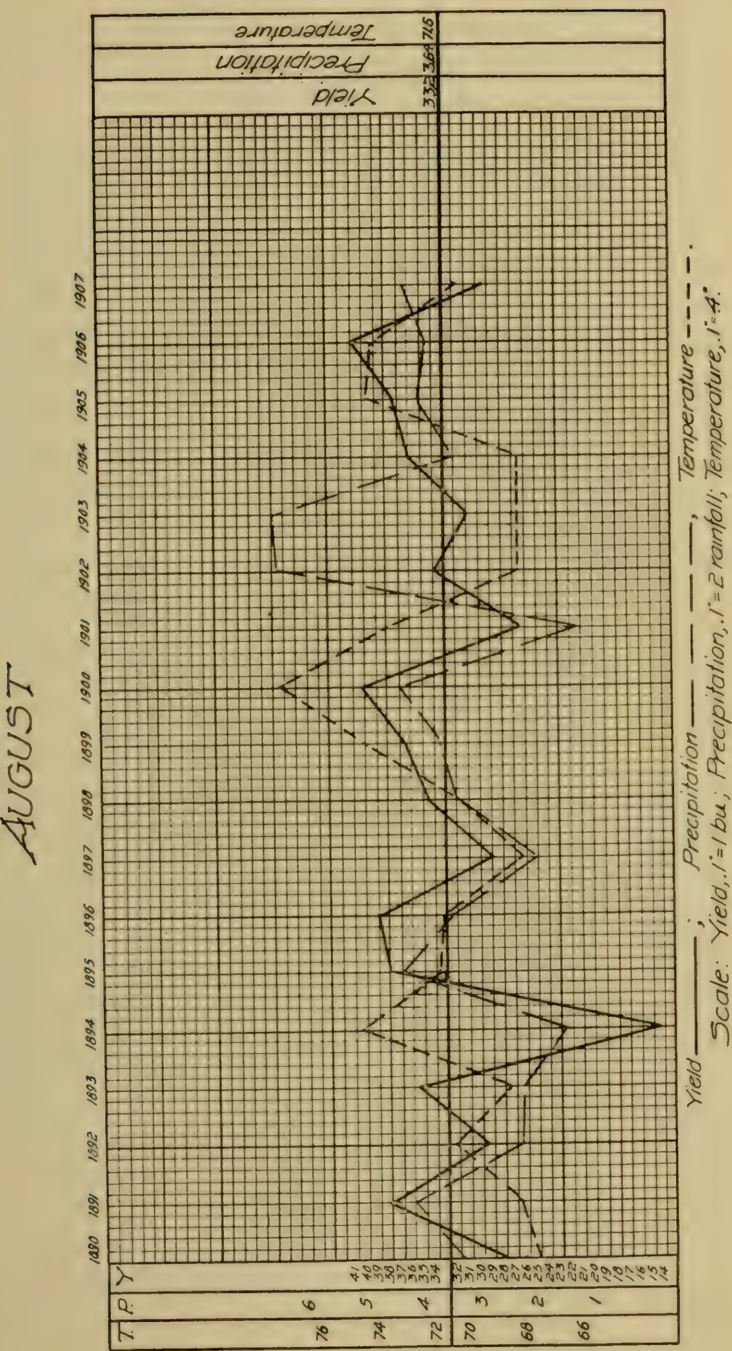
①
MAY
Temperature
Precipitation
Yield
33.6 4.4 59.8
T. P. Y.
1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907
Yield —— : Precipitation —— : Temperature – – – –.
Scale: Yield, 1"=1bu; Precipitation, 1"=2" rainfall; Temperature, 1"=4°.

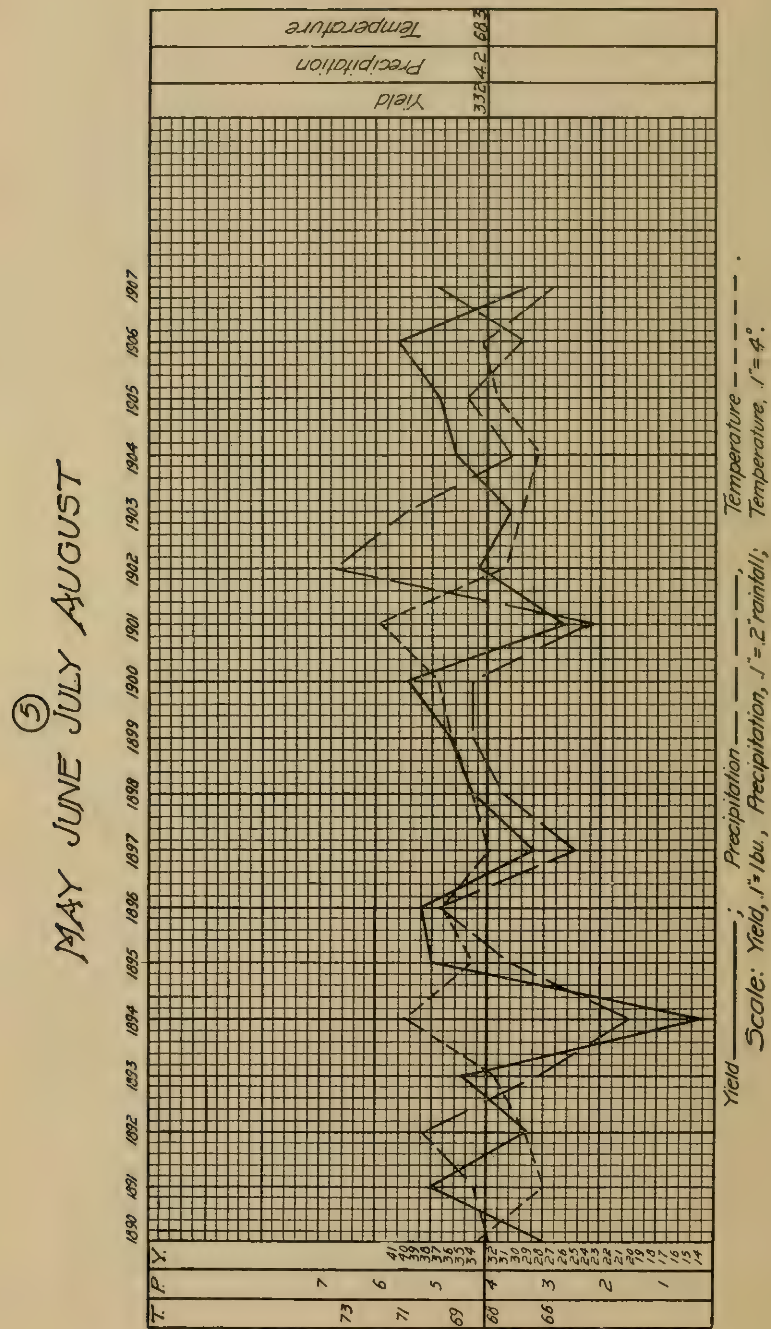

② JUNE
Yield
Precipitation
Temperature
1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907
T.
P.
Y.
Yield ——— ; Precipitation ——— ; Temperature - - - -
Scale: Yield, 1" = 1bu.; Precipitation, 1" = 2" rainfall, Temperature 1" = 4°.

③
JULY



Yield ——, Precipitation — — —, Temperature — - — -
Scale: Yield, .1"=1 bu., Precipitation, .1"=2" rainfall; Temperature .1"=4°


AUGUST
Temperature
Precipitation
Yield
1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907
T. P. Y
Yield ——; Precipitation — — —, Temperature - - - -.
Scale: Yield, .1"=1 bu.; Precipitation, .1"=2 rainfall; Temperature, .1"=.4°.



5
MAY JUNE JULY AUGUST
Yield
Precipitation
Temperature
33.2
4.2
68.3
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
T.
P.
Y.
Yield ———; Precipitation — — —, Temperature - - - - .
Scale: Yield, .1"=1bu., Precipitation, .1"=.2" rainfall; Temperature, .1"=.4°.

Latest Kil Frost	SIOUX CITY Latest Killing Frost		Earliest Killing Frost		Days Between
April					
April					
April					
May					
April					
April					
May					
April					
April					
April					
April					
May 1			September	17	
May 1	May	7	September	13	129
April 2	April	7	October	6	182
April 2	May	7	October	8	154
May 1	May	3	September	25	145
May 1	May	19	September	30	134
April	May	21	September	27	129
April	April	19	September	19	153
April	April	29	September	17	141
April 1	April	26	October	6	163
April	May	4	September	20	139
April 2	May	4	September	17	136
April	April	19	September	17	150
May	April	23	September	13	143
April 2	April	15	September	16	165
April 1	April	27	October	23	180
April	April	24	October	20	180
May	May	6	September	30	148
of Growi	May	15	September	12	121
gth of G					152.3

osts

THE GROWING SEASON IN IOWA

DES MOINES			DAVENPORT			DUBUQUE			KEOKUK			SIOUX CITY		
Latest Killing Frost	Earliest Killing Frost	Days Between	Latest Killing Frost	Earliest Killing Frost	Days Between	Latest Killing Frost	Earliest Killing Frost	Days Between	Latest Killing Frost	Earliest Killing Frost	Days Between	Latest Killing Frost	Earliest Killing Frost	Days Between
	September 12		March 28	October 27	212	March 18	October 22	219	March 4	October 19	228			
April 18	September 24	159	April 11	October 30	201	April 5	October 14	193	April 13	October 24	193			
April 11	November 7	210	April 1	October 4	185	April 15	October 17	186	April 17	October 4	169			
April 13	November 9	210	April 14	November 10	209	April 1	November 3	217	April 16	October 24	190			
May 22	November 13	175	May 22	November 2	163	May 2	October 19	171	March 22	November 13	235			
April 1	October 20	202	May 22	October 3	133	May 5	October 1	150	April 24	October 15	172			
April 8	October 23	198	April 22	October 23	182	April 21	October 23	186	April 8	October 23	197			
May 7	October 4	150	May 9	October 6	149	May 11	October 6	149	April 8	October 6	166			
April 2	October 1	181	April 8	October 1	175	April 8	October 1	177	April 6	October 1	177			
April 25	October 25	183	April 26	October 12	169	April 16	October 12	180	April 5	September 29	206			
April 20	September 29	162	May 13	October 3	142	May 13	September 28	139	April 20	September 27	160			
April 4	September 27	176	April 6	October 6	182	April 6	September 27	175	April 6	September 27	174		September 17	
May 16	September 13	120	May 6	September 28	145	May 6	September 28	146	April 10	October 19	191	May 7	September 13	129
May 11	October 5	147	May 5	October 8	155	April 12	October 16	188	April 7	October 20	195	April 7	October 6	182
April 29	October 9	163	April 15	October 19	186	April 15	October 23	192	April 6	October 23	199	May 7	October 8	154
April 23	September 25	155	April 13	October 15	184	April 23	September 27	158	April 23	October 15	174	May 3	September 25	145
May 19	October 14	148	April 8	October 6	180	April 8	October 7	183	April 12	October 9	179	May 19	September 30	134
May 12	September 30	141	May 14	September 30	137	May 14	October 9	149	April 14	September 30	169	May 21	September 27	129
April 3	September 28	178	April 8	October 7	181	April 8	October 18	194	April 4	October 20	198	April 19	September 19	153
April 9	October 29	193	April 17	October 29	194	April 20	October 17	181	April 19	October 29	192	April 29	September 17	141
April 4	October 14	193	April 7	October 23	198	April 7	October 15	192	April 6	October 14	190	April 26	October 6	163
April 16	September 29	166	April 6	September 30	167	April 16	September 29	167	April 16	September 29	195	May 4	September 20	139
April 4	October 8	187	April 5	November 8	216	April 9	November 4	210	April 13	November 8	208	May 4	September 17	136
April 20	October 4	167	April 21	October 4	165	April 21	October 4	167	April 18	November 3	209	April 19	September 17	150
April 4	October 14	193	April 15	October 28	195	April 15	October 14	183	April 8	October 14	188	April 23	September 13	143
May 3	October 18	159	March 30	October 18	203	April 30	October 24	178	May 1	October 24	177	April 15	September 16	165
April 21	October 23	186	April 21	October 23	189	April 21	October 27	190	April 21	October 23	186	April 27	October 23	180
April 18	October 12	178	April 18	October 12	178	April 16	October 12	180	April 17	October 12	179	April 24	October 20	180
April 1	October 10	193	May 7	October 10	157	May 9	October 10	155	April 1	October 10	193	May 6	September 30	148
May 4	October 12	162	May 11	September 25	137	May 4	October 13	163	May 4	October 13	163	May 15	September 12	121
of Growing Season		173.6			175.6			177.1			188.4			152.3

th of Growing Season for State 173.4 Days.

smaller growth and earlier ripening. Therefore, in wet seasons, the corn is liable to be injured by early autumn frosts.

The peculiar adaptability of the climate of the corn belt states to the growing of this cereal is accounted for by the fact that the greater part of the rainfall occurs during the crop season. For example, in Iowa 71 per cent of the total precipitation, or 22.48 inches, occurs during the six crop months, while 51 per cent, or 16.29 inches, falls during the four most critical crop months of May to August, inclusive.* During the three spring months 28 per cent of the precipitation occurs, in the summer and autumn respectively, the percentages are 39 and 23, while but 10 per cent falls during the winter.

RELATION OF CORN GROWING TO TEMPERATURE. Corn is a semi-tropical plant and requires for its maximum growth a moderately large rainfall, well distributed through the growing season, together with a large amount of sunshine and a relatively high temperature. An examination of the accompanying charts will show that in Iowa the combination of large precipitation and high average temperatures is rarely found. In fact, these two seem to be opposed to each other. A heavy rainfall is accompanied by a low average temperature, a low rainfall and high temperatures (e. g. 1894 and 1901) are found together. For these reasons no very direct relationship between yields and average temperatures can be traced.

Another feature of temperature, that of frosts, is not shown by the charts. Late spring and early autumn frosts decrease the yields, but such influences cannot be plotted. Unseasonable frosts shorten the growing season, the importance of which is obvious. **Frosts**

For the purpose of familiarizing the student with the conditions of the weather in the early part of the season and to show the dates of frosts during the fall, the following table is given. Being very complete and representing data from different parts of the state it can be used as a guage for future reference. Like data from the different states may be secured from the local stations of the United States weather bureau.

*Report Iowa Weather and Crop Service (1902)

CORN AND SOIL FERTILITY

SOIL ADAPTED TO CORN. With a favorable climate, the factor which influences the yield of corn most is the nature and condition of the soil. Corn will thrive on a wide variety of soils, but it will grow best and give the most profitable returns on a dark loam that it well supplied with humus or organic matter. The soil should be well drained at the surface, although a water table three or four feet below is an advantage rather than otherwise. Such a soil is most often found on the bottom lands of the glaciated areas of the corn belt. Profitable crops may also be produced upon light soils, if they are so handled, by manuring and the growing of leguminous crops, that the supply of humus is maintained.

Corn does poorly on thin ground

Although corn is a vigorous grower, a gross feeder, and can utilize such materials as coarse barnyard manures better than most other cereals, it does not do well on poor land. Some crops are not dependent for grain production on the total growth of the plant; but the nature of corn is such that it will not produce a heavy yield of grain unless the soil is rich enough to permit a considerable growth of stalks and the largest yield is not secured unless the stalks attain a strong vigorous development. For this reason it is best to grow other crop on very poor land until its fertility can be built up.

Soil does influence composition of corn

INFLUENCES OF SOIL ON COMPOSITION OF CORN. The composition of the corn plant and particularly the protein content, varies with the conditions under which it is grown. Among the factors which determine the composition, the fertility of the soil is a most important one. This subject has been studied extensively at the Wisconsin Experiment Station.* It was there found that corn grown in sand to which no fertilizer had been applied, contained but 8.44 per cent protein, as compared with 9.94 per cent, when a small amount of sodium nitrate was added to the soil, and 11.5 per cent when that amount of fertilizer was doubled.

The results of the experiments point toward the following conclusions:

(1) "That the percentage of protein in the plant is dependent directly upon the amount of nitrate in the soil;

(2) That corn on different fields may make very nearly equal growth, while differing materially in percentage of protein produced;

(3) That beyond a certain point, the percentage of protein is not increased by excess of nitrates; and

*Wisconsin Station Reports 1902, pp. 192—209; 1904, pp. 193—9.

(By Courtesy of the Soil Department of Iowa State College)
This Map is Introduced to give the Student a Working Basis for Study.

(4) That in the presence of a sufficient amount of nitrates in the soil, variations in the growth of the plant are caused by the amounts of the salts in the soil other than nitrates."

At the Minnesota Station, *Snyder found that the composition of corn fodder varies with the conditions under which it is produced. Fodder grown on manured land contained 8.85 per cent protein, while that from unmanured ground contained but 6.32 per cent. The importance of this is readily seen when it is remembered that "high grade corn fodder is more valuable than the best grade of timothy hay, while corn fodder grown on poor unmanured soil that has received poor cultivation, where the crop has not been properly cared for and the leaves are lost, has about the same feeding value as straw."

(Courtesy Lowden Mfg. Co.) **Fig. 19.**

HOG BARN, WITH LITTER CARRIER DEPOSITING MANURE IN RACK, TO KEEP THE STOCK FROM TRAMPLING IT IN THE MUD ABOUT THE LOT.

CONTINUOUS GROWING OF CORN. A glance at the history of those agricultural regions of America which have proved to be particularly well adapted to some one "money" crop, reveals a reckless disregard for the original fertility of the soil. In each of these districts, the one crop has been raised on the same ground continuously, until much of the soil has been greatly depleted. The impoverished cotton and tobacco lands of the south, the wheat lands of the northwest, which now produce but a fraction of the yields that they once did, and the run-down farms so numerous throughout the corn belt, all stand as a reproach to the wasteful cropping systems followed.

Corn is the "Money" crop

The continuous growing of a single crop upon the same land year after year causes

*15th Bi. Report Kansas Station, Board of Agriculture, Page 395.

(1) A great deterioration in the physical condition of the soil.

(2) A waste of the soil fertility, especially of the humus and nitrogen.

(3) An increase of the weed enemies and the insect pests that attack the crop, and as a result of all these, decreased crop yields.

HUMUS. The productive capacity of most of the land of the corn belt is largely measured by its physical condition and its content of humus and nitrogen. Deterioration in the physical condition of a soil is accompanied by soil washing and lessening of its water-holding capacity. These results are brought about by the rapid exhaustion of the humus. The frequent cultivation which is given the corn crop promotes the aeration of the soil and thus permits the organic matter to be rapidly oxidized. The humus serves as a binding material to hold the soil particles together. In fine grained soils, such as clays, it gives a more loamy texture, such as is seen in soils which are in good condition. Such soils will not bake or become cloddy, or run together when wet, and are not so subject to washing as soil containing less organic matter. Humus also helps to fill the otherwise too

Land must be in good physical condition for greatest returns

(Courtesy Kemp & Burpee) Fig. 20.

MANURE SPREADER IN OPERATION ON PASTURE LAND WHICH IS TO BE PLANTED TO CORN THE NEXT YEAR.

Humus an important factor.

large air space in loose, open, sandy soils, thus preventing too rapid leaching and holding the moisture nearer the surface, where it can be utilized by plants. Humus acts as a sponge in the soil. It is one of the best known absorbents of water, and hence its presence adds greatly to the water-holding capacity of soils. In Minnesota, *Snyder found that a native soil contained 3.97 per cent of humus and had a water-holding capacity of 62 per cent, while a soil cultivated for 23 years, but otherwise similar, contained 2.59 per cent of humus and had a capacity for water of only 54 per cent.

Humus absorbs and holds moisture

Continuous cropping influences humus supply

The very rapid depletion of the fertility of the soil by continuous cultivation of one crop is also largely due to the resulting loss of humus. Humus influences fertility in two ways:

(1) By supplying nitrogen directly, and

(2) By helping to make the mineral elements soluble.

Nitrogen a valuable element and easily lost

Continuous cropping of corn depletes nitrogen supply

It is from the humus that all crops except legumes must obtain their supply of nitrogen. While nitrogen is no more essential to the growth of corn than some other soil elements, it is the one which is required in the largest amount, and is the one most easily lost from the soil. Throughout the corn belt, it is much more often the supply of nitrogen than that of any other element which limits the crop production. In Minnesota it has been found that "The loss of nitrogen from four grain farms amounted to from three to five times as much as that removed by the crops. This loss was due to the rapid decay of the humus and the liberation of the nitrogen which forms an essential part of the humus." At this same Station, *when corn was grown continuously on the same plot for 12 years, the loss of nitrogen amounted to 1,400 pounds, or 18 per cent of the total amount originally present, and the waste of humus corresponded to that of nitrogen. The yield of corn was much less than that grown on similar plots, but in a rotation. By its direct action in rendering the minerals of the soil soluble and available to plants, humus performs a most important function and greatly influences the crop yields obtainable. **A large part of the mineral supplies of a fertile soil are found chemically combined with humus, and it is chiefly in this form that they are used by the crops. Thus, the loss of humus by continuous cropping places another check on crop yields, for no matter how large the natural supply of minerals in a given soil, they are useless to growing crops until rendered soluble.

Plant food must be in an available form

*Minnesota Bulletin, No. 89.
**Minnesota Bulletin, No. 94.

NECESSITY OF ROTATIONS. If the great wastes and rapid depletion of the soil which follow continuous cropping are to be avoided, it is necessary to adopt some systematic rotation of crops. The objects of a rotation are:

(1) To maintain or improve the physical condition of the soil.
(2) To conserve or improve the soil fertility.
(3) To guard against insect pests and noxious weeds.
(4) To distribute the labor throughout the season.

To accomplish the first two objects it is necessary to check the unnecessary waste of humus and to replace by plowing under crop

Fig. 21.

MOWING A CROP OF ALFALFA, ONE OF THE LEGUMES WHICH NOT ONLY DEPOSITS NITROGEN IN THE SOIL, BUT OPENS UP THE SUBSOIL TO CONSIDERABLE DEPTH.

residues that which is gradually lost. This cannot be done by simply alternating corn and oats, or by any rotation which does not include a leguminous crop.

Some plants feed deeper than others

Different crops occupy different strata of the soil, and make different demands upon the elements of plant food. The deep-rooted legumes utilize plant food which lies beyond the reach of the shallow-rooted cereals, after the former are removed from the soil a large amount of hitherto unavailable plant food is brought within the reach of the latter in the form of decaying roots. When it is remembered that roots of clover, for instance, represent nearly one-half of the weight of the crop, the importance of this source of humus is apparent.

The principal benefits of rotations are derived from the legumes included. Without a legume, a rotation is hardly worthy of the name. The members of the legume family of crops, alfalfa, the clovers, soy beans, cowpeas, vetch, etc., possess the power of utilizing the nitrogen of the air through the medium of bacteria which grow and form nodules upon the roots. The decaying roots help to replenish the supply of nitrogen and humus. By use of legumes in the rotation, the nitrogen and humus supplies of the soil can be very cheaply and profitably maintained or increased. Leguminous catch crops should be frequently grown and if the soil is especially deficient in humus or nitrogen these crops should be plowed under. If the land is subject to washing or blowing, the catch crops should be left on the ground during the winter.

Legumes necessary in a rotation

Legumes furnish cheapest source of nitrogen

At the Indiana Experiment Station,* for 15 years corn, oats and wheat were grown in rotation with each other in comparison with the same crops rotated with timothy and clover. No manure or fertilizer was used. During the last nine years of the experiment, the yields of the corn crops of the legume rotation were 22 per cent higher than those of the other rotation.

Clover increases a yield in following crop

At the Illinois Experiment Station continuous corn growing has been compared with rotations of corn and oats; and corn, oats and clover with the following results.

LATEST YIELDS FROM THE UNIVERSITY OF ILLINOIS EXPERIMENT FIELD at URBANA, TYPICAL CORN BELT PRAIRIE SOIL.**

(Three Year Averages in Bushels Per Acre.)

Crop Years	Crop System	13-Year Experiments	29-Year Experiments
1905-6-7	Corn every year	35 Bushels	27 Bushels
1903-5-7	Corn and oats	62 "	46 "
1901-4-7	Corn, oats and clover	66 "	58 "

The lesson of these experiments is that 12 years of cropping, where corn follows corn every year, reduces the yield from more than 70 bushels to 35 bushels per acre, after which the decrease is much less rapid, amounting to only 8 bushels reduction during the next 16 years. Undoubtedly the rapid reduction during the first 12 years of continuous corn growing is due in large part to the destruction of the more active decaying organic matter, resulting ultimately in insufficient liberation of plant food within the feeding range of the corn roots. In addition to this,

Continual cropping with corn brings a decrease in yield

*Indiana Bulletin. Nos. 55 and 64.
**Illinois Bulletin No. 125 (May 1908.)

the development of corn insects in soil on which their favorite crop is grown every year, is sometimes an important factor in reducing the yield.

"Where corn is followed by oats in a two-year rotation, the destruction of the humus is less rapid and the multiplying of corn insects is discouraged by the change to oats every other year. During the first 11 years the yield decreased from more than 70 bushels to 62 bushels, and during the next 16 years a further reduction of 16 bushels has occurred."

Corn and oat rotation undesirable

It is to be noticed that in computing the average yield for the corn-oats-clover rotation, the yield for the very dry year of 1901 was considered, and yet this method proved the most profitable.

At this same Station, the sowing of legume catch crops between the rows of corn in the "corn-oats-clover" rotation at the time of the last cultivation, raised the yield from 66 to 69 bushels. This was done in the so-called "Grain Farming" experiment.*

MANURES. In the maintenance of the fertility of corn belt land, farm manures form a very important supplement to crop rotation. Manures serve a treble purpose in the soil.

(1) To supply the elements of plant food to plants directly and immediately.

(2) To increase the humus content and thus improve the physical condition of soils.

(3) To increase the total or potential supply of plant food which may be drawn upon later.

By careful handling of manures from 60 to 85 per cent of the fertilizing constituents contained in the food stuffs fed to animals can be returned to the soil. Thus, the value of manures as a source of plant food is at once obvious. The importance of manures as a source of humus is well shown by an experiment at the Minnesota Station,** where two plots, originally similar, were cropped in the same manner except that one was manured and the other was not. At the end of 35 years the first contained 3.32 per cent of humus and a water-holding capacity of 48 per cent, while the second contained 1.8 per cent humus and could hold but 39 per cent of moisture.

Manure should be returned to the soil

In connection with the Illinois experiments just referred to, a system of "live stock farming" is being studied, in which manure was applied to the plots each year in proportion to the crop yields the

Corn responds liberally to an application of manure

*The Department of Soils at the Iowa Experiment Station are carrying on a like experiment. To date the yields of corn indicate that cow peas thus grown in corn reduces the yield from eight to ten bushels per acre.
**Minnesota Bulletin No. 89.

previous year. For the years 1905, 1906 and 1907, manure was applied to plots similar to those used in the "grain farming" experiment, with the result of raising the average yield to 81 bushels per acre, as compared with 69 bushels without the manure and 35 bushels for continuous corn.

Results equally favorable for barnyard manure have been obtained by the Iowa Station on the Missouri Loess soils of that state.*

Fig. 22.

CORN WHICH SHOWS THE EFFECT OF A PREVIOUS LEGUMINOUS CROP. Note the rank growth and straightness of the stalks.

Manure adds humus

At the Minnesota Station** a four and a five-year rotation, which included corn, oats, clover, wheat, and barley, were compared with the continuous growing of each of the cereals mentioned. Manure was applied to the corn in the rotations, but the continuous cropping plots received none. The experiment was continued for twelve years. Excessive losses of humus and nitrogen, together with decreasing crop yields, were found on each of the continuous cropping plots, while on the manured rotation plots the yields and humus and nitrogen sup-

*Iowa Bulletin No. 96.
**Minnesota Bulletin No. 89.

plies were maintained and in one case slightly increased. The corn in the rotation yielded 20 bushels per acre more than that grown on the plot which grew corn exclusively and continuously.

FERTILIZERS. It is probable that at the present time it would not prove profitable to use commercial fertilizers for the production of corn on the soil of the corn belt west of Illinois. There may be a few restricted areas, such as peaty swamp soils which would require potassium, and a few acid soils which should be limed, to which this rule does not apply. However, the investigations of several of the Experiment Stations* of this region would seem to support such a statement. But that does not mean that these soils are inexhaustible or that the methods of cropping now commonly in vogue can be safely continued indefinitely. By these same methods much of the land of the eastern states has been reduced to a condition where expensive fertilizers must be used. Even in Illinois, Dr. Hopkins has proved that large areas of soil require the application of phosphorus. Chemical analyses of some Iowa soils show that their supply of that element is by no means inexhaustible. Already, on many soils, in practically every community of the corn belt, the effects of an insufficient humus and nitrogen supply are seen in lessened crop yields. If many of the present methods of handling such soils are not soon radically revised, the day of the commercial fertilizer cannot be long postponed.

Intelligent farming can ward off the use of fertilizers

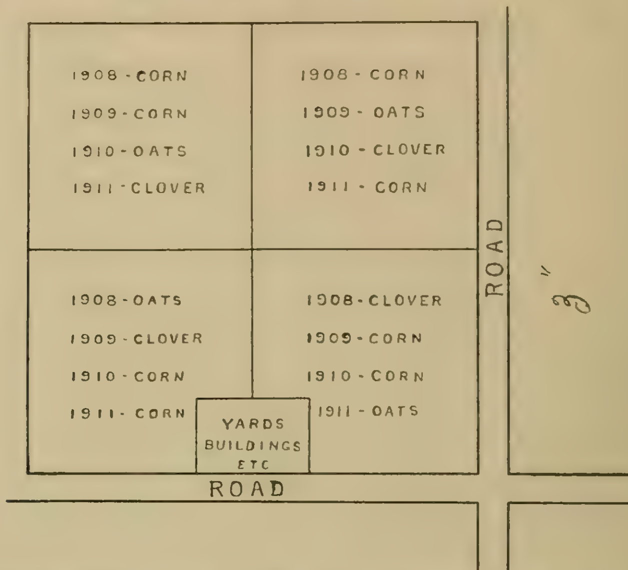
It is much easier and vastly more economical to maintain the productivity of a fertile soil than to build up an exhausted one. By the adoption of a proper rotation including leguminous crops and supplemented by barnyard manures, the time when it will be necessary to use commercial fertilizers can be indefinitely postponed on the greater part of the corn belt land west of Illinois. The work of the Minnesota Station has shown that by such means the expensive nitrogen and the humus supplies can be maintained and even increased.

Rotation of crops and live stock farming maintain fertility

A ROTATION FOR THE CORN BELT. Throughout the greater part of this region the most profitable cereal crop that can be grown on fertile soil is corn. The problem of a rotation, then, is how to secure the largest area for that crop consistent with the maintenance or improvement of the fertility of the soil. A four-year rotation that answers these requirements and one that is being widely practiced is two years of corn, followed by small grain the third year, and clover the fourth. The clover is seeded with the small grain. The manure

*Minnesota Bulletin No. 89.
Minnesota Bulletin No. 94.
Iowa Bullein No. 96.
Kansas Bulletin No. 147.
Indiana Bulletin No. 88.

produced should be returned to the soil, preferably on the clover stubble just before plowing for corn, and as much as possible of the stalks and straw should be plowed under.



The diagram here given shows in a very simple way the outline and position of a suggested crop rotation. The name of each crop appears opposite the year in which it is grown on that field. The purpose of this explanation is to point out more clearly the steps to be followed in a system of rotation.

ACKNOWLEDGMENTS. We wish to express our appreciation of the interested co-operation of the Weather and Crop Service Bureau of Iowa, which in the person of George M. Chappel furnished unhesitatingly much of the information in this chapter.

Several students of the Department have worked faithfully in arranging these charts.

COLLATERAL READING:

Iowa Climate and Crops,
Iowa Year Book of Agriculture, 1903, pp. 121-157.

Relation of Precipitation to Yield of Corn,
J. Warren Smith, Year Book U. S. Department of Agriculture, 1903.

The Experiment Stations and Corn Culture,
J. I. Schulte in Am. Rep. 1904, Office Experiment Station, P. S. Department of Agriculture.

Influence of Environment on the Chemical Composition of Plants,
Wiley, Year Book U. S. Department, 1901, pp. 299-318.

Indian Corn,
Bulletin No. 147, Kansas Experiment Station.

Effect of Manures upon Composition of Corn,
Connecticut Experiment Station Report 1895, page 125, 1896, page 315.

Practices in Crop Rotation,
Year Book U. S. Department of Agriculture, 1902, pp. 519-532.

Thirty Years of Crop Rotation,
Illinois Station Bulletin No. 125.

Soil Areas of Iowa,
Iowa Station Bulletin No. 82.

Maintenance of Soil Fertility,
Iowa Station Bulletin No. 96.

Studies of Rotations, Humus, Etc.,
Minnesota Station Bulletins Nos. 89-94.

Various Articles in Fifteenth Biennial Report of Kansas State Board of Agriculture, 1905-6, pp. 1-242.

Cereals of America,
Hunt, Chapter XII.

Reports of Iowa Weather and Crop Service,
Iowa Year Books of Agriculture.

Effect of Certain Methods of Soil Treatment Upon the Corn Crop,
Nebraska Bulletin No. 54.

Climatic Studies with Wheat, Corn and Oats,
North Dakota Bulletin No. 47.

Corn, Meterology, Soil Temperature,
Alabama Bulletin No. 10.

Co-operative Soil Tests of Corn,
Alabama Bulletin No. 59.

Comparative Yield of Corn from Seed Grown in Different Latitudes,
Arkansas Bulletin No. 59.

Adaptation of Seed Corn,
Farmers' Bulletin No. 244.

Continuous Corn Culture,
Rhode Island Bulletin No. 113.

Corn and Wheat, Fertilizer Tests with
Minnesota Bulletin No. 94.

Corn, Field Experiments with Fertilizers,
Kentucky Bulletin No. 55.

Experiments with Corn in Wisconsin on Sandy Soil,
Wisconsin Bulletin No. 147.

Corn, Results of Fertilizer Experiments with
Wisconsin Bulletin No. 147.

CHAPTER VI

SELECTION AND PREPARATION OF SEED CORN FOR PLANTING

Virgin Soil

The soil of the corn belt has a high productive power due very largely, if not entirely, to its virgin fertility. The system of crop rotation heretofore practiced, including the application of manure, has not in general added to the original potential supply of plant food. The season is usually sufficiently long to mature the crop. More improved methods of culture are adopted each year. Growers are recognizing that weeds in corn are not conducive to high yields. The ground is kept in better physical condition and abundant moisture is conserved. Yet the average yield per acre for the heaviest corn-producing States, Iowa, Illinois, Nebraska, Kansas and Missouri was respectively 39.5, 36.1, 34.1, 28.9 and 32.3 bushels for 1906. In 1907 the yield was even lower, being respectively 29.5, 36, 24, 22.1, 31.

Causes of Poor Stand

Assume that all the corn in these States was planted with a 3 foot, 6 inch planter, which would make 3,556 hills or 10,668 stalks to the acre, providing three kernels grew in each hill. A yield of 38 bushels means one 12-ounce ear in each hill. Therefore, the corn growers of these States either have but one-third of a stand, or else two stalks in each hill are barren. Upon these two points (poor stand and its causes and the elimination of the unproductive stalk), the discussion of the selection and care of seed corn will be based.

Corn adapted to your own locality

BUYING FOREIGN SEED. By all means. do not omit picking seed corn this fall with the idea that in the spring you will purchase entirely new seed and start in the business right. Seed grown in a different section of the corn belt, on dissimilar soil, is not sure the first year or two under new environment. There is no corn so adpated to a given locality as corn which has been successfully grown in that locality for a period of years.

Results of County stations

The results of three years of trial (1905, 1906, 1907) at County Experiment Stations located on the county farms in different parts of the State of Iowa are very striking on the point of buying foreign seed. There were 39 experiments in all. The corn from the "dealers" (large seed companies who catalog their sales) was secured by purchasing from them small quantities of seed through some farmer in the vicinity of each county farm. The term "outside breeders" refers to corn growers who make a specialty of good seed corn. This was bought in small quantities. The quality was the same as that which was being sold to farmer customers. The corn from the "farmers" was secured directly from the planter box or sack in the field the day that the farmer was planting.

The table here shown gives the summary for the State.

Source of Seed.		
Farmers	1,028	samples
Dealers	137	"
Outside Breeders	87	"
Farmers' Average Yield	61.9	Bu. Per Acre
Outside Breeders' Average Yield	59.5	" " "
Dealers' Average Yield	53.0	" " "
Eighty-five Highest Farmers' Average Yield	73.2	" " "
Eighty-five Lowest Farmers' Average Yield	47.7	" " "

HARVESTING SEED CORN.—The Time. October 10th has been named by the Iowa Grain Dealers' Association, at the suggestion of Professor P. G. Holden of the Iowa State College, as the date for gathering seed corn. *For a period of thirty years the average date of the first killing frost in the fall in Iowa is October 8th. To set a definite day as "Harvest Day" for the entire corn belt is impossible. Its significance lies simply in the suggestion. But the farmer who has learned through experience and observation in his locality, can forecast frost fairly accurately. The only thing then is to pick seed before the cold freezing weather comes on. When going into the field early in the fall, before any hard frosts have come, it will generally be found that the corn as a whole is immature; yet on examination an occasional ear here and there will be seen with its husks turning brown. These, when pulled back, reveal an ear in the dent stage, firm and ready to be picked for seed, while right in the same hill another ear having had an equal opportunity is still in a very immature state. This is the time to select the large, early, well-matured seed ears, instead of waiting until later (husking time for example), when it is impossible to distinguish between the early and late maturing corn. This may be done the latter part of September. *Maturity should never be sacrificed for size of ear.* There are plenty of good sized ears that mature in the corn belt, but they can only be properly found by selecting them early in the field.

Seed corn harvest day.

Maturity first consideration

*Geo. M. Chappel, Iowa Crop Service.

Immature corn shrivels

The corn will shrivel to a greater extent when gathered early, if picked too immature, and the kernels will have a tendency to be starchy. This practice continued from year to year will tend to produce an early maturing corn. Good ears may be selected at husking time later in the autumn, but they should be stored separately and very thoroughly tested.

Selecting the ears in the field

The Method. In case the farmer has no "Selection Bed" in which has been planted the best and earliest maturing ears, it is then necessary that seed ears be selected from the general field. The most practical method by which this is done is to take a sack and go through the field, before the hard frosts have come on and select the choicest, best matured ears. As many as three or four rows may be observed on the way through. Every well-formed, breedy looking ear of good size and well matured, at this time may be considered valuable for seed purposes, and from twelve to fourteen ears are sufficient for the planting of an acre. From three to five bushels of corn is as much as may be expected to be found in a single day. These bushels, however, will contain the most valuable seed ears that the field has to offer. A small plot of selected corn simplifies this process, as the best ears may then be found in a comparatively small area.

(Courtesy Funk Bros.) Fig. 23.
THE PICKING SQUAD.
Gathering seed corn in the field.

During this process, consideration of the strength and character of the parent stalk, height of the ear and size of the shank should be noted. The characteristics are quite generally reproduced. The stalk should be of good size at the base, gradually tapering, not necessarily tall. Strong, vigorous stalks of medium height, in general produce the best ears. The largest, best formed, and to a large degree, the earliest maturing ears, will be found at a medium height. The shank should be of medium size and of sufficient

Description of stalk

(Courtesy Successful Farming)

Fig. 25

BAD METHOD OF STORING SEED CORN.

The ears are too close together for good circulation of air, consequently there is danger of moulding and that it will not be sufficiently dried out to prevent freezing. It is much easier way to tie with a string, as shown by Fig. 27. If the string method of tying is followed, a good circulation of air is afforded and the ears dry out properly. What must be avoided is freezing of the corn before it is dried out. The above is a common method employed by many farmers in the corn belt in drying their seed corn, and may result in mouldy corn, especially if stored in this way during a damp or wet fall.

2 1

(Courtesy Successful Farming) Fig. 24

GOOD AND BAD STALKS.

No. 1 is an illustration of a good stalk, well balanced, the ear about four feet from the ground, well set and drooped sufficiently to shed the rain. No. 2 shows a rather weak stalk with long joints and the ear set too high and much too near the top.

length that the ear may hang with tip down. It is also well to note whether the stalks about it are strong, or are barren and dwarfed. If the ear seems to be very ripe, look out, the stalk may be diseased. As a general rule, the farmer should gather twice as much seed as will be required to plant his fields the year following.

STORING SEED CORN.—The Method. The early pioneers in corn culture generally tied two ears together by the supple husks

(Courtesy Successful Farming) **Fig. 26.**

Ears tied too closely together on string for best results. A common error in storing seed corn when string method is employed.

and hung them over a wire or rail. Others stripped all the husks off, tied two or more ears together and hung them up. With the increased interest in seed corn, many dealers thought that they had hit upon an ideal plan when the light wooden racks were built and the ears laid in tiers horizontally. But, because of the moisture and the subsequent heating, the kernels were either molded or sprouted. Seed corn which has just been husked requires just one thing. It *must* have a very *free circulation* of *air* at ordinary temperatures. That is to say, each ear must have access to a complete circulation of air in order that its excess of contained moisture may evaporate rapidly enough to prevent fungus growths and chemical changes in the kernels.

Free circulation of air around corn

Different Experiment Stations recommend several devices and methods which accomplish the desired results with varying degrees of satisfaction. Wire racks with both horizontal and vertical strands, thus separating each ear into a sort of pigeonhole, are made by some manufacturers and sold on the market. Some farmers drive spikes at an angle through a two-by-four and simply slip an ear over each spike.

Fig. 27
SEED CORN HUNG UP BY TWINE ON WIRES
There is plenty of room for the moisture in ears to escape

(Courtesy Ulbrich Seed Corn Tester Co.)
Fig. 28
A METHOD OF STORING SEED CORN WHICH ADMITS THE FREE CIRCULATION OF AIR ABOUT THE EARS

The method which has proved of the highest efficiency at the Iowa Experiment Station and which is being rapidly adopted by the farmers of the state, is suspending from the ceiling or rafters ten or more ears, each looped at about the middle on a single or double strand of binding twine. For corn which is meant for show, suspension from both ends of the ear is more satisfactory because then each ear holds its straight form. The circulation of air is unhindered, and the method is very practical. Moreover, the damage by mice is slight because the corn cannot be easily reached. Especially is this so if the binding twine be tied to a wire which may be suspended from rafter to rafter.

LAYING IN THE FIRST EAR*

This method, known as the double string method of tying up seed corn, is rapid and efficient. Note that the strings held in the left hand are longer than those in the right. Also that the strings in the right hand are held wider apart. As the strings pass around the ear they are about equal distant from butt and tip.

*The plan of stringing seed corn is called to the attention of the authors just as the book is going to press. It is the most rapid and economical method we have ever seen. Suggested by A. C. Ruppel and E. B. Arnold, students at the Iowa State Colllege.

LAYING IN THE SECOND EAR

The first ear is held securely between the feet. The right hand and strings are passed through between those held in the left, leaving a place in which to lay the second ear. Notice that the second ear is reversed, butt for tip. Care should be exercised to keep the strings equal distant from the tip and butt of each ear. Always hold the string tight.

LAYING IN THE LAST EAR

The left hand strings are still a little longer than those of the right. The first ear is still securely held between the feet. The string is tight and plenty of air space is present between the ears. The ears are woven in by the strings. No knots have been tied. The weight of the ears bind the strings closely to the ears.

READY FOR HANGING

The longer string is looped through the shorter. No knot is necessary if the corn is to be hung up immediately. If, however, the ten ears are to be laid down on the floor again, a second hitch of the longer string through the shorter will be necessary to prevent the ears from slipping out of their places. In case it is desired to suspend twenty ears from one point, the second string is looped through the longer string of the first ten, and the process of weaving is continued.

TAKING OUT THE EARS

The hitch and loop which were made in the string previous to hanging, are unloosed. The lower ear of the ten is grasped, thus inverting all the ears. The weaving process is reversed. One by one the ears drop from their places by their own weight.

Seed may be left hanging until spring, but if the mice are not in evidence it is better to take the ears down and store them in racks after the fall winds have thoroughly dried out the excess moisture.

Critical Period of Storage

The first four weeks is the critical period of storage. Seed corn selected in the field in the fall of 1906 on the following dates, showed a very high percentage of moisture.

Date	Kernels	Cob
September 14	41.78 Per cent	58.58 Per cent
September 21	37.35 "	57.17 "
September 28	33.04 "	55.86 "
October 5	28.52 "	52.28 "
October 12	25.97 "	49.05 "
October 19	20.15 "	40.99 "
October 26	22.09 "	37.24 "
November 2	17.83 "	26.82 "

The above table taken from the thesis of E. L. Morris and O. A. Cohagan (1907), shows the large amount of water present in early gathered seed corn. It shows that the cob contains the greater per-cent of the moisture and that the cob is also much slower in losing this water. Up to November 2d the cob was very heavy and damp, the pith cells being quite turgid.

Fig. 29
SEED EARS STORED UPRIGHT.

Hanging over oat bin objectionable

The Place. Unless the small grain has been threshed early in the season and has had time to cool off after the sweating process, do not hang the seed corn over the oat bin in the granary. Furthermore, the ordinary granary has hardly enough direct ventilation to dry out the newly gathered corn before colder weather. A double corn crib, with a sort of garret fixed over the drive, is almost an ideal place for the drying of early picked corn, as the wind has free access to the ears and a thorough drying is soon effected.

Attic has poor ventilation

The attic over the living room is often advocated as the best place for seed corn storage. Early in the season, when the ears are sappy and require the circulation of air, the ordinary attic has too few windows and the temperature is usually so high that mold or germination often results.

Corn which has been dried thoroughly need not be moved from the granary or loft because of cold weather. But to be safe, seed so stored is better placed in the attic when the lower temperature of winter comes on. On the ordinary farm, the seed corn store room or separate building has not come to be a permanent fixture. When much seed is sold, such a building is almost necessary.

A test at the Iowa State College

Mr. D. S. Bustamante, in his thesis for Master's Degree in Agriculture, while at the Iowa State College, stored corn during the fall of 1906 in the following places which are described by him. Ninety ears were gathered on October 20th, just before the killing frost occurred. They were stored in nine lots of ten ears each, as follows. The average humidity and average temperature for the entire period is also given.

1. Attic of a dwelling house, ears tied up in strings and hung from the roof; 47 humidity, 42 temperature.

2. Farm Crops Laboratory, ears tied up in strings and hung; 26 humidity, 68 temperature.

3. Cellar of Agricultural Hall basement, ears placed in a small box surrounded by screens and placed above the heating pipes; 82.3 humidity, 52 temperature.

4. Green House, ears placed in a box, and this over the radiators; 22.5 humidity, 107 temperature.

5. Dairy Cold Storage, ears placed in a bag and this in the cold storage. No particular aim was had to cool the place to low temperatures. —— humidity, —— temperature.

6. Pump Cellar, ears tied up in strings and hung right over the pump, where water was more or less present in the ground; 63.5 humidity, 33.5 temperature.

7. Outside and inside, ears were tied up in strings and placed alternately one week outside and another week in the attic of the house; 67 humidity, 40.2 temperature.

8. Outside, ears were tied up in strings and hung outside, but protected from rain or snow; 71 humidity, 18 temperature.

9. Closed box, ears were tightly packed in a small box and a board nailed over it so that circulation of air was almost absent; —— humidity, —— temperature.

Thermometers and hygrometers were kept in the corn in seven places and the temperature and humidity recorded daily, from which the above averages were taken. The conclusions drawn by Mr. Bustemante from this extended test are here given.

1. High temperatures and low humidity, as were the conditions in the green house, are detrimental to the vitality of seed corn.

2. Low humidity and average room temperature, as illustrated from the results obtained from corn stored in the Farm Crops laboratory, are also injurious to the seed.

3. High humidity and somewhat low temperatures are not so detrimental to corn as somewhat high temperatures and low humidity as shown by the results of corn stored in basement of Agricultural building.

4. Average humidity with low temperature, as shown by results of corn stored outside, show less ill effects than high humidity and low temperatures.

5. Average humidity and average temperature, aided by good ventilation, as illustrated by results of corn stored in the attic, gave the best results.

6. The amount of moisture present in the corn and that present in the atmosphere, have more influence on the vitality of the seed than the degree of temperature.

THE EFFECT OF MOISTURE AND FREEZING UPON THE VITALITY OF CORN

Experiment with moisture and its effects on seed corn

The purpose of this experiment was to determine just what effect freezing would have upon corn which was air dry and that containing different percentages of moisture.

Ears 1-5 were soaked in water at ordinary temperatures for five hours.

Ears 6-10	6 hours
Ears 11-15	7 hours
Ears 16-20	8 hours
Ears 21-25	5 hours
Ears 26-30	6 hours
Ears 31-35	7 hours
Ears 36-40	8 hours

Immediately after being taken from the water, the ears numbering 1 to 20 were placed in a refrigerator plant where the temperature varied from 12 to 20 degrees Fahrenheit above zero. Here they were left for 76 hours. Ears 21-30 were left under ordinary room temperatures for 52 hours and were then frozen for 24 hours. Ears 31-40 were not frozen at all, but were left in a room at 70 degrees Fahrenheit.

*The kernels were afterward taken from each ear and analyzed for moisture as well as given a germination test. The following table shows the average percentage of moisture and the percentage of germination before and after the treatment, with the consequent loss in vitality.

Number of ear	Percent of moisture	Percent of perfect vitality before treating	Percent of perfect vitality after treating	Amount of loss	Percent loss of vitality
1- 5	22.3	88.3	28.3	60.0	69.0
6-10	23.5	91.7	46.6	45.1	49.2
11-15	29.8	68.2	26.4	41.8	61.3
16-20	30.0	84.7	44.9	39.8	47.0
21-30	31.2	97.4	61.6	35.8	35.7
31-40	27.3	89.9	82.3	07.6	08.4

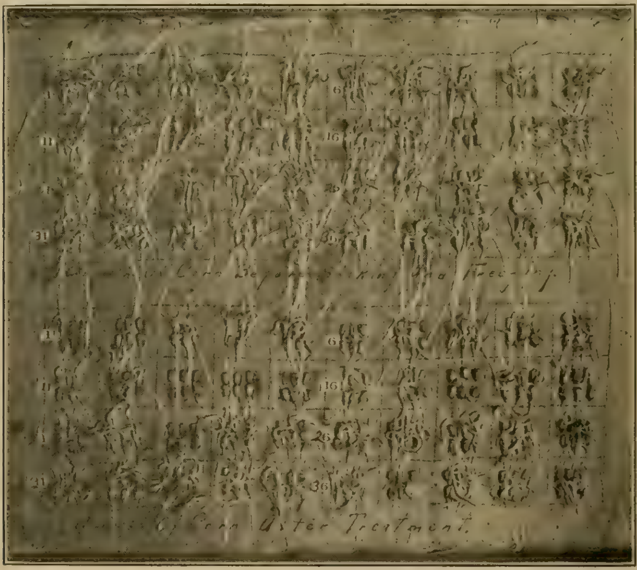


Fig. 32.

THE EFFECT OF MOISTURE AND FREEZING UPON THE VITALITY OF CORN.

The numbers above untreated correspond to those below which were treated.

*Research by W. F. Schnaidt.

Conclusions:

1. When very full of moisture, even freezing for a short time is detrimental.

2. Excessive moisture when not attended with low temperatures, also weakens vitality.

Mr. L. C. Burnett, in his thesis for Master's Degree in Agriculture at the Iowa State College, found the following results in germination tests with seed corn stored in the places herein named.

	Percent Kernels Germinating.		
	Strong	Weak	Bad
1. Seedroom	95.0	3.3	1.7
2. Garret (kitchen)	92.5	7.5	—
3. Tool Shed (closed)	91.7	6.6	1.7
4. Tool Shed (open)	91.7	8.3	—
5. Hung outdoors	85.4	8.3	6.3
6. Dry garret	83.3	16.7	—
7. Furnace room	79.6	18.5	1.9
8. Cellar (not dry)	75.0	23.3	1.7
9. Hay mow	58.3	41.7	—
10. Shock (outside)	57.3	20.0	22.7
11. Hanging on stalk	55.0	15.0	30.0
12. Lying on ground	46.7	25.0	28.3
13. Shock (center)	43.0	20.0	37.0
14. Cellar (very wet)	40.0	51.7	8.3

Corn stored dry vs. corn stored just as it comes from the field.

	Dry Corn Stored December 23d			Field Corn Stored Oct. 3d			Percent Increase of Strong Kernels	Percent Increase of Bad Kernels
Place of Storage	Strong	Weak	Bad	Strong	Weak	Bad		
Open Shed	91.7	8.3	...	91.7	8.3	...	....	...
Hay Mow	70.0	30.0	...	58.3	41.7	...	11.7	...
Holden's Cellar	64.0	27.5	8.3	75.0	23.3	1.7	11.0 loss	6.6

Test made April 30, 1906.

The table shows that the damp cellar kills six and six-tenths per cent of the corn placed in it, even after the corn was thoroughly dried out. The temperature in the cellar was never below freezing.

There was an actual gain in the figures for the corn that remained outside in the shed. If it can be considered that no loss was incurred there after January 1, 1906, we may conclude from this that the frost does not injure dry corn.

Effect of early drying on seed corn

We may also conclude that moisture injures the vitality of corn, even if the temperature does not fall below the freezing point. From

Fig. 33.
THE RESULT OF STRONG AND WEAK SEED.
The kernels in each case were planted at the same time. Germination with one was strong and vigorous, with the other the plant was always weak and developed a very small root system.

the results of the second table, we may conclude that early and rapid drying of seed increases its ability to withstand not only frost, but also moisture.

THE NEED OF TESTING SEED CORN. Corn which has been stored properly through the winter season is often thought to need no testing. But the high price of land and the incumbent risk in planting untested seed, demands a more definite knowledge of its germinating ability.

The following tables are taken from the thesis of Mr. Burnett. The tests include 1,570 samples. The reason for inserting the results in detail is that the figures represent tests from all parts of the state, which shows the variations in conditions in each county. To students and farmers of Iowa these figures are especially significant.

TABLE SHOWING AVERAGE TEST—NORTHERN SECTION.

County	Number Patrons	Samples	Per Cent Strong	Per Cent Weak	Per Cent Worthless
Allamakee	3	8	70.5	11.8	17.7
Black Hawk	10	14	71.9	11.3	16.8
Bremer	5	5	71.5	15.0	13.5
Buchanan	9	12	58.0	20.4	21.6
Buena Vista	19	23	64.0	16.8	19.2
Butler	11	11	67.7	7.6	24.7
Cerro Gordo	17	19	69.1	12.5	18.4
Cherokee	13	15	66.4	18.1	14.5
Chickasaw	4	5	63.6	17.2	19.2
Clay	10	10	67.6	12.0	20.4
Clayton	15	21	73.8	13.7	12.5
Delaware	4	5	59.6	18.4	22.0
Dickinson	4	8	57.7	17.8	24.5
Dubuque	10	14	62.0	12.3	25.7
Emmett	7	7	67.7	11.4	20.9
Fayette	14	15	60.9	16.8	22.3
Floyd	16	20	71.7	14.2	14.7
Franklin	13	14	66.8	13.3	20 0
Hancock	11	15	67.7	16.1	16.2
Howard	5	6	56.7	19.3	24.0
Humboldt	12	15	66.1	14.9	19.0
Kossuth	38	44	70.3	16.6	13.1
Lyon	6	6	62.7	18.3	19.0
Mitchell	16	17	64.6	16.4	19.0
O'Brien	19	19	68.3	17.0	14.7
Osceola	6	6	70.3	12.1	17.6
Palo Alto	11	14	64.9	16.3	18.8
Pocahontas	17	20	70.4	14.7	14.9
Plymouth	21	23	65.3	15.8	18.9
Sioux	7	12	61.0	16.8	22.2
Winnebago	13	18	70.3	13.1	16.6
Winneshiek	5	6	78.3	10.7	11.0
Worth	10	14	69.7	14.3	16.0
Wright	25	29	68.1	16.3	15.1

TABLE SHOWING AVERAGE TEST—CENTRAL SECTION.

County	Number Patrons	Samples	Percent Strong	Percent Weak	Percent Worthl'ss
Audubon	12	18	71.0	15.2	13.8
Benton	21	27	73.7	15.8	10.5
Boone	7	9	59.0	17.8	23.2
Calhoun	12	18	72.2	16.4	11.4
Carroll	23	29	68.7	15.0	16.3
Cedar	30	39	66.6	17.9	15.3
Clinton	15	23	69.6	18.6	11.8
Crawford	10	10	71.6	17.8	10.6
Dallas	23	35	72.6	15.2	12.2
Greene	10	11	74.0	16.1	9.9
Grundy	13	18	75.0	14.1	11.0
Guthrie	7	7	68.0	17.1	14.9
Hamilton	22	26	66.6	17.0	16.4
Hardin	17	21	66.5	15.1	18.9
Harrison	10	18	79.6	12.5	7.9
Ida	11	12	69.2	16.0	11.8
Iowa	9	13	74.3	13.4	12.3
Jackson	8	8	68.0	16.1	15.9
Jasper	19	26	71.0	15.2	13.8
Johnson	20	32	76.0	14.0	10.0
Jones	19	22	67.3	17.3	15.4
Linn	18	24	77.1	15.1	12.8
Marshall	14	20	76.1	17.9	16.0
Monona	11	15	75.7	15.6	8.7
Muscatine	14	21	72.8	15.8	11.4
Polk	4	9	79.5	16.1	4.4
Poweshiek	8	9	72.4	15.6	12.0
Sac	21	28	67.2	13.4	19.4
Scott	20	22	66.6	20.6	12.8
Shelby	12	15	66.4	11.0	12.6
Story	40	54	66.8	15.4	17.8
Tama	9	13	68.1	15.6	16.3
Webster	28	35	69.8	14.1	16.1
Woodbury	37	44	63.9	17.0	19.1

TABLE SHOWING AVERAGE TEST—SOUTHERN SECTION.

County	Number Patrons	Samples	Percent Strong	Percent Weak	Percent Worthl'ss
Adair	6	7	66.6	20.0	13.4
Adams	3	3	79.3	13.4	7.3
Appanoose	4	5	67.6	18.9	13.5
Cass	12	15	70.6	17.9	11.5
Clark	3	3	70.0	12.0	18.0
Davis	5	7	77.0	15.3	7.7
Decatur	5	7	58.6	18.0	23.4
Des Moines	14	14	70.4	15.2	14.4
Fremont					
Henry	11	12	69.8	18.0	12.2
Jefferson	13	14	71.1	16.2	12.7
Keokuk	22	27	74.8	13.9	11.3
Lee	12	17	72.5	16.0	11.5
Louisa	16	22	69.4	17.3	13.3
Lucas	3	3	71.3	18.7	10.0
Madison	8	8	76.2	12.3	11.5
Mahaska	13	16	70.2	14.7	15.1
Marion	13	17	70.8	15.5	13.7
Mills	6	9	72.4	17.6	10.0
Monroe	2	2	85.0	11.0	4.0
Montgomery	7	10	75.8	10.0	15.0
Page	9	10	68.8	16.8	14.4
Pottawattamie	17	18	72.1	16.8	11.0
Ringgold	4	5	70.0	16.0	14.0
Taylor	6	9	70.7	17.5	11.8
Union	7	10	71.4	14.2	14.4
Van Buren	4	6	71.0	15.2	13.8
Wapello	4	5	72.2	14.8	13.2
Warren	4	5	71.2	13.6	15.2
Washington	13	18	71.4	15.6	13.0
Wayne	16	21	72.7	15.6	11.8

The Extension Department of the Iowa State College, during the early spring of 1907, tested at their county stations in seven counties a total of 397 samples of seed corn collected from the planter boxes of the farmers of those counties. The following tables represent the results obtained: A fair test

GERMINATION.

County	Number of Samples	Percent Strong	Percent Weak	Percent Bad
Sioux	49	50.9	27.2	21.9
Story	56	58.2	32.6	9.1
Marshall	55	76.6	13.2	10.1
Montgomery	60	66.2	23.3	10.5
Page	59	63.4	26.6	10.0
Henry	56	75.2	16.0	8.8
Cedar	62	63.1	27.7	9.2
Total	397	Av. 65.0	Av. 23.8	Av. 11.2

Poor Stand is Conducive to Low Yield. In tests made at the county stations of the Extension Department of the Iowa State College, as regards the relation of stand to yield, the following very striking results were obtained. The samples were sent in by the farmers and planted in plots containing 210 hills each. The standard taken was three stalks to the hill. An accurate acount was kept of the stand and yield per plot. Afterwards the basis of an acre was figured for tabulation.

SIOUX COUNTY, 1906.

	Number of the Sample	Percent Stand	Bushels Per Acre
10 highest yielding samples	64	78.1	86.0
	65	64.8	85.3
	30	87.6	84.0
	7	85.4	82.6
	10	88.8	80.8
	8	89.4	80.1
	34	78.7	78.1
	21	84.6	78.0
	63	92.4	77.2
	44	87.3	74.8
	Average,	83.7	80.7

	Number of the Sample	Percent Stand	Bushels Per Acre
10 lowest yielding samples	62	43.8	46.7
	60	79.1	47.4
	1	54.8	51.3
	22	50.2	51.7
	19	76.7	55.8
	56	41.9	56.9
	14	61.1	57.3
	46	94.8	58.1
	36	85.0	58.6
	38	77.8	59.3
	Average,	66.5	54.3

KOSSUTH COUNTY, 1906.

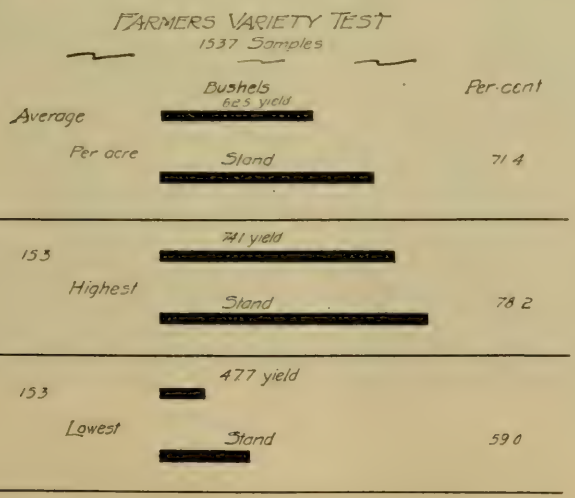
	Number of the Sample	Percent Stand	Bushels Per Acre
10 highest yielding samples	25	89.5	91.5
	50	86.5	89.6
	16	90.0	89.0
	116	87.1	88.9
	77	91.4	88.6
	22	82.9	87.6
	19	85.7	87.4
	103	65.2	87.4
	48	85.2	84.7
	18	83.2	83.8
	Average,	85,7	87.9

	Number of the Sample	Percent Stand	Bushels Per Acre
10 lowest yielding samples	70	25.9	33.7
	67	43.2	45.9
	58	36.1	47.9
x	87	45.2	50.1
	108	53.1	55.5
	80	39.7	57.0
	73	78.6	57.7
	72	86.8	58.6
	75	71.9	59.0
	110	75.0	59.0
	Average,	55.5	52.4

Not only is a high percentage of stand necessary for increased production, but the stand must be uniform and lack missing hills. No. 25, of the Kossuth County Station, which yielded 91.5 bushels, the highest of any plot in the state, showed a surprisingly uniform stand, 3-3-3-1-1-3-3-3-2-2-3-3-3-0-3-2-3-3-3-3-0-3-3-2-3-2-3-3-3-3-2-3-2-2-2-3-3-2-3-1-3-2-3-2-3-3-2-3-3-3-3-3-3-3-3-3-2-2-3-3-3-3-3-3-3-3-3-3-3-3.

Compare with the above, No. 70, also of Kossuth County, which only yielded 33.7 bushels, showing by 25.9 per cent of a perfect stand with a count as follows: 1-1-0-1-1-1-1-1-0-0-1-1-1-1-0-1-0-1-0-1-0-1-0-0-0-0-0-1-0-2-2-0-1-0-1-1-2-1-2-0-1-1-0-1-0-0-2-3-2-2-2-3-1-1-2-1-2-1-1-0-2-2-1-1-1-2-2-2-2-3.

The final summary for three years at eleven county stations, with a total of 1,537 farmers' samples, the relation between stand and yield was found to be as follows:



Through the influence of the agricultural press, the short courses, corn trains, and a general movement in advance in farming methods corn growers are recognizing the importance of seed testing. Yet the awakening seems slow. Out of 182 representative farmers throughout the state answering inquiries from the Farm Crops Department, 79 tested every ear of their seed corn, 85 tested in a general way, and 18 did not test at all.

As the result of one short course of two weeks at Mt. Pleasant in 1906, the students attending the advanced classes in 1907 had all tested their corn the spring before.

Early testing

The Time to Test. Some corn growers make a practice of running a preliminary test during the month of January. This is done in order to find out whether or not all the seed is badly damaged. Should such be the case, other seed could be procured and tested before planting time. The method has a sound basis and should be followed more closely. One of the serious difficulties in the way is the liability to freezing during the test. The method is especially applicable to seedsmen who should know how much reliable seed they have on hand before the advertising season opens.

Final test

The regular and final test should be made during the month of March. There is less danger of the young sprouts freezing from exposure, and by this time the granary or barn has been emptied to such an extent that floor space is available. The planting season is near at hand and the tested seed has less chance to change in vitality from the time of testing until it is in the ground. The work can be completed, and the corn shelled, sorted, and sacked ready to palnt, leaving the seed room free.

Wet sawdust uniformly

MAKING THE TEST.—Fitting Up the Testing Box. The number of ears to be tested determines to a certain extent the size of the testing box. A convenient size for the practical corn grower is a box sufficiently large to hold kernels from 200 ears. This will require a box 24 by 48 inches. Six inches in depth is not objectionable should fencing lumber be the only thing available. This box should have a layer of two inches of wet sawdust packed tightly over the bottom. It will be found convenient to wet the sawdust in an old sack, letting sack and sawdust soak in warm water for 20 or 30 minutes, that the sawdust may have equal moisture throughout. While the soil is Nature's seedbed, yet young plants in sprouting feed entirely upon the plant food stored up within the kernel.

Fig. 35.
PACKING THE SAWDUST IN THE GERMINATION BOX.
The brick is used because the corners can be filled uniformly.

Fig. 36.

MARKING OFF AND NUMBERING THE SQUARES.

Note that the cloth is fastened down to a smooth surface with tacks. Only the outside rows need be numbered.

Take a piece of new white muslin, which should be a little larger than the box, and mark off two hundred squares, each 2x2 inches. corn having especially broad kernels may require squares 2x3 inches. This may be done with black or blue crayon. The squares may be numbered from one to 200, beginning in the upper left-hand corner and following consecutively from the left to right for each row or the outside rows only need be numbered. Tack the cloth in place stretching it uniformly tight over the sawdust.

Take six kernels from each ear, two from opposite sides of the tip, two from opposite sides of the middle, and two from opposite sides of the butt. See that no two kernels are taken from the same row. This will be a good representation of the germinating power of each ear. It is not well to take the kernels from one side only, for frequently an ear is found in which the kernels on one side germinate strong, while those from the other side fail to grow.

Be sure to get a uniform test

By placing the blade of a pocket knife between two rows of kernels, and prying slightly, a kernel will readily come out into the hand holding the ear. The six kernels should be laid on the floor just opposite the butt of the ear. Continue this process until six kernels have been removed from all the ears. Now take the germination box and, beginning on the first row, follow right down, placing the six kernels from the butt of each ear into a square in the box, the number of the square corresponding to the number of the ear. Thus, the kernels from ear No. 1 in square No. 1; kernels from ear No. 2 in square No. 2, and so on until the 200 groups of six kernels each are all in their respective places. Another piece of plain muslin should be cut just the exact size of the box. This covers the corn kernels when laid in place. Next a third strip of muslin larger than the box by twelve inches should be placed over the second. The remainder of the box above should then be filled level with damp sawdust. Fold the edges of the upper strip of muslin over on the sawdust and the germination box is complete.

Taking ont the kernels

A great many patent frames are being put on the market. Some have points of value, others are not so practical. In time, a device more easily manipulated than the one described may be manufactured. As economy is a factor, the best corn tester must be a labor saver.

Laying Out the Ears and Filling the Box. If the seed is hanging in the attic or loft or stored in a seed room it should be laid out in rows on the floor or improvised tables. During this process, a keen eye will detect some ears which from their outward appearance indi-

Other indications

Fig. 37.

REMOVING THE KERNELS WITH A KNIFE.

The strip in front of the ears shows how the kernels from each ear may be deposited.

cate low vitality; as for example, a moldy cob or dark colored germ, giving evidence of having been injured, probably by freezing. These should be cast aside at once. Ears which show a lack of breeding may be discarded immediately, also. Having laid the ears out in rows on the floor, where they are held in place by two nails at each end of the rows, each tenth ear should be numbered, after which the kernels may be taken out.

It will be found convenient to handle corn which is to be tested in trays of ten ears each. A small strip with holes bored in it large enough to hold six kernels each, may be set in front of the tray. After the kernels from each of the ten ears have been transferred to this strip, they can be caried to the germination box and emptied on the squares corresponding to their respective numbers.

For convenience in counting the test afterward, it is best to place the kernels in two tiers of three kernels each, and as evenly as possible. Always lay the kernels side by side with the germ side up. The tips of all the kernels should point toward that end of the box having the squares with the highest numbers. Dampen the loose piece of muslin and lay it over the kernels, taking care not to displace any of them. On top of this place the larger cloth filled with wet sawdust. Pack the corners down and press the entire mass firmly against the corn. The box is now ready to be set away for six to seven days, just as the temperature dictates. A furnace room furnishes a convenient place for the germinating box. It should be left in a suitable place where the temperature will be favorable for germination, from 50 to 70 degrees Fahrenheit being very desirable. Do not let the temperature fall below freezing.

Too much care can not be taken in adjusting the kernels

The Result of the Test. By the time the stem sprouts have grown two inches in length a careful study of the results can be made. Beginning at one end of the box roll up the cloth containing the sawdust, pressing down hard as it is rolled back. If the mass is lifted bodily from the box, the kernels are likely to be dislodged. The second piece of muslin can then be peeled back slowly, and carefully removed. Some rootlets may have penetrated it, hence there is a liability of displacing the kernels.

Reading the test

When this has been done, place the box at the head of row No. 1. Begin with ear No. 1. Examine the result of square No. 1. There should be two separate sprouts appearing—the stem sprout and the root sprout, the former protruding from the upper or crown end of the kernel, the latter extending from the tip end of the germ. The root sprout is smaller in diameter and longer. It will often appear one

Fig. 38.
TRANSFERRING THE KERNELS TO THE TEST BOX.
This method is rapid and deposits the kernels in the right squares according to the numbers.

Fig. 39.
FOLDING OVER THE EDGES OF THE UPPER AND LARGER CLOTH.
Be sure to keep the corners square and the sawdust well packed into them.

Fig. 40.
ROLLING BACK THE TOP COVERING OF SAWDUST PREPARATORY TO READING THE TEST.
Note that the single cloth immediately over the kernels is not displaced.

or two days before the stem sprout may be seen. At the time of examination there will be several smaller rootlets besides the primary sprout. Not infrequently the root sprout will grow while the stem sprout, because of weakness or some injury, will fail to appear The opposite is also true, but to a less degree. Both the root and stem sprouts should come stocky and vigorous to insure strong vitality.

(Courtesy Iowa State College) Fig. 41.
EARS LAYING OUT AFTER THE KERNELS HAVE BEEN TRANSFERRED TO THE GERMINATION BOX.
Every tenth ear is numbered.

A great difference will be noted in different ears

We will assume that the six kernels from ear No. 1 all showed strong root and stem sprouts. That is, the stem sprout was of good length and large in diameter. A long, slender sickly stem sprout indicates weakness. In other words, ear No. 1 is a vital seed ear. Move to ear No. 2. The kernels in square No. 2 show five healthy sprouts, but the sixth is small and has quit growing. This is not a first-class ear for seed. If you have much more seed than you will use, then push this ear back until one-half or three-quarters of its length extends back of the line of ears. By this action, you mean to throw this ear out entirely and not plant a single kernel from such an unreliable source. But do not take the ear out immediately because the arrangement of the row of ears would be altered and confusion would result. On the other hand, should the supply of seed corn be a little short this ear will be pushed back but a quarter length. This means that you will save all such ears and give them another test to eliminate the very weakest, and plant the best if necessary.

Pass to ear No. 3. You are surprised to find an apparently sound ear has three kernels which failed to germinate. The other three are weak and growth has already ceased. You pronounce this a bad ear and push it back three-fourths of its length in the row. Ear No. 4 shows six strong. Ear No. 5 shows six germinated, but they are all weak and one died soon after the sprout came out. This is bad and is pushed back. This process is continued, studying the outcome of each ear carefully. It is an interesting study and requires good judgment.

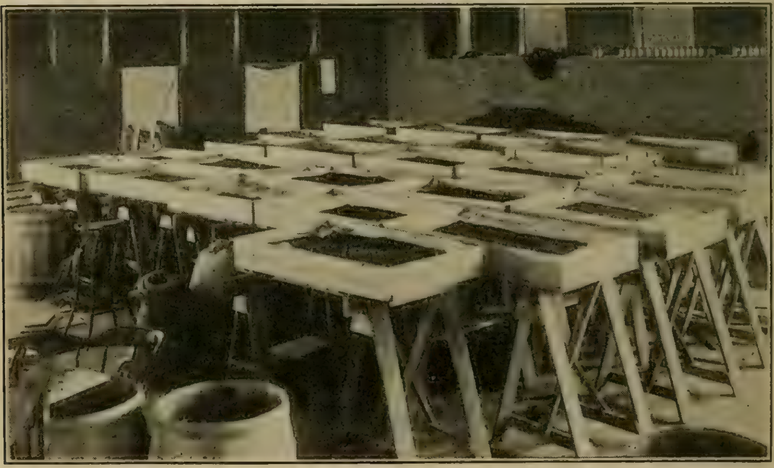


Fig. 42.
AN EXTENSIVE TEST ON.
More uniform temperature can be maintained when the boxes are elevated.

After the two hundred ears have been classified as to condition of vitality, they should be piled up in their respective classes. The bad ears had better be fed to the stock at once to prevent any chance of their becoming mixed with the good seed through carelessness or the mistake of helpers. The weak ears should be rearranged on the floor in another room, or any place out of the way, and another test run for them.

Disposing of bad ears

Mr. Burnett found that it cost $1.20 to test one hundred ears by the sawdust-box method, allowing 20 cents per hour for two hours' labor in testing, and 80 cents for the cost of buying the material and making

(Courtesy Prof. P. G. Holden)

Fig. 43.

TESTING CORN BY THE FIRESIDE IN THE FARM HOME.

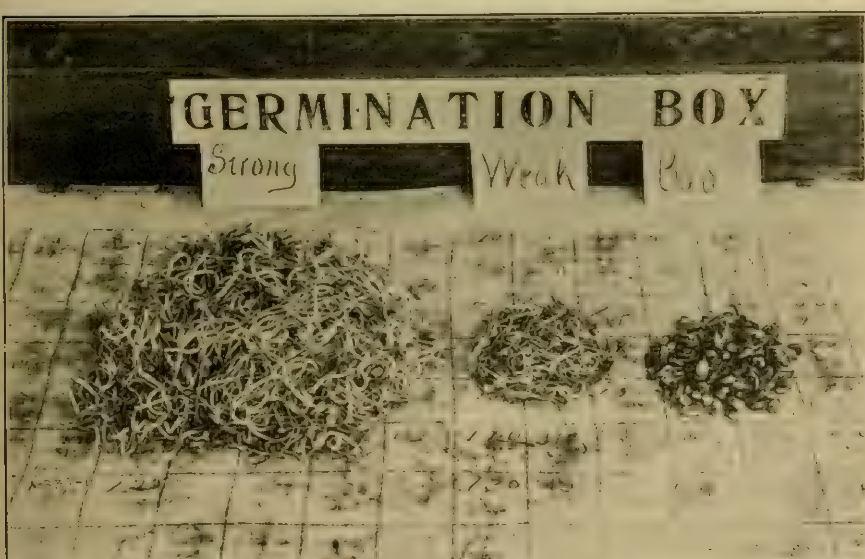


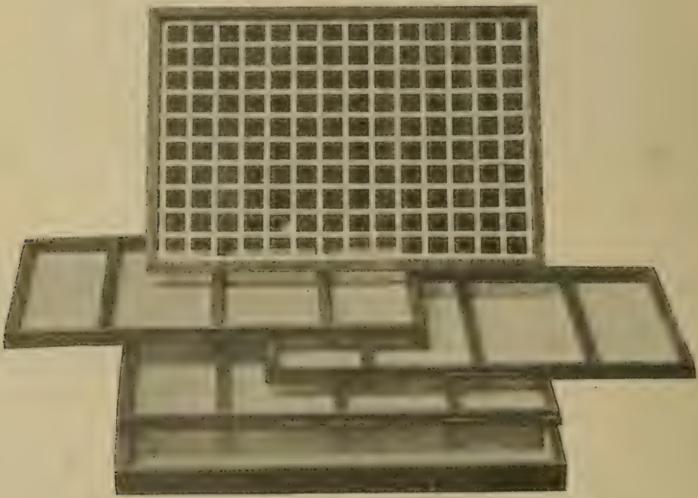
Fig. 44.

AFTER READING THE TEST.

the box. This refers to the cost of the first one hundred, subsequent tests cost less.

Removing butts and tips

SHELLING AND GRADING. Butts and tips had better be shelled off by hand, because the number of irregular kernels and the extent of crooked rows can best be ascertained by the eye. The practice of cutting off the buts and tips with an ax, produces many split kernels and wastes some corn by shelling. Shelling all the seed by hand, where a limited amount is used, is a method not to be criticised. A small hand sheller, however, accomplishes the same end much more rapidly. One man can turn and feed one ear at a time very conveniently.



(Courtesy Ulbrich Seed Corn Tester Co.)
Fig. 45.
A TESTER WHICH HAS PROVED VERY EFFICIENT AND ECONOMICAL.

A common method of grading

In front of the hand sheller have, for example, three boxes labeled large, medium, and small kernels. Besides the man who turns the sheller, another man will be needed to look after the grading. He should be provided with two pans, one to catch the shelled corn while he is emptying the other. The kernels of each ear thus being caught separately in a pan, can be graded to the size very accurately. If, for example, No. 1 has large kernels, empty these into the box marked "large kernels." Should ear No. 2 have medium sized kernels, empty them into the box marked "medium sized kernels," while the small kernels from ear No. 3 should be emptied into the box marked "small kernels." You will now have three sizes of seed—

large, medium and small. In case some of the ears have especially long kernels, it is well to make another grade or two, as may seem necessary. The man who grades can rapidly empty the pans into the proper boxes.

Fig. 46.
THE WRONG WAY TO PLACE KERNELS IN A GERMINATION BOX.
The result of test is difficult to ascertain.

So far as this operation is concerned, the corn has been graded without the use of the corn sorter. The corn sorter will, however, take out the small, excessively thick, and also the large irregular kernels. The three different lots which you have graded—large, medium, and small kernels, may each respectively be run through a corn sorter and in this way the ill-shaped, small, and excessively large kernels which were left on the ears after shelling off the butts and tips will be removed. The sorter will do it more rapidly than it could be done by hand.

Many patent graders are appearing on the market. The principle of sorting by gravity is the best one so far evolved. With the increased volume of business to be done by seed houses and large growers, the commercial grader will come into use very generally. The chief objection to them is the fact that they take little or no consideration of the length of kernel, the very factor which causes difficulty in planting.

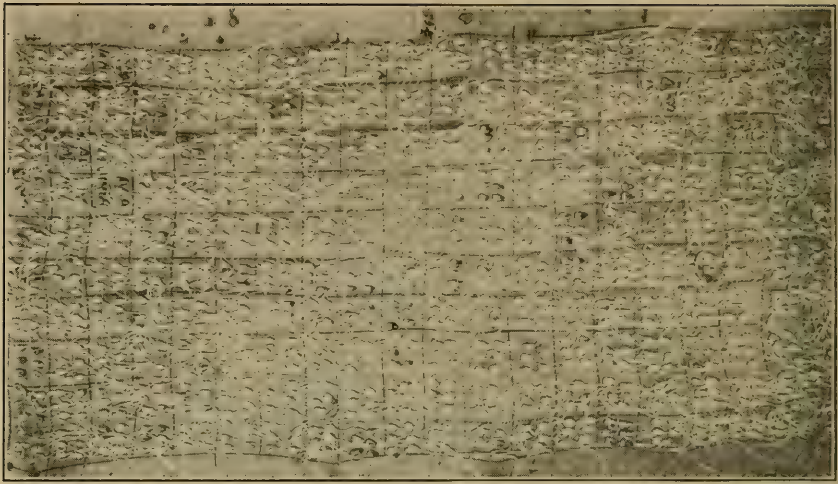


Fig. 47.
THE RIGHT WAY TO PLACE KERNELS IN A BOX.
This shows a very average general test. Notice some bad kernels here and there.

Fig. 48.
A STRONG TEST.
Every kernel shows vigorous sprouts.

In letters to the Farm Crops Department from 186 representative farmers over the State of Iowa, 86 stated that they tried to grade their seed corn either by hand or by a small grader. Nearly all of them followed the practice of shelling off the tip and butt kernels.

Corn with a few years careful selection back of it will be found to produce kernels much more uniform as to size and shape than that which is produced from the common run of seed.

Cost of Testing. The two following statements are taken from personal letters from two seed corn growers who tested every ear sold in 1908. Cost of an Iowa test

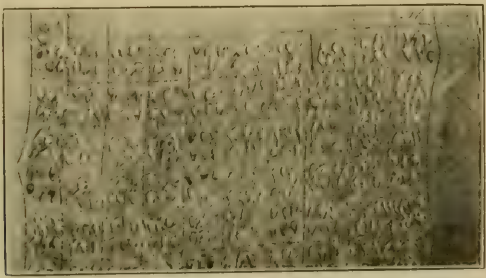


Fig. 49.
A WEAK TEST.
Some kernels have produced strong sprouts, others have put out a sickly stem, others

1. "Yours at hand and contents noted. It cost me to test my corn last winter, as nearly as I can figure, about 25 cents per bushel.

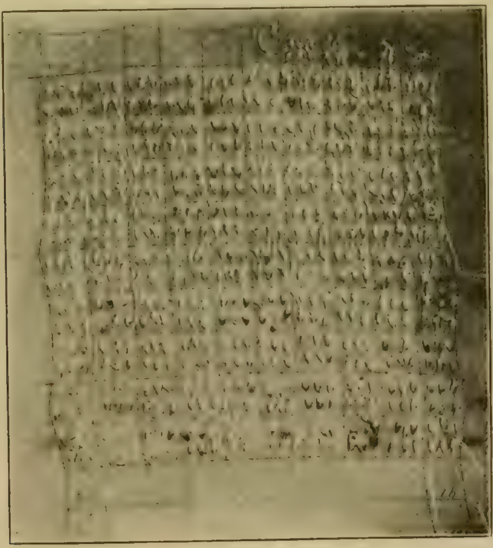


Fig. 50.
A BAD TEST.
Many kernels have rotted in the box, others have sent out weak and dwarfed sprouts.

"I used boxes 3x4 feet that held 4 1-2 bushels or 358 ears. There were eight of these boxes, with four and one-half yards of muslin to the box. Sawdust free.

Muslin, 35 yards at 9 cents	$ 3.15
Time to get boxes ready, 4 hours at 15 cents	.60
Cost of filling box with kernels, 3 hours per box, and 8 boxes 24 hours at 15 cents	3.60
Oil to furnish heat, one gallon per day at 12 cents (Time to germinate, 10 days)	1.20
Time to take off test, 10 hours at 15 cents	1.50
Total	$10.05

Thirty-six bushels	$10.05
One bushel, almost	.28"

(2) "Your letter at hand in regard to the cost of testing seed corn on a commercial scale; and in reply will say that I estimate that it costs me $1.00 per bushel to test corn. This includes everything, heat, labor, the cost of handling the extra corn which you have to throw out, etc."

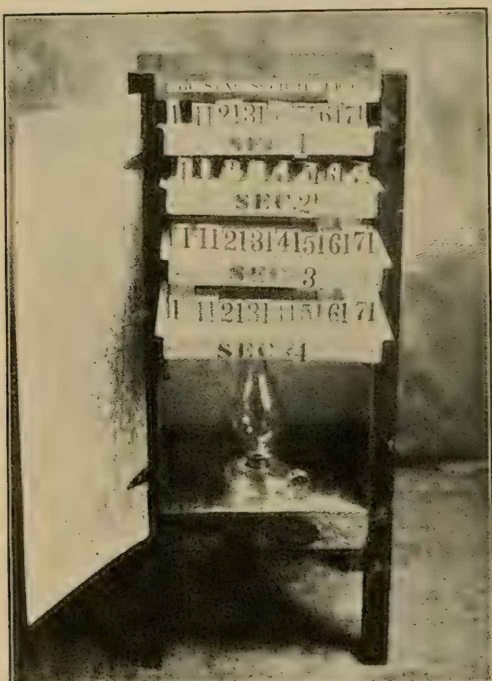


Fig. 51.

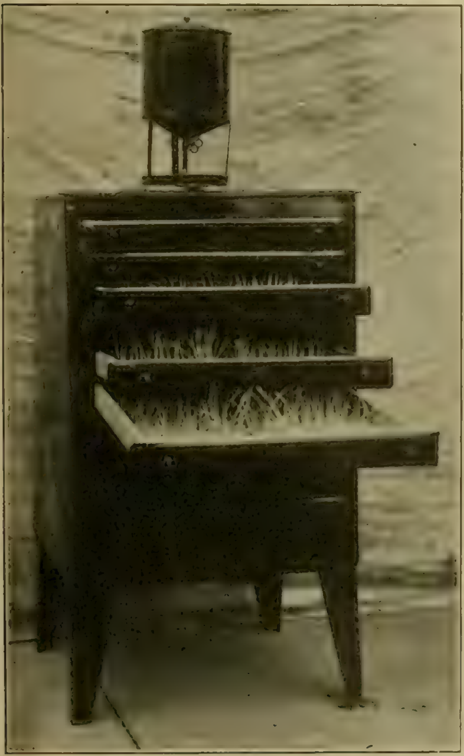
A PATENT TESTER WHICH HAS THE GOOD QUALITY OF SEPARATING THE KERNELS OF EACH EAR INTO LITTLE CUPS, WHICH MAY BE SET OUT IN FRONT OF THE CAR.

It will be noted that these vary considerably. The latter, however, takes account of the amount of corn thrown out for poor vitality. This was a large item the spring of 1908.

Hand Sorting the Graded Shelled Corn. There may be present a limited number of immature and even blackened kernels which were pollinated later than the others. The germination test, of course, did not prove their presence. There will be more or less mice eaten grains and kernels cracked by the sheller. Hence it will pay the smaller grower to have the children sort these out and the larger farmer can economically afford to hire it done. To facilitate this process, a convenient method is to pour the shelled

Removing cracked kernels

corn on the table in a pile. At a little distance below the edge of the table, a drawer may be opened or a bench built. Place two pans at this point. The operator should be seated and can handily sort the discarded kernels into one pan and the desirable ones into the other. This process is more rapid than usually considered. Allowing the shelled corn to roll down an incline to the operator will save time.



(Courtesy Adams Seed Co., Decorah, Ia.)
Fig. 52.
STANDARD SEED CORN TESTER.
Shows method of heating uniformly. Moisture maintained easily.

CALIBRATING THE PLANTER. The corn planter should now be set up in good order, ready for calibration. This may be done on the barn floor or, if the weather permits, outside on the dry earth. A separate pair of planter plates must be selected for the planting of each grade of corn. Prop the planter up so that it will be free from the floor. It is necessary to use but one side in calibrating, unless it becomes necessary to file the plates. This is not to be advised, as it may take considerable time, and other plates can be purchased. The wheel can now be turned by hand with little effort and at the same time a record taken of the rate of dropping. It is well to have two working at this—one to turn the wheel and the other to keep record. The first set of plates may not drop more than 65 per cent of a perfect drop. That is, if three kernels be taken as the required number, the plates may only plant three kernels 65 times out of 100.

Another set of plates may have to be tried. This should be continued until a drop of over 90 per cent is secured. Planter boxes with **Change plates** hinges are very convenient for the transition in these tests. The edge drop planter has come into very general use. It takes into account the thickness of the kernel and drops one at a time until the required number have accumulated, then the check wires free them to

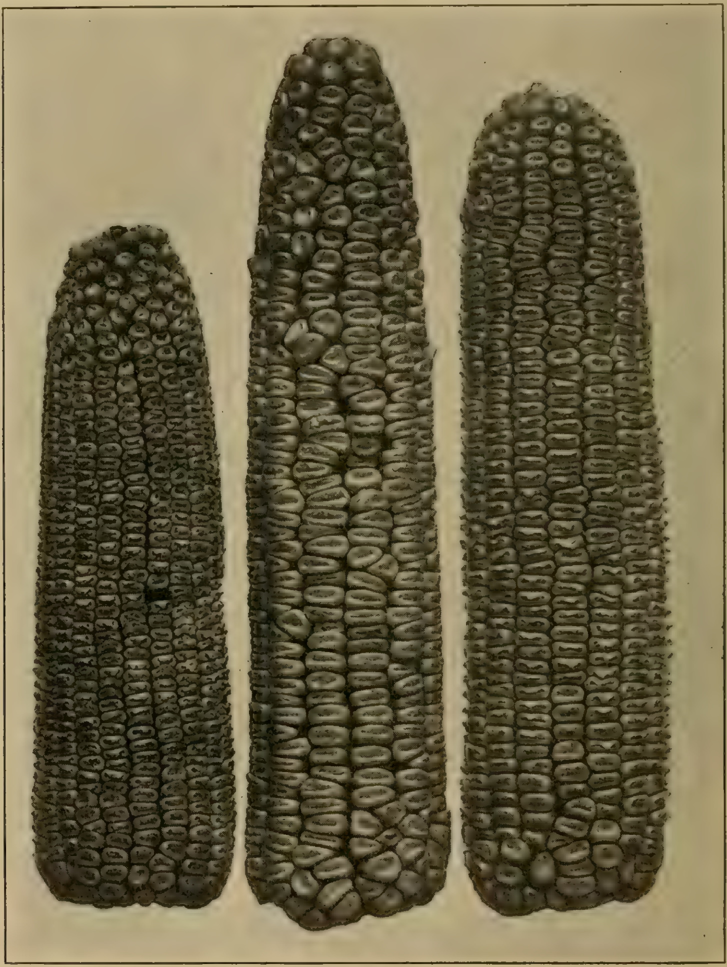
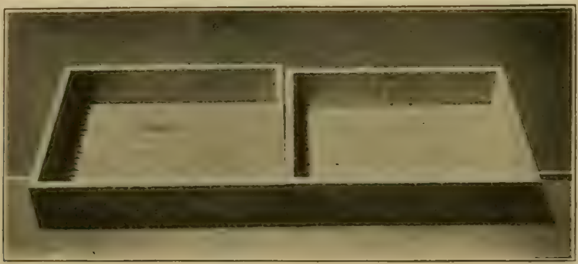


Fig. 53.

THREE TYPES OF KERNELS WHICH WHEN SHELLED TOGETHER CANNOT BE EXPECTED TO BE DROPPED ACCURATELY BY THE ORDINARY PLANTER.

gether. For the farmer who grades his corn thoroughly and tests his planter each year, the edge drop will do more accurate work. On the other hand, where the undesirable practice is followed of planting all sizes of kernels with the same plate, the round hole plate will come nearer planting uniformly under all conditions. By calibrating the planter, the accuracy of drop has been increased in some cases as

Accuracy of drop can be increased



(Courtesy Agricultural Engineering Department of the Iowa State College.)

Fig. 54.

HAND-SHAKE CORN SORTER.

Very rapid and efficient sorting can be done in a small way with this device.

much as 19 per cent, by simply filing the holes until the kernels dropped through more uniformly. Tests of 72 per cent have been raised to 85 per cent; 42 to 61; 74.6 to 89.8. Of 178 correspondents

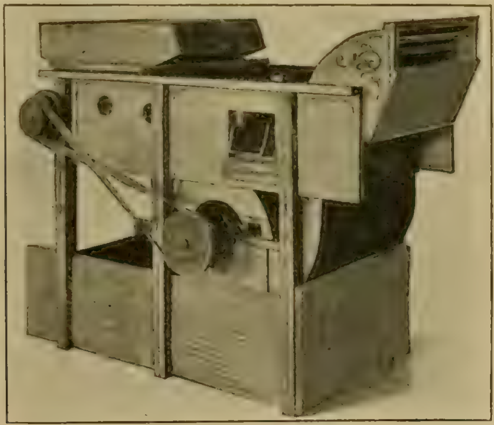


Fig. 55.

A GRAIN CLEANER WHICH HAS A CORN GRADING ATTACHMENT.

This does away with buying two machines.

replying to inquiries of the Farm Crops Department, 153 replied affirmatively in regard to calibrating and testing the drop of their planters.

The planter should be calibrated for each of the three grades. The corn should then be sacked and the planter plates tied with the sack. Where different varieties are to be planted by the same machine, oftentimes the medium plates for one variety will plant the large kernels of another.

THE CORN GROWERS REMINDER

Remember.

1. That home-grown seed is the surest.
2. To harvest the seed corn before the first killing frost.
3. To hang it up in a well ventilated place.
4. That corn full of moisture is liable to freeze and thus lose its vitality.
5. To store seed in warm place during extremely cold weather.
6. To make a germination box during the winter.
7. To test each ear of seed corn during the month of March.
8. To grade the tested seed.
9. To calibrate the corn planter to drop the graded seed.
10. That poor seed is the chief cause of poor stand.
11. That a poor stand means a small yield.

ACKNOWLEDGEMENTS

Professor P. G. Holden is to be accredited with many valuable pointers in this chapter. It is the outcome of the rapid evolution of methods adopted by the Iowa State College.

The Extension Department of the Iowa State College, has very kindly placed at our disposal much data of a state-wide nature covering tests under varying conditions.

We owe much also to the corn growers who co-operated with us in furnishing first-hand material.

COLLATERAL READING

Selection of Seed Corn,
Farmers' Bulletin No. 193.
Corn Improvement,
Indiana Bulletin No. 110.
Seed Selection According to Specific Gravity,
New York (Geneva) Bulletin No. 256.
Seed Grain,
Minnesota Bulletin No. 24 (Press).

Corn Culture,
Georgia Bulletin No. 65.
Increasing the Yield of Corn,
Tennessee Bulletin No. 2.
Seed Corn Buying and Judging,
Farmers' Bulletin No. 225.
Seed Corn, Selection and Preparation,
Iowa Bulletin No. 77.
The Improvement of Corn,
Pennsylvania Bulletin No. 133.
Corn Improvement for Missouri,
Missouri Bulletin No. 59.
Selection of Seed Corn,
Iowa Bulletin No. 68.
Handling Seed Corn,
Farmers' Bulletin No. 244.
A Study of Delaware Seed Corn,
Delaware Bulletin No. 77.
Seed Corn, Better Grades of,
Page 34 of U. S. Report No. 83.
The Testing of Corn for Seed,
Illinois Bulletin No. 96.
A Test of the Vitality of Seed Corn,
Illinois Circular No. 49.
Selecting Seed Corn,
Florida Bulletin No. 46.
A. B. C. of Corn Culture,
Professor P. G. Holden.
Corn Experiments,
Kentucky Bulletin No. 26.
Corn Experiments,
Kentucky Bulletin No. 33.
Indian Corn,
Kansas Bulletin No. 147.
Seed Corn, Testing of for Vitality,
Kansas Bulletin No. 136.
Selection of Seed Corn, Method and Time,
Idaho Bulletin No. 57.
Seed Corn,
Farmers' Bulletin No. 272.

CHAPTER VII.

CARE OF THE CORN CROP

PREPARING THE GROUND AND PLANTING

1. PREPARATION OF THE GROUND BEFORE PLOWING.

2. PLOWING THE GROUND.

   A. Objects of Plowing.
   B. Points of Merit in Plowing.
   C. Depth of Plowing.
      (1) Deep Plowing.
      (2) Shallow Plowing.
   D. Fall Plowing.
   E. Spring Plowing.
   F. Plowing Sod.

3. TREATMENT OF PLOWED GROUND BEFORE PLANTING.

   A. Disc.
   B. Special Harrows.
   C. Smoothing Harrow.
   D. Rolling.

4. PLANTING WITH CHECK ROWER.

   A. Time of Planting.
   B. Depth of Planting.
   C. Distance Between Rows.
   D. Number of Stalks Per Hill.
   E. What is a Perfect Stand?
   F. Replanting of Corn.

5. DRILLING CORN.

6. LISTING.

   A. Preparing the Ground.
   B. Use of the Lister.

PREPARATION OF THE GROUND BEFORE PLOWING.

Small grain stubble land which is to be plowed in the fall should be disced thoroughly immediately after the grain shocks are removed. The surface will dry out less and the weeds will receive quite a setback. The moisture which would have been evaporated from the surface will be stopped in its upward passage just beneath the sub surface strata. The soil will remain loose and when plowed later will not turn up in lumps. Where the ground is low and sub-

Freezing disintegrates the soil

Fig. 56.
HEAVY CORN STALK RAKE.
Stirs the ground more and will work where the hay rake is too light.

ject to overflow, often weeds grow so rank after harvest as to necessitate their being mowed before any plowing is done. In localities which practice the short rotation of corn and oats or corn and wheat. the stubble is often covered with barnyard manure before plowing. The heat and moisture of autumn and the freezing of winter disintegrate the soil and decompose the straw and other material to such an extent that by planting time the following spring the humus thus added is thoroughly mixed with the soil.

Raking corn stalks

The rolling uplands in southern Iowa lack very much in humus, hence the stalks should always be incorporated in the already sticky silty soil. Corn planted the first year following sod, may produce such an excessive growth of stalks as to make raking necessary.

Where corn is cut for silage the stubble may be split up and the rows leveled to advantage by discing before plowing. Land upon which fodder shocks have stood all winter is better treated thus also. But the greater number of fields in the corn belt are stocked with cattle during the winter and when spring comes the bare stalks remain

Reasons for burning corn stalks

standing. A railroad iron or heavy harrow is usually used to drag them down. The practice of raking them up with a hay rake or heavy corn-stalk rake is less in vogue at present because the soil requires humus and fertilizing materials. Yet a very heavy crop may require the disposition of the bulk of the stalks by burning. The

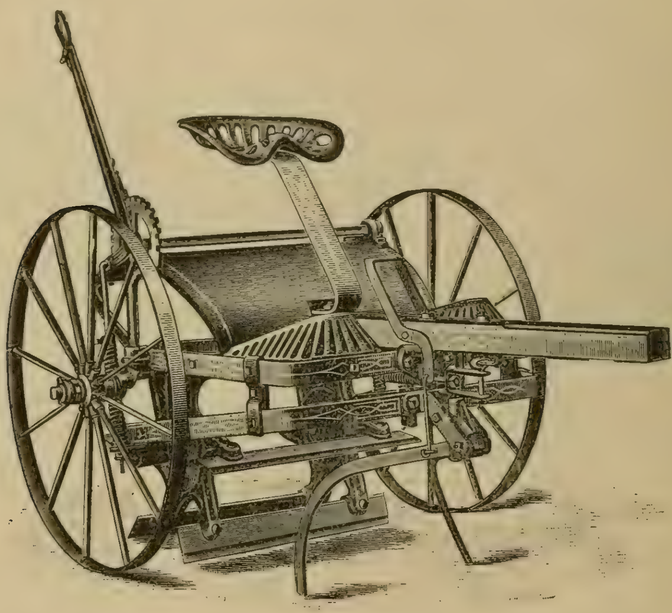


Fig. 57.

SINGLE ROW STALK CUTTER.

The stalk cutter can be used early in the spring before the field is dry enough to disc. The hooks in front straighten out the stalks lengthwise with the row.

chief arguments advanced in favor of burning corn stalks are: first, the freeing of the surface soil of trash which would otherwise prevent the planter from running at a uniform depth, and may even at times cause the deposition of kernels on the surface; and second, the partly covered stalks catch in the shovels of the cultivator the first time over and dislodge whole hills of corn.

Corn stalk cutter

The single-row stalk cutter is little used at present because, except for cutting the stalks, it does very little toward loosening the surface of the soil. Its only claims of practical value are: first, the fact that being of light draft, it can be used early when the ground is not yet dry enough for heavier tools; and second, a boy can operate it.

Since the implement companies have put out double-row cutters, drawn by three horses, the single-row cutters have largely fallen into disuse.

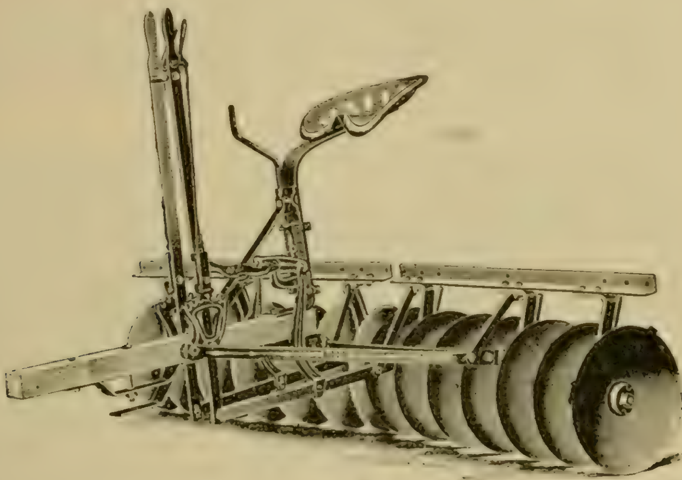


Fig. 59.
FULL DISC HARROW.
The most commonly used in Iowa.

Stalk fields are now usually disced in the spring before plowing. By so doing, the surface soil is loosened and a dust mulch thereby secured which accomplishes three things: First, the surface openings of the capillary tubes are broken. This not only preventing the loss

Three uses of the dust mulch

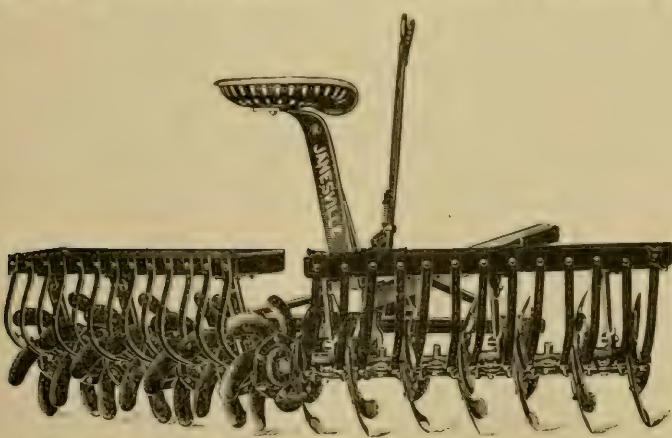


Fig. 60.
SPADING DISC HARROW.
When set at an angle it will cut stalks completely. In sod the pieces of turf are thrown about, but not cut up.

of moisture, but that moisture which does rise is held just below the surface; Second, this moisture being present keeps the soil from drying out, and when turned over by the mold board the soil crumbles and falls into the furrow loosely. Third, the surface which has been previously fined now becomes the bottom of the furrow slice, which because of its texture reunites with the severed capillary tubes, thus re-establishing the course of the moisture upward.

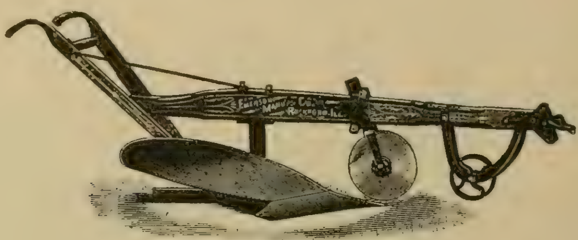


Fig. 61.
BREAKING PLOW.
Used in plowing sod. Notice that the moldboard is very sloping.

Weeds in spring injure the physical condition of the soil

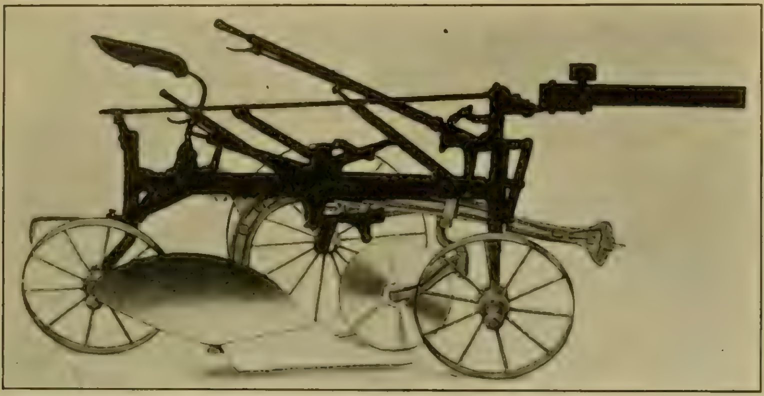
Weeds and grass allowed to grow up in corn-stalk land in spring, before plowing are first injurious to the physical condition of the soil because they compact and harden the surface, which in turn allows the rapid evaporation of moisture. When this green mat is turned under later, it acts as a partition between the furrow slice and the bottom of the furrow. Second, weeds also utilize a large amount of available plant food, which is always scarce in spring-plowed ground, and at the same time the decaying green material renders the soil more or less acid. Rotting green manure requires a great deal of moisture which must necessarily be drawn from the surface soil. Often the furrow slice becomes very dry within a few days.

Discing corn stalks

Two methods of discing are practiced. By one, the field is disced with the stalks standing. In such cases, the disc is driven at an angle to the rows across the field. The ridges are leveled and the stalks cut to pieces. The other plan, the one usually practiced, is to harrow or drag the stalks down and then disc them crosswise of the row: that is, crosswise of the way the stalks are laying. In case of heavy stalks, the discs, even if very heavy and sharp, will often ride over if they are piled deeply between the rows. The advantage of the first method is becoming apparent to many.

Discing sod land in the fall, when it is to be plowed immediately, is of little service. At that time the disc will not cut deeply because the ground is so dry. The freezing and thawing of winter and spring have time to disintegrate the layers. Experience has shown that the rougher such sod turns up, the greater will be this erosion because of the lodgment of snow and the openness which admits the entrance of rain. In plowing sod in a short rotation, where a large crop of le-

Use a weed-hook in case of heavy stalks



(Courtesy Janesville Machine Co.)

Fig. 62.
SULKY PLOW.
Used in plowing both sod and stubble. Being heavy and having a rolling coulter in front, this plow will operate even where considerable trash is on the ground.

gumes or grass is on the surface, a "weed-hook" should be used in order to drag everything into the furrow to insure complete covering. This is essential for proper decomposition.

Where sod is to be plowed in the spring, a thorough discing just when the frost is out two or three inches, will tear up the surface layer and allow the furrow slice to break over like stubble ground.

Disc sod before it is to be plowed in the spring

When such a short time remains in which to rot the surface turf and reconnect the capillary tubes, it is essential that the underside of the surface slice not only lay closely to the bottom of the furrow, but that such surface be of fine texture. The disc also disturbs and destroys many hibernating injurious insects.

PLOWING THE GROUND.—The Objects of Plowing Are: To alter the texture of the soil to a considerable depth, and to bury completely any vegetation or other organic matter on the surface of the ground. It is essential that any legume, grass or stubble on the surface be turned completely under. Live stock farmers usually apply manure to land just before plowing for corn, in order to get the most out of it in the "money crop." The complete burial of this material is desirable.

Corn is the money crop

(Courtesy Janesville Machine Co.)

Fig. 63.

GANG PLOW IN OPERATION.

Plows two furrows at a time. There are also plows with three or more mold boards.

First, such organic matter, if present in large quantities, may be in the way of cultivation.

Second, partial covering of easily or partly decomposed material. especially in loose and sandy soils, causes a loss of plant food. The extreme porosity of the seed bed also makes it difficult for the roots to spread.

The Points of Merit in Plowing. A straight furrow of uniform width and depth. The farmers of England and Scotland encourage their sons to take pride in a clean furrow. To many western Americans, such intelligent interest seems foolish, the real point of merit with them being to get over the ground as rapidly as possible. A number of localities in Indiana and Ohio have within the last few

Plowing matches

years held plowing matches which have shown the skill of the younger lads of the community. At Wick and Cherokee, Iowa, similar contests are carried on each year, at which time speakers from a distance are invited to speak and a day is set aside for a local picnic and educational outing.

A clean-cut slice both on its land side and floor. Beside indicating pride and interest in plowing, a clean land side and a consistent floor of even width and depth insures a complete alteration of texture. In-

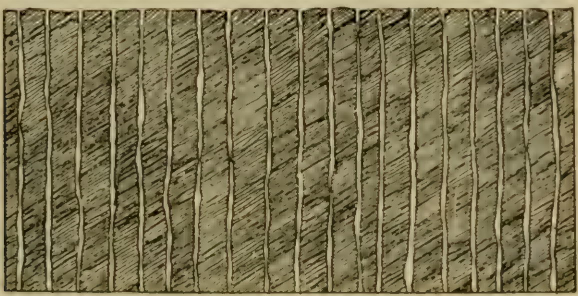


Fig. 64.
DIAGRAM SHOWING THE DIRECTION OF THE CAPILLARY TUBES AND TEXTURE OF THE SOIL EARLY IN THE SPRING AFTER THE SURFACE HAS DRIED OUT AND NO CULTIVATION HAS BEEN DONE.

The tubes extend to the surface and convey the moisture from below to their upper extremities, where it is discharged and carried away by evaporation due to the sun and the velocity of the wind.

stead of the furrow slice being completely inverted it should be left more or less on edge in order to permit the most effective action of weathering agencies and of implements in the preparation of the seed bed.

Uniformly plowed ridges. Where a small plow follows a larger one, often the ridges are very uneven. More surface is exposed for drying out, and, as a rule, the trash is not well covered. Fully twice as much work is required to get such a field in shape for the corn planter. This uneven ridging sometimes occurs on hillsides, in which case it cannot be prevented.

Complete burial of the grass or stubble is also important.

Depth of Plowing. This is a question that cannot be answered definitely, but must be considered in connection with the character of the soil, the time of the season, the climate, and the purpose to which the ground is to be put.

Plow more deeply in rich soils

Deep plowing. For a deep, rich soil, deep plowing is very generally considered best if done in the fall. Fred McCulloch, of Hartwick, Iowa, found in 1904 that fewer weeds appeared in the corn field which was plowed in the spring five inches deep than in the one plowed three inches in depth. For thin clay soils, sub-soiling is better than very deep plowing, because it does not turn the compact clay to the surface, yet at the same time it loosens the soil to a considerable depth. Plowing should not be of the same depth from year to year, for as by so doing the soil is not mixed well and a hard surface is left at the bottom of the furrow where the horses walk and the plow drags. A little sub-soil turned to the surface occasionally will be acted upon by the atmospheric elements and plant food liberated. As it becomes mixed with the surface soil and vegetable growth, the depth of surface soil will be increased. A compact soil is less pervious to air and moisture, and if organic matter is covered too deeply it will not decay for some time on that account. In general, to accomplish the most desirable results, it is advisable to plow a little deeper each season for several successive seasons, and then for one season give a plowing at about half of the depth of the deepest plowing. It is well to have the farm mapped, the various fields numbered and records kept of the annual treatment and production of each field.

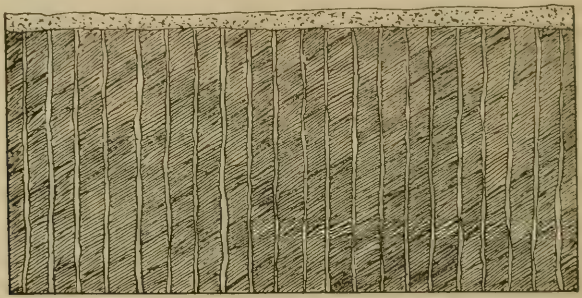


Fig. 65.
DIAGRAM SHOWING THE SURFACE SOIL STIRRED SLIGHTLY AND A MULCH ESTABLISHED.
This is brought about by discing corn stalk ground early in the spring. The moisture rising from below is not allowed to escape, but is checked in its upward course, just below this mulch.

A compact soil is impervious to air

Plow shallow in spring

Shallow plowing. Shallow plowing is not practiced in the fall in the corn belt, but is customary in the spring because the deeper the plowing the greater is the amount of labor required to re-establish the capillary connection with the sub-soil. This labor is performed by Nature when plowing is done in the fall, while much discing, harrowing, and even rolling is often necessary to rectify the severing of capillary connection in the spring. This capillarity is not re-established so readily with deep plowing as when the plowing is shallow

Plowing breaks up the capillary connection with the sub-soil. which must in turn be re-established or vigorous plant growth is impossible. Deep spring plowing and spring sub-soiling are likely to result in diminished crops, especially if done after the spring rains The loosening of the soil to great depths admits air and facilitates the loss of soil moisture. It also interrupts capillarity so that the moisture is not readily drawn from greater depths.

Capillarity must be reestablished before crops can grow well on a soil

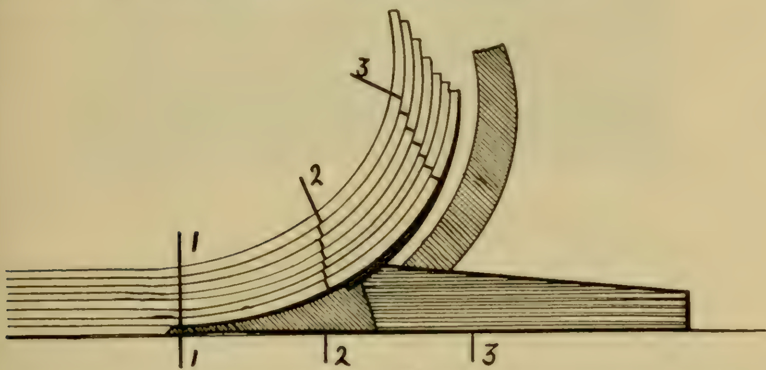


Fig. 66.

DIAGRAM SHOWING THE EFFECT OF THE MOLD BOARD UPON THE CAPILLARY TUBES IN THE SOIL.

The layers of soil by gliding over each other break off the tubes. The more abrupt the mold board the greater the amount of crumbling of the furrow-slice.

Fall Plowing. Fall plowing is not considered advisable in the south, where the winters are very mild, accompanied with little or no cold weather. In Illinois, Iowa, Minnesota and Nebraska, the temperature becomes low and the weather is so variable as to cause considerable heaving of the surface. Freezing disintegrates the soil, and the mellowing of the furrow slice allows the nitrifying bacteria to begin action early in the spring. Weedy areas are plowed in the fall to check the growth and bury the immature seeds. In fact, many consider this the only object of fall plowing. Wherever a crop whether a crop of weeds or of fall forage, grows late in the fall, the following corn crop is slow in starting. That is, the available plant food was drawn upon until cold weather set in, thus not allowing the formation of soluble compounds during the warm weather of the autumn months. In the rougher corn sections, fall plowed fields wash so badly and ditches form so quickly that the practice should be discontinued. This is especially true of soils which have been depleted of their humus. There being no organic matter present to retain the moisture and hold the particles of soil, the whole mass slumps away and is carried to lower levels. Such conditions have compelled corn growers in these localities to rotate, and in some cases to even sow the fields to grass permanently.

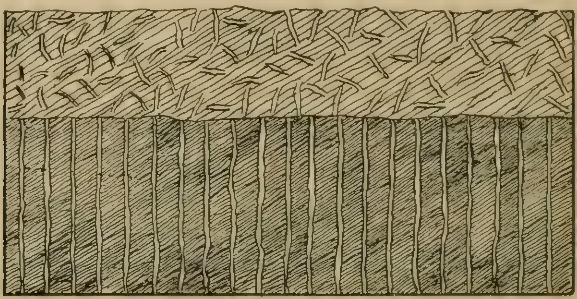


Fig. 67.

DIAGRAM SHOWING THE POSITION OF THE CAPILLARY TUBES AFTER A FIELD HAS BEEN PLOWED TO A DEPTH OF 4 TO 6 INCHES.

As the furrow-slice is turned they are broken. Hence the moisture from below is checked in its upward current just below the bottom of the furrow. Hence plants germinating near the surface are cut off from all supply beneath. This is why corn on spring plowed ground starts slowly in the early part of the season.

Fall plowing should be more generally practiced

Fall plowing cannot be recommended for all climates and localities, but should be more generally practiced than at present. If a cover crop or sod be turned under in the fall, decomposition will

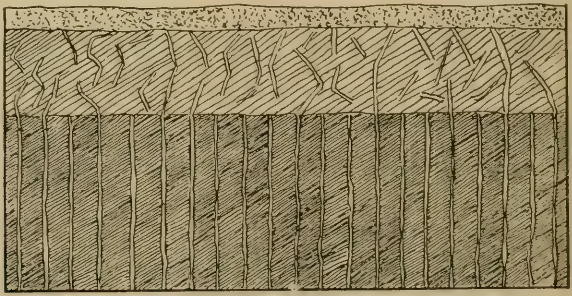


Fig. 68.

DIAGRAM SHOWING WHAT EFFECT DISCING, HARROWING AND ROLLING HAS UPON THE PLOWED FIELD.

Of course the surface is made much finer. But the disc reaches down to greater depths and begins to settle the loose earth upon the furrow-bottom. The packing gradually re-establishes the capillary connection. The fact that spring plowing requires some time during the early part of the season to accomplish this process tends to hold the moisture of the soil until later in the summer when it is most needed.

increase the amount of plant food available for the crop the next summer. This is true to some extent even though the crop is not turned under, inasmuch as the simple loosening of the sod admits atmospheric oxygen and increases chemical action upon vegetable and mineral matter. Fall plowing is one of the methods of combatting grub worms, cut worms and wire worms, which are often destructive to corn. Because the surface of soil plowed in the fall is dryer at planting time in the spring than that of the ground not so treated, it does not necessarily follow that there is less moisture in fall plowed land

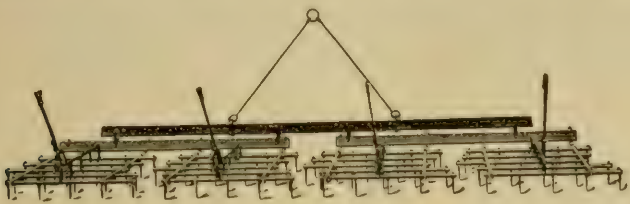
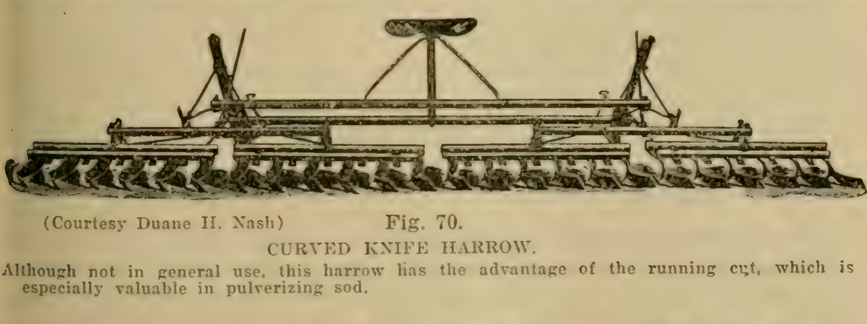


Fig. 69.
FOUR SECTION, 100 TOOTH, 20 FOOT SMOOTHING HARROW.
The teeth are adjustable by the use of the levers.

In fact, fall plowed ground should contain more moisture for the growing crop the following season than that land plowed in the spring. With fall plowing the rain and moisture may better penetrate the sub-soil. Because of the rough surface much moisture is held which might otherwise be lost. Not infrequently poor management of fall plowed ground causes in the spring a very serious loss of moisture. Ground plowed in the fall should be thoroughly disced early the following spring to prevent heavy loss of moisture by evaporation When the ground is left in a rough condition not only will the stirred portion of the soil be readily acted upon and dried out by the winds and sun of early spring, but there is ready access to the sub-soil as

Well managed fall plowed ground contains more moisture



(Courtesy Duane H. Nash) Fig. 70.
CURVED KNIFE HARROW.
Although not in general use, this harrow has the advantage of the running cut, which is especially valuable in pulverizing sod.

well. Fall plowed land which has been thus neglected may be expected to contain less moisture than had the ground been plowed in the spring. By the use of the disc and harrow in early spring on fall plowed ground, a surface mulch can be established which will prevent this excess evaporation and insure to the farmer a greater amount of moisture in the soil for the following crop than had the land been plowed in the spring. Fall plowed ground properly cared for in the spring may be expected to mature a crop of corn a little earlier than will the spring plowing, and in case of a dry season there will be much less damage from drought.

Fall plowing matures crops earlier

Spring Plowing. Fields which have been in corn the previous year, must, according to the common practice of husking in the field

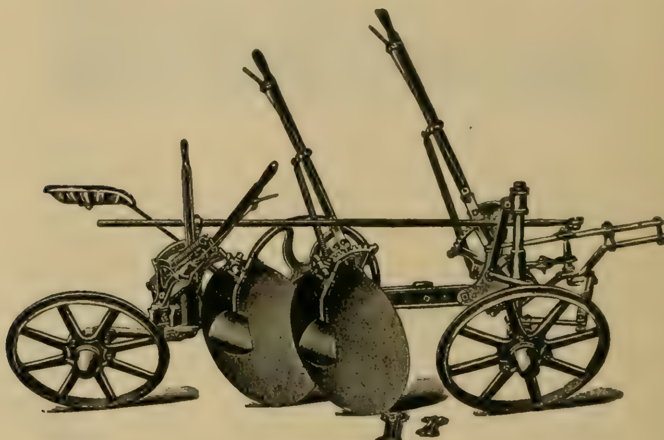


Fig. 71.
DISC PLOW.
Used in low wet ground where a mold board plow would not scour.

and allowing stock to forage among the stalks during the winter, be plowed in the spring. Just how early this can be done depends to a large extent upon, first, the weather during April and May. Excessive rainfall and a lack of sunshine will prevent plowing even on well drained fields. As long as the bottom of the furrow slice turns up slick and the particles of soil run together rather than crumble, plowing had better be postponed. Such a surface will bake immediately in the sun and the clods thus formed will sometimes remain unchanged during the entire season. Second, the lay of the land. Fields sloping to the north are sometimes ten to 14 days later in drying out in the spring than are similar areas facing the south. Low areas underlaid with an impervious clay often require the warm winds of May to evaporate the surface moisture sufficiently to admit of plowing. Third, the amount of available labor. Where large areas are to be plowed, although the teams are started early in the season it is

Conditions of early plowing

sometimes late before all the furrows are turned. The sowing of large areas of small grain also often prevents early plowing. Not many years since, it was a common idea to allow fields to grow up to weeds which were turned under, with the supposition that so many enemies had been destroyed for the crop of the season. Thinking farmers have found that it is the weed seeds which are turned up from the bottom of the furrow slice which do the most damage. These should be brought to the surface early in the spring in order that they may be destroyed before planting time. Early plowing also admits of more thorough preparation of the seed bed just before planting.

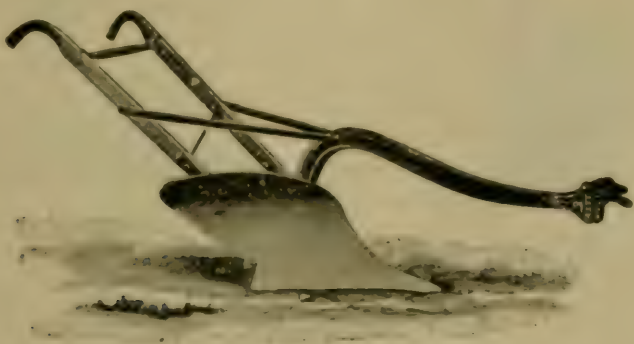


Fig. 72.
GENERAL PURPOSE PLOW.
Mold board is set at sufficient angle to allow the use of this plow in sod or stubble.

The time of plowing land which was in corn the previous year is here shown for different localities of Iowa in 1908. Time of plowing in Iowa

COUNTY	TOWN	TIME OF PLOWING	
		Week	Month
Sioux	Hawarden	First	May
Allamakee	Waukon	First	May
Mills	Glenwood	Third	April
Dallas	Dallas Center	Fourth	April
Page	Blanchard	Second	April

Plowing Sod. The virgin sod land of the corn belt is rapidly becoming a thing of the past. A study of statistics of wild hay meadow shows a steady decrease in production. In such land the breaking plow is used to some extent in peeling back a shallow furrow in the fall, a deeper plowing to follow in the spring. Little alteration of texture can be brought about in turning the virgin prairie sod.

First, the heavy draft due to the obstinate turf produced by the roots of prairie grasses, and second, the fact that considerable time is needed to decompose such turf, requires that it be plowed in the fall, thus allowing the freezing to break up the furrow slice. The closer the furrow slices are laid together, the greater the retention of moisture and consequent heaving. Because the roots fill the surface layer of soil so full of humus and undecayed organic matter that cultipation of the crop is difficult the first year, the mat of grasses on the surface is usually burned before plowing. In such cases, the practice is warranted because the sod is slow in reconnecting the capillary tubes and "firing" of the corn often results during the summer because of this condition.

Flowing prairie sod

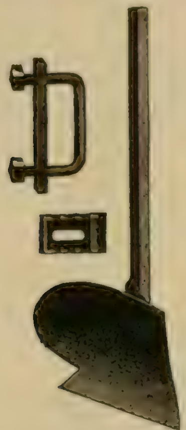
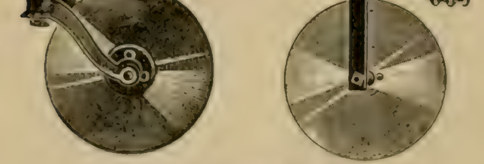


Fig. 73.
(Courtesy B. F. Avery & Sons)
STEEL JOINTER.
Used to tear up stiff sod just in front of the mold board.

Because of the newness of this soil and the large amount of plant food which is available early in the season, flax is largely used for the first year's crop, especially in the northern districts. In the southern part of Iowa, the northern part of Missouri, and over a large part of Kansas, winter wheat is often sownthe first year.

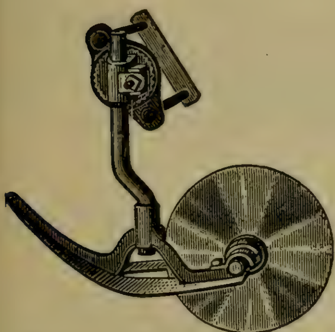


(Courtesy B. F. Avery & Sons)
Fig. 74.
TYPES OF ROLLING COULTERS.

Rotation of crops has now come to be a permanent factor in improved farming. Clover and timothy meadow, because of a short rotation in which corn is the heavy yielder and money crop, hardly ever becomes really sodded. Furthermore, because corn follows them directly and is expected to produce heavily the first season, a greater amount of alteration in structure in the sod is desired. Hence a plow with steeper mold board is used. Plowing pasture lands and meadows in the fall has five distinct advantages. In the first place, the work can be done at a more slack time. Second, the freezing and thawing of the winter months alters the physical texture of the soil.

A large amount of alteration of texture of soil required

Third, the decomposition of the turned under organic matter renders plenty of plant food available for the use of the young corn plant in early spring. Fourth, capillary connection is re-established not only because of the changed texture of the soil, but also because the turf rots away. Fifth, the hibernating quarters of many injurious insects are disturbed and destroyed. Some, such as the army worm, are turned under so deeply as to bury the pupa completely.



(Courtesy B. F. Avery & Sons)
Fig. 75.
ROLLING COULTER WITH SHOE IN FRONT WHICH PREVENTS EXCESSIVE TRASH FROM LODGING ABOVE THE COULTER WITHOUT BEING CUT.

If sod is plowed in the spring, it should be done early.

Why plow sod early

First, the rush of farm work requires it. There will be plenty of corn-stalk land which canot be plowed until later because of being so wet. Wet sod, although it turn up slick on the bottom of the furrow slice, will not bake and become cloddy because of the presence of such an abundance of humus.

Second, there is but a short time at best in which to re-establish the capillary connection. This is best accomplished by early plowing, for when the sod is full of moisture it breaks up as it falls over and the turf has time to decay.

Third, the sod has lost no moisture because of the growth of spring grasses. Such grass, if allowed to grow until later, not only uses moisture and available plant food, but in itself is a menace, because it lays in the bottom of the furrow and prevents the rise of moisture from below.

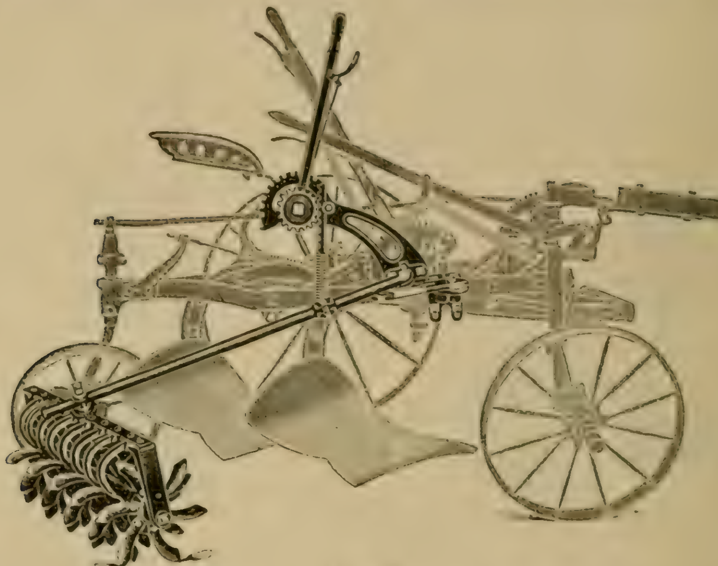
Time of plowing sod in Iowa

To show the time of plowing sod in different parts of Iowa under varying soil conditions, as well as a difference in latitude, the following table is given for 1908.

COUNTY	TOWN	TIME OF PLOWING Week	Month
Sioux	Hawarden	Third and Fourth	April
Allamakee	Waukon	Second	April
Mills	Glenwood	Third	March
Dallas	Dallas Center	First	April
Page	Blanchard	First	April

TREATMENT OF THE GROUND BEFORE PLANTING.

Much stress has been laid upon the question of having a proper seed bed for corn. There is no question but that corn well put in is already half tended. The definition of the ideal conditions which can some years almost be reached are, first, soil of such physical condition that the smaller particles are compacted closely around the seed. This in-



(Courtesy Kramer) Fig. 76.
ROTARY DISC ATTACHED TO PLOW.
Because it pulverizes the soil right off the mold board there is no chance for the formation of clods.

An ideal seed bed sures perfect germination of viable seeds. Second. There should also be plenty of available plant food. This is dependent upon air and

(Courtesy J. W. Dunham & Son) Fig. 77.
SMOOTH STEEL ROLLER.

moisture as well as bacteria. Third. Freedom from weed seeds.

With the Disc. Experience and experiments have proved the value of the disc. The agricultural press has been urging the corn growers to use it freely. Because the blades cut deeply into the newly turned-up mold, the spaces between the larger lumps of earth are reduced and the whole mass settles down more closely to the subsoil. **Discs**

The full-bladed disc harrow for the general purpose of pulverizing and loosening the ground is the best tool yet devised. It has the advantage of being suitable for use on either sod, stubble or corn stalk lands. **Full-bladed**

The cutaway and spading discs are also used in a more limited way, the former being adapted for cultivating hay lands, the latter more especially for corn stalk ground. **Cutaway Spading**

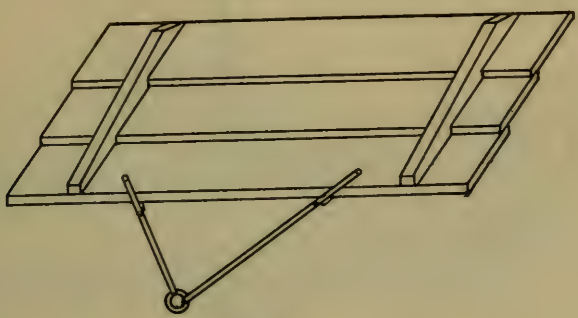


Fig. 78.
PLANKER.
Used in smoothing and packing.

Discing spring plowing is a common practice among the farmers of the corn belt. Often heavy rains run the surface particles together to such an extent that a tooth harrow is incapable of loosening them. Grain stubble which has been plowed the previous fall requires at least two discings before it is in shape to plant.

The disc may be set deeper the first time than the second. Discing both lengthwise and crosswise leaves no surface unturned. Fall-plowed sod should be disced very early in the spring because,

First, the loosening of the surface admits air into the sod to decompose the organic matter, which lies next to the bottom of the furrow. Because of this action, plant food is rendered available. **Reasons for discing fall plowing**

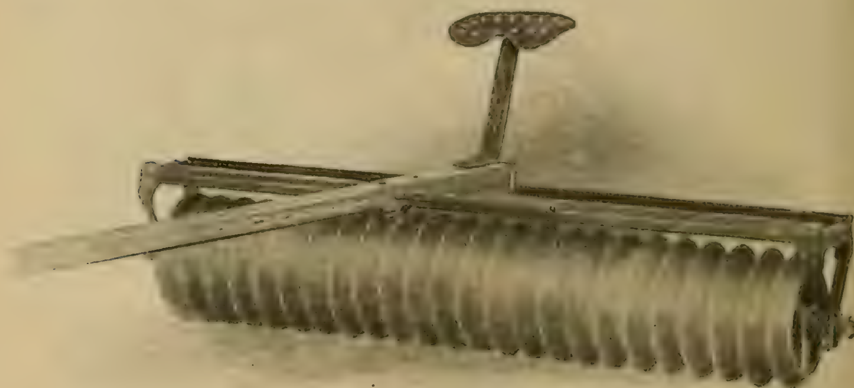
Second. The physical condition of the soil being finer, the whole mass settles more closely upon the sub-soil, reuniting the capillary tubes and conducting moisture from the greater depths to the surface.

Third. Weeds which have started to grow are destroyed.

Fourth. The numerous weed seeds present in the surface soil are induced to germinate because of the admittance of warm air. They can be destroyed later by vigorous harrowing.

Fifth. Helps to form a mulch and thus conserves moisture.

Sod which is not plowed until spring, even though it is turned over as early as the weather permits, depends chiefly upon the disc for preparation. The firing of sod corn in July can usually be traced directly to spring plowing or an insufficient discing of fall plowing. Large pieces of turf admit the air and allow moisture to be taken directly from the sub-soil.



(Courtesy of J. W. Dunham & Son) Fig. 79.
COMBINED PULVERIZER AND PACKER.
Best adapted to grip clods and crush them.

Special Harrows. For stony land, or in timbered sections where the teeth are liable to catch on roots, the spring-tooth harrow has a decided value. The teeth can be set to gouge forward and hence tear up sod more than the fixed tooth harrow. The later manufacturers mount the frame on runners, which does away with bouncing effect common in spring-tooth harrows when set too deep. Some are also mounted on low trucks with the same end in view.

Spring-tooth harrows

Curved knife harrows and drag pulverizers are used to some extent, but where corn stalks are present in any number they ride over them too easily. For fining the surface of a field which has already been well worked, the pulverizer is especially well suited.

Smoothing Harrow. The rigid, straight-toothed harrow does efficient work on ground free from trash. Because of an excess of stalks the slant tooth and lever harrows are more practical and popular.

Large, four-section harrows covering 18 to 22 feet of surface are now largely used even on smaller farms, because of the high price of farm labor. One man and four horses can harrow between 30 and 40 acres in a single day. Because the harrow covers territory so rapidly and leaves the ground in such a good state of tilth, it should be used much more generally. Harrowing produces a finer tilth of the surface and thereby conserves the moisture already in the soil. Large lumps massed together have between them much air space. Such space allows the rain water to percolate to lower depths so rapidly that the growing plant cannot use it. At the same time, the lowering of the water level admits the surface air, which in turn dries out the individual lumps and robs them of their moisture. Roots will not develop in these open spaces, and not finding finer earth through which to extend themselves, soon die from lack of moisture and plant food.

Reasons for harrowing

When plowing in the spring, the newly upturned furrow should never be allowed to remain unharrowed over half a day. By harrowing the ridges will be levelled, clods prevented from forming, and evaporation reduced. To do this, the plowman will have to unhitch from the plow and hitch to the harrow just before the close of each half day. A small section drag drawn by an extra horse at the time of plowing also answers the purpose. A rotary disc in section just wide enough to cover the newly turned furrow, and working automatically, does the pulverizing more thoroughly than any other method. To the farmer in the corn districts of less than 24 inches of rainfall, this matter is important. To the grower in the low, wet districts, where the soil contains a large per cent of humus, the evaporation of excess moisture is desirable.

Harrow each half day's plowing

If the ground be plowed too wet and turns over slick, then a day's drying may be necessary before any harrowing is done. A tooth harrow is of very little use on fall plowing, because the soil has cemented together too firmly. After sod plowing has been thoroughly disced, the use of the harrow produces a finer and more uniform surface.

Plowing wet ground

When desiring to tear up pieces of sod or loosen deeply the surface of a fall plowed field, the harrow teeth should be set straight, or almost so. Where a field is harrowed twice before planting, the teeth should be set at an acute angle. If the surface is of fine tilth, but a little uneven, allowing the harrow to drag over completely flat will do much toward producing an ideal seedbed. In all events, to se-

Setting the harrow teeth

cure an even depth of planting the land should be free from ridges. In order to facilitate planting and to better see the line of the marker, the field should be harrowed crosswise just previous to planting. In sections of little rainfall during the summer months, and in areas where the soil is of a fine, silty nature, it will always pay to again harrow fields which have been previously put in good shape, but have been rained upon heavily before the corn was planted.

Weeds killed when young use very little moisture

The harrow is of especial value as a weed killer. Newly germinated weeds have few roots and are easily torn loose. Furthermore, weeds killed when very young do not draw out the moisture in the soil nor render the available plant food insoluble. The harrow not only destroys weeds sprouting in the ground before the corn is planted, but causes the germination of other seeds which have been dormant because of lack of heat and moisture.

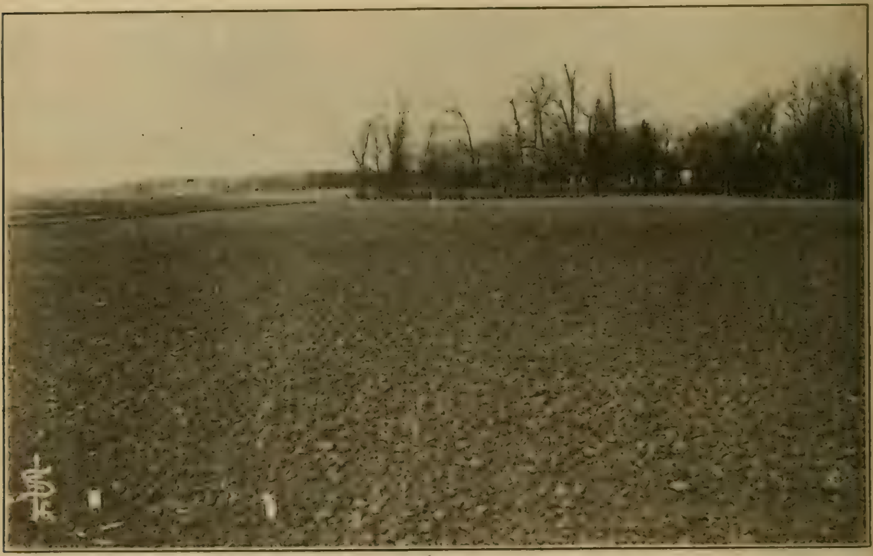


Fig. 80.
FIELD NOT READY FOR PLANTING.
The surface has been allowed to dry out too much before the harrowing was done. The rounded shape of the clods shows that the jostling of the harrow was ineffective in breaking them up because of their dryness.

Rolling. The smooth iron or wood roller is used to produce an even surface and to settle the surface soil upon the sub-soil. Corn ground which has been plowed in the fall, or ground of a silty nature which is spring plowed, does not need rolling before planting. It is usually very compact. But in loose soils of a sandy nature, or porous soils which have just been freshly spring plowed, the roller, if heavy, is valuable in re-establishing the capillarity of the surface soil. In the hands of one who looks upon the roller as an implement for smoothing only, it is often a very unprofitable tool, because, if the surface is left without a light harrowing the evaporation of moisture soon dries out the soil. Establishes the capillarity

Corrugated rollers which leave the surface slightly ridged prevent rapid evaporation of the soil moisture. Corrugated rollers

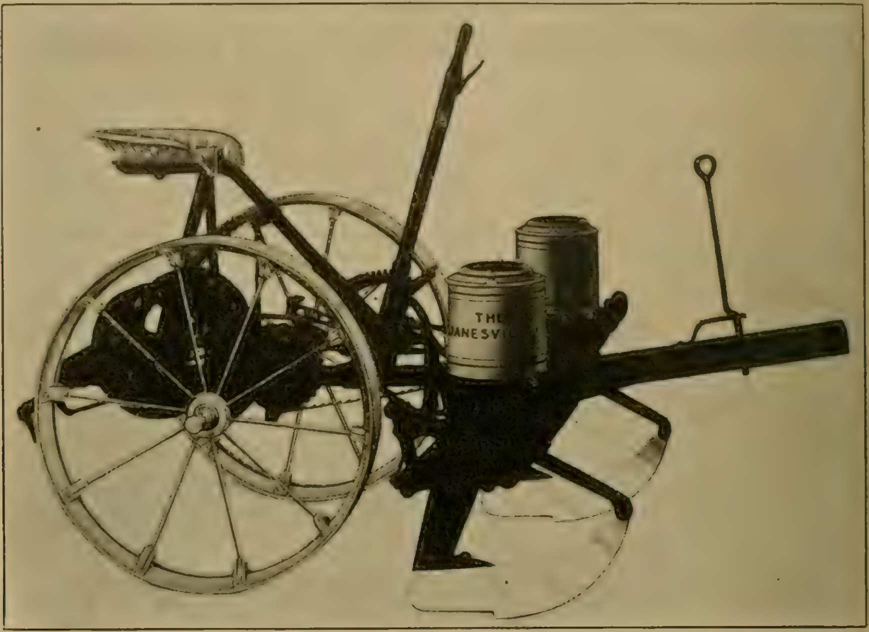
First. The uneven surface reduces the velocity of the wind near the ground.

Second. The dust mulch thus formed breaks off the upward discharge of the capillary tubes. Furthermore, this type of roller also grasps and crushes the larger clods instead of simply burying them unbroken. The sub-surface packer invented by H. W. Campbell to meet the demands of the more arid districts, settles by excessive weight the sub-strata of soil, but leaves the surface loose to conserve the moisture which is present at greater depths. In districts of constant winds of high velocity, this point is essential.

PLANTING WITH CHECK-ROWER. With the growing interest in the selection and breeding of seed corn, together with the endeavor for higher yields, the farmer demands of the corn planter more accuracy of dropping. When tested seed fails to appear and a poor stand results, the planter is usually to blame. For many years the round hole plate has been almost exclusively used. The opening was large enough to hold the total number of kernels for an entire hill. The check wire caused the drop, turning the plate to the next opening with each click of the machine. The one advantage of this planter was the fact that this hole being so large, kernels of varying sizes could be accommodated. Little attention has been paid to the grading of corn until within the last few years. In seeking to secure accuracy, this larger hole was reduced until it admitted but one kernel. More holes were made in the plate, which was continuously turned by the main axle of the planter. This formed a cumulative drop which, when sufficient kernels had been counted out, were checked off by the wire. For growers who produce corn of a uniform type and who grade the seed closely, the edge drop plate has proved of greater accuracy. However, in planting kernels of different lengths the plates must be calibrated closely. Round-hole drop Edge-drop

Every farmer knows the tendency of planters to carry the kernels before dropping, which results in a zigzag appearance of the corn crossways of the field. In purchasing a planter, this factor should be looked into. The valves should work quickly.

[Fur]row-openers The runner furrow-openers which have always been used on corn planters, sometimes fail to give satisfaction on sod land, or in fields which are crowded with trash. The planter will often ride out, leaving the corn uncovered. In an effort to prevent this disc furrow-open-



(Courtesy Janesville Machine Co.) Fig. 81.
CORN PLANTER.
Showing the long curved runner furrow-openers and open wheels.

ers are sometimes attached. The disc also pulverizes the soil in which the kernel is to rest. Except under the conditions mentioned these attachments are unnecessary. Both single and double-disc furrow-openers tend to make the planter harder to guide.

Types of planter wheels On the rougher and more rolling corn lands, the concave planter wheel is used because the fields are harrowed immediately after planting. This practice does away with two disadvantages, features of the concave wheel; the tendency to leave a furrow for washing, and the smooth surface which dries out badly. The open wheel is better for level lands not subject to washing. It has a little more draft, but leaves no flat surface to bake in the sun. The double wheel tends to cover the hill more surely.

Improved methods of culture together with the increasing prevalence of weeds have caused the practice of checking corn to grow in popularity. Of 200 representative farmers from different parts of Iowa, 92 per cent check their corn. The reasons given for so doing were the more effective eradication of the weeds, and in some cases increased yield.

On ground which has been well prepared and which is not too hilly, it is possible for one man to plant 12 to 15 acres per day. The objections raised to checked corn are a greater tendency to blow down in heavy summer winds and the fact that the roots are not so equally distributed throughout the soil. There is practically no difference in the yield per acre between drilled and checked corn, providing there are the same number of plants per acre.

Objections t checked corn

Time of Planting. The best yields and most mature corn are produced by planting corn *early*. Years of experience have proved this fact conclusively. The length of season in a given locality determines the date of planting. In Iowa, corn must be planted as soon as the ground is properly prepared and sufficiently warm, not colder than 55 degrees Fahrenheit. Very little seed is in the ground before May 1st, and the northern counties are even later. On sod land, where the cut worm is quite prevalent, late planting must be practised. As better seed corn is used from year to year, earlier planting will come more into vogue. Corn of strong vitality can be placed in cold ground with less risk than that of weak germinating power.

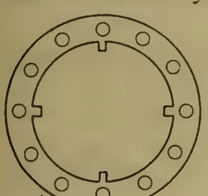


Fig. 82.
ROUND-HOLE-DRILL-DROP PLANTER PLATE.
Planter plate showing the comparative size and number of holes.

Date of planting determined by length of season

Soil conditions have as much to do in determining the date of planting as does the weather. For example, farmers on the soil of Missouri loess in northwestern Iowa, can plant as much as 14 days earlier than farmers in the central part of the state in the same latitude, but located on the undrained, low soil of the Wisconsin glacial deposit.

Plant strong seed early

From Bulletin No. 13 of Illinois is taken this table showing yield of air-dry corn from plantings at different dates, at the Experiment Station at Urbana.

Plantings.	Bushels of Air-dry Corn per Acre. 1888	1889	1890	Average
April 22,		52		
April 27-29,	80	44	67	64
May 4-6,	87	51	71	70
May 11-15,	86	56	75	72
May 19-20,	87	50	71	69
May 26-27,	83	55	74	71
June 1-5,	81	50	61	64
June 8-13,	50	50	60	53

Yields on different dates

Hunt, in his "Cereals of America," gives the following summary of the work of all the Experiment Stations.

STATION	SEASONS	EARLIEST	BEST	LATEST
Illinois	8	April 22-26	May 11-18	June 17-22
Indiana	7	May 1-2	May 1-8	May 28-30
Kansas	2	April 18-20	May 1	May 29-30
North Dakota	1	May 18-25	June 1-8	June 15-July 2
Ohio	7	April 26	May 14-24	June 4-12
Oklahoma	2	March 21-28	March 28	April 25
			April 18	May 13
South Dakota	3	May 1	May 15-25	June 10

Dates of corn planting as shown by the Cereal Gazette* of May, 1908.

District No. 1, of which O'Brien County is the center, will begin May 10th.

District No. 2, of which Hancock and Cerro Gordo are the center, will begin May 10th.

District No. 3, of which Fayette is the center, will begin about May 10th.

District No. 4, Crawford in center, will begin May 10th.

District No. 5, Story in center, began May 6th.

District No. 6, Jones in center, began May 5th.

District No. 7, Montgomery center, began about May 1st.

District No. 8, Lucas center, began May first.

District No. 9, Jefferson and Henry in center, began about May 5th.

In the June Report the following figures show the status of corn planting by June 1, 1908.

District	No. 1,	83	per cent.
"	No. 2,	77	"
"	No. 3,	78	"
"	No. 4,	85	"
"	No. 5,	86	"
"	No. 6,	84	"
"	No. 7,	84	"
"	No. 8,	75	"
"	No. 9,	75	"

By a few personal letters to farmers in different parts of Iowa in the spring of 1908, the dates of planting in their respective localities were found to be as follows.

COUNTY	TOWN	DATE OF PLANTING Week	Month
Sioux	Hawarden	Second and Third.	May
Allamakee	Waukon	Second	May
Dallas	Dallas Center	Second	May
Mills	Glenwood	Second	May
Page	Blanchard	First and Second.	May

Depth of Planting. The depth of planting corn is controlled by first, the physical properties of the soil and its fertility. A stiff, sticky clay, retentive of moisture and lacking in humus, should be planted shallow. Kernels covered more than two inches in such a soil will, if the surface receives a beating rain, remain dormant a long time because of lack of oxygen. The plant food is not in available form except near the surface. A loose, sandy soil requires deeper planting because of a lower water level. Although the moisture level of sod land is usually very low, as a rule it is difficult to plant corn very deep in such soil.

Depth of planting is controlled by three conditions

Second. The position of the water level. Farmers of north central Iowa cannot plant deeply because the water level is near the surface. This excess of moisture removes two essentials for germination —warmth and oxygen. The western edge of the corn belt is lacking in moisture, consequently the planter must be set more deeply. It is seldom advisable to plant deeper than 2 1-2 inches. It will be remembered that the young plant depends entirely upon being nourished from the endosperm of the seed, or the food supply within the kernel, until such time as it is able to draw its food directly from the soil. Should this kernel of corn be placed four or five inches beneath the surface of the ground, it is often found that while the seed will germinate, there is not enough plant food to maintain the growth of the sprout until it can reach the surface. Naturally, in this case the plant dies, while if it had been planted shallow, so that the young plant could have come to the surface before the plant food in the kernel had been exhausted, it would have grown to maturity.

Third. The time of planting. In the spring the atmosphere warms early and by penetrating the seed bed gradually raises its temperature. Therefore, in early planting, only the surface soil is warm enough to germinate the kernels. The sub-surface strata is cold and wet. Later when the surface soil has become warmer, the seed may be covered to greater depth.

Yield of Corn from Plantings of Different Depths.

DEPTH	BUSHELS PER ACRE 1888	1889	1890	AVERAGE
1 inch..................	109.7	83.0	77.8	90.2
2 "	88.4	83.0	72.8	81.4
3 "	100.8	51.0	70.3	74.0
4 "	88.0	87.0	58.4	77.8
5 "	73.1	81.0	62.3	72.1
6 "	60.3	92.0	60.3	70.9

The above figures taken from Bulletin No. 13 of Illinois, show from an average of three years, with corn planted at different depths, a few bushels in favor of the shallow planting. Of course, Illinois conditions are different from those of some of the other states, and must be interpreted accordingly.

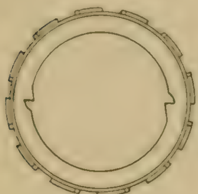


Fig. 83.
EDGE DROP PLANTER PLATE.
This plate takes into consideration the thickness of the kernel which is the most constant character.

Distance Between the Rows. The distance between the rows of corn varies from three feet in the north and west to more than six feet in the southeast.

The factors which decide how far apart the rows should be are; first, the fertility of the soil. A thin soil, low in organic matter and especially lacking in nitrogen, produces very little growth of foliage. The roots must feed over a large area; consequently the rows are set further apart. A piece of sod land which tends to force the corn along and produce excessive tillering, may be planted in rows closer together.

Factors influencing distance between rows

The custom of the locality or even the section of the corn belt. The Georgia Experiment Station in 1897, 1898, and 1899, found that better results could be obtained by having the rows four feet apart with only one stalk every three feet in each row. In 1900, the same station found that on ground which could produce around 30 bushels of corn per acre, the best results could be had with the rows four feet apart with one plant every two feet in the row. The Indiana Experiment Station, in carrying on investigations for a period of eight years, secured the best yields with planting in rows three feet apart and one plant every 10 3-4 inches in the row.

Under Iowa conditions, the majority of growers usually check three feet, six inches both ways, making 3,556 hills per acre. By such a plan, each hill has 1764 square inches of surface. The cultivators as usually used on the farm are set for this width, and there is no line of weeds left in the center between the rows. On the poorer soils of the state a three-foot, eight inch planter is used, which plants 3,240 hills per acre. Sometimes the corn is planted three feet eight inches one way, and a three foot six inch check wire is used.

Third, The nature of growth of variety is another factor influencing the closeness of planting. Large, rank growing varieties require greater distance between the rows, because of over-shading. Low growing kinds requiring short seasons may be planted more closely.

The occasional planting of other crops with corn may make a greater distance between hills and rows desirable.

Number of Stalks Per Hill. There is more or less difference of opinion upon this particular point. In the early years of corn growing in the central West, the number of kernels per hill was controlled by such an adage as "Always plant five kernels, one for the blackbird, one for the crow, one for the cut worm and two to grow." However, it may be said that the amount of corn that can be produced on a given area of land is determined by the soil, seed, and management, together with the climatic conditions. Naturally, land rich in fertility can maintain a greater number of stalks per acre than can poorer land. While in the former case four or five kernels to the hill may not be too many, in the latter two kernels to the hill would be sufficient. Three kernels to the hill is generally considered as the standard, and it may be said that there is very little good corn-producing land that can not maintain three good stalks to the hill.

Number of kernels varies with the soil

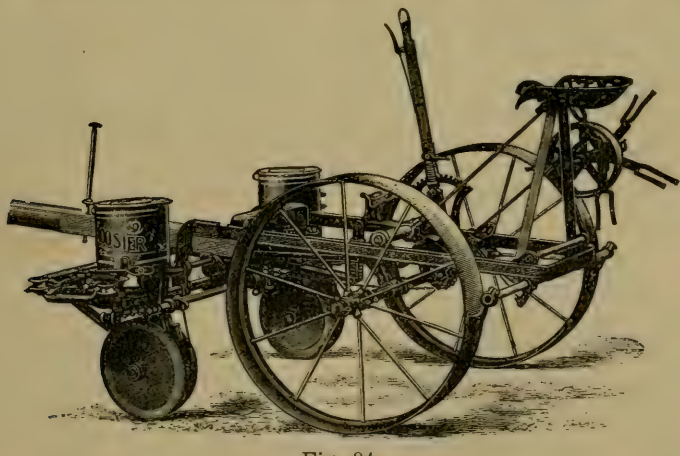


Fig. 84.
CORN PLANTER.
Showing disc furrow-openers.

If corn is planted thick on land of poor fertility, the result is stover and not ears. On the other hand, two or three kernels are often planted to the hill on land so rich in fertility that much greater yields would have been secured by planting four and possibly five kernels. In the latter case, with two and three kernels a great many suckers are produced, sometimes as many as two to three per hill. Had there been four or five kernels to the hill in this case, the fertility of the ground would have been utilized in producing stalks of corn bearing ears, rather than suckers.

Of 200 representative Iowa corn growers corresponded with, 60 per cent planted from three to four kernels, and none more than five kernels per hill.

Test at Illinois Station

The Illinois Experiment Station carried on experiments to determine what influence the number of kernels per hill had on yield. The results are shown in the following table:

	PERCENT OF STAND				YIELD OF BUSHELS			
Date of Planting	Five Kernels	Four Kernels	Three Kernels	Two Kernels	Five Kernels	Four Kernels	Three Kernels	Two Kernels
April 29........	92.5	93.7	63.5	62.5	67.0	63.6	37.5	33.8
May 6..........	82.5	91.4	100.0	100.0	63.3	58.8	65.0	55.8
May 13.........	88.8	90.6	93.7	103.1	53.8	52.3	55.5	60.0
May 20.........	88.1	84.4	92.7	109.4	62.2	56.8	62.0	56.1
May 27.........	74.4	63.6	77.1	90.6	45.8	38.8	33.9	27.8
June 3..........	69.8	76.6	85.4	79.7	29.5	26.9	25.3	20.7
Average	82.7	83.3	85.4	91.0	53.6	47.8	46.5	42.3

On average good corn land, the yield per acre in shelled corn increases with the number of stalks per hill up to four or five. After this the amount of stover increases and the amount of grain decreases. As the number of stalks increases to the hill, the number of good, strong seed ears will decrease after two and three stalks to the hill, and there will be found more inferior ears and nubbins.

Tables from results of county Experiment Stations in Iowa

The following tables are taken from the results of experimental work carried on by the Agricultural Extension Department of the Iowa State College. The experiments were carried on at various county farms. Representing as they do, almost all the conditions of soil and climate in Iowa, they are very valuable to the farmer in the corn belt.

THICKNESS OF PLANTING.—Sioux County.

Number of Kernels or Stalks	Bushels per Acre	% Stand Oct.	% Stand at Harvest Based on 3 Stalks	Av. Stalks per Hill at Harvest	% Suckers	% Barren	% Smutted	% Seed Ears	% Market Ears	% Nubbins	% Worthless
1	39.4	79.7	26.6	.8	38.4	2.7	2.9	8.4	71.7	9.8	10.1
1½	51.3	87.6	44.0	1.3	14.7	1.8	1.6	9.7	74.9	8.0	7.4
2	60.9	87.8	58.9	1.8	11.9	2.3	1.7	7.6	76.4	8.3	7.6
2½	63.7	87.3	72.7	2.2	5.9	2.4	1.1	5.7	79.3	8.7	6.3
3	73.4	86.2	86.2	2.9	4.2	2.9	1.1	4.7	75.7	12.5	5.0
3½	74.7	86.9	101.4	3.0	2.9	4.7	1.1	4.0	73.1	16.2	6.7
4	73.7	86.3	115.1	3.5	1.7	4.9	1.0	2.9	66.3	23.2	7.5
4½	73.7	85.7	128.5	3.9	1.9	7.1	1.1	2.5	62.5	26.9	8.1
5	72.2	85.1	141.8	4.3	1.8	8.3	1.0	1.9	53.4	35.2	9.7

Kossuth County.

An Average of One Test in 1905 and Four Tests in 1906.

Number of Kernels or Stalks.	Bushels per Acre	Per cent Stand Oct.	Per cent Stand at Harvest based on 3 Stalks.	Av. Stalks per Hill at Harvest.	Per cent Suckers.	Per cent Barren.	Per cent Smutted.	Per cent Seed Ears	Per cent Market ears.	Per cent Nubbins.	Per cent Worthless.
1	38.4	87.6	29.2	.9	76.7	5.4	2.9	4.9	74.5	14.8	5.8
1½	46.1	88.1	44.1	1.3	43.6	4.4	1.4	3.9	78.1	13.1	4.8
2	58.4	88.8	59.2	1.8	27.4	4.5	1.2	4.1	79.5	12.0	4.4
2½	66.7	89.0	74.2	2.2	15.7	4.6	1.2	3.4	80.3	12.7	3.3
3	75.4	87.9	87.9	2.6	11.3	4.3	1.6	3.3	81.2	10.7	3.9
3½	78.7	88.2	102.9	3.1	7.8	5.9	1.0	2.4	82.8	12.1	2.7
4	82.6	87.5	116.7	3.5	5.9	6.6	.7	2.2	82.6	12.1	3.0
4½	81.3	84.2	126.3	3.8	3.9	6.9	.9	2.0	82.8	11.9	3.3
5	82.5	80.6	134.3	4.0	2.5	7.8	1.9	1.6	81.9	12.9	3.6

Chickasaw County, 1906.

There were five samples of seed represented in this test, one plot of each number of kernels per hill being plantd from each sample.

Number of Kernels on Stalks	Bnshels per Acre	% Stand Oct.	% Stand at Harvest Based on 3 Stalks	Av. Stalks per Hill at Harvest	% Suckers	% Barren	% Smutted	% Seed Ears	% Market Ears	% Nubbins	% Worthless
1	30.7	83.8	27.9	.8	22.0	1.7	5.0	2.8	76.4	11.1	9.7
1½	40.8	80.7	40.4	1.2	13.0	2.3	2.3	3.0	83.5	9.3	4.2
2	50.6	84.7	56.5	1.7	9.2	3.3	1.7	2.6	87.2	7.6	2.6
2½	55.7	86.6	72.2	2.2	6.6	2.6	.0	1.3	87.8	9.6	1.3
3	59.7	79.1	79.1	2.4	3.0	4.8	3.0	.6	82.0	14.3	3.1
3½	59.0	75.0	87.5	2.6	4.4	7.6	1.6	.5	78.0	17.2	4.3
4	68.9	76.3	101.4	3.1	4.2	5.6	2.8	1.0	77.6	16.9	4.5
4½	63.1	79.2	118.8	3.6	4.8	8.7	1.6	.4	68.0	27.2	4.4
5	60.1	75.8	126.3	3.8	1.8	12.7	1.1	.0	63.6	29.4	7.0

Greene County, 1906.

Number of Kernels or Stalks	Bushels per Acre	% Stand Oct.	% Stand at Harvest based on 3 Stalk	Av. Stalks per Hill at Harvest	% uc kers	% Barren	% Smutted	% Seed Ears	% Market Ears	% Nubbins	% Worthless
1	52.4	91.1	30.4	.9	127.0	3.9	6.3	12.4	65.8	12.0	9.7
1½	62.3	89.8	44.9	1.4	68.4	8.9	3.8	11.9	68.5	12.0	7.5
2	91.9	90.7	60.5	1.8	47.5	9.4	3.5	11.8	73.5	8.8	5.9
2½	73.7	87.3	72.8	2.2	30.7	10.4	2.6	8.3	76.8	9.0	5.9
3	74.1	86.9	86.9	2.6	20.0	11.2	2.1	5.9	78.4	9.4	6.3
3½	73.9	86.0	100.3	3.0	15.0	16.4	4.5	4.3	74.7	14.7	6.3
4	73.5	85.0	113.3	3.4	13.6	19.6	2.2	2.8	76.0	14.0	7.2
4½	76.5	88.4	132.6	4.0	11.2	22.5	1.4	2.5	68.8	19.8	8.9
5	73.9	81.6	136.0	4.1	11.7	27.2	1.4	1.6	67.9	21.3	9.1

Story County.

Average of Three Years' Work During 1905, 1906 and 1907.

Number of Kernels or Stalks.	Bushels per Acre	Per cent Stand Oct.	Per cent Stand at Harvest based on 3 Stalks.	Av. Stalks per Hill at Harvest.	Per cent Suckers.	Per cent Barren.	Per cent Smutted.	Per cent Seed ears.	Per cent Market ears.	Per cent Nubbins.	Per cent Worthless.
1	31.1	87.6	29.2	.9	19.8	4.9	1.1	15.6	67.1	11.1	6.2
1½	42.1	87.8	43.9	1.3	10.2	3.6	.4	14.0	73.4	7.5	5.1
2	50.9	90.5	60.3	1.8	3.1	3.8	.7	11.3	77.8	7.0	3.8
2½	59.3	89.7	74.8	2.2	2.6	5.0	.7	6.0	80.6	9.3	4.1
3	65.8	89.7	89.7	2.7	1.2	6.0	.1	6.3	79.8	9.8	4.1
3½	68.9	85.7	100.0	3.0	2.3	10.8	.3	4.8	79.5	12.1	3.5
4	70.0	85.2	113.6	3.4	4.2	16.7	.6	3.6	77.1	15.4	3.8
4½	69.9	82.8	124.2	3.7	1.4	15.8	.4	3.1	74.4	17.3	5.2
5	74.8	80.6	134.3	4.0	1.8	21.9	.5	2.6	71.4	20.6	5.4

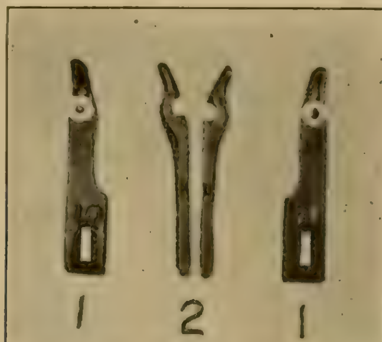


Fig. 86.
(Courtesy Kaylor Roller Fork Co.)
ROLLER-FORK FOR CORN PLANTER.

The rollers in the fork allow the check wire to work much more freely. It prevents the button from catching.
No. 1. Side view.
No. 2. Complete.

Polk County.

Summary of Three Experiments in 1905 and 1906.

Number of Kernels or Stalks.	Bushels per Acre	Per cent Stand Oct.	Per cent Stand at Harvest based on 3 Stalks.	Av. Stalks per Hill at Harvest.	Per cent Suckers.	Per cent Barren.	Per cent Smutted	Per cent Seed ears.	Per cent Market ears.	Per cent Nubbins.	Per cent Worthless
1	33.6	75.7	25.2	.8	20.7	5.9	9.0	14.1	69.0	9.1	7.8
1½	47.1	78.2	39.1	1.2	9.6	5.8	1.5	10.1	75.6	7.6	6.7
2	59.0	82.8	54.9	1.7	8.1	5.8	1.0	11.7	76.7	7.1	4.5
2½	67.1	79.2	66.0	2.0	8.5	4.8	1.3	8.6	81.3	5.1	5.0
3	71.4	73.9	73.9	2.2	4.1	9.6	1.6	10.4	76.7	7.9	4.9
3½	72.1	72.3	84.4	2.5	3.4	9.7	.9	6.4	73.6	12.2	7.8
4	73.1	71.1	94.8	2.8	2.2	10.4	1.1	6.1	77.4	9.4	7.1
4½	76.7	68.3	102.5	3.1	2.6	10.3	.8	7.7	70.7	13.5	8.1
5	75.7	65.8	109.7	3.3	2.5	12.8	.9	5.7	70.7	16.9	6.6

Marshall County.

Summary of Experiments with Eight Lots of Seed During Three Years, 1905-1906-1907.

Number of Kernels or Stalks.	Bushels per Acre	Per cent Stand Oct.	Per cent Stand at Harvest based on 3 Stalks.	Av. Stalks per Hill at Harvest.	Per cent Suckers.	Per cent Barren.	Per cent Smutted.	Per cent Seed ears.	Per cent Market ears.	Per cent Nubbins.	Per cent Worthless
1	42.0	73.4	24.5	.7	127.4	2.7	4.4	3.1	72.5	5.8	18.6
1½	50.7	81.9	41.0	1.2	81.2	2.9	2.7	3.7	74.0	7.1	15.2
2	60.5	77.3	51.5	1.6	52.7	2.2	3.7	3.3	76.1	4.6	16.1
2½	65.6	75.9	63.3	1.9	46.7	2.9	3.0	3.0	75.9	4.8	16.2
3	68.7	72.9	72.9	2.2	33.0	3.7	4.7	2.5	75.7	4.7	17.1
3½	71.9	73.2	85.4	2.6	24.8	3.9	3.4	2.0	76.6	5.9	15.4
4	78.2	69.8	93.1	2.8	21.2	3.1	3.4	2.3	74.1	6.7	16.7
4½	75.2	67.6	101.4	3.0	19.4	4.3	2.7	1.5	71.3	6.2	20.9
5	81.5	63.1	105.2	3.2	20.0	5.2	4.5	1.3	69.0	10.9	18.8

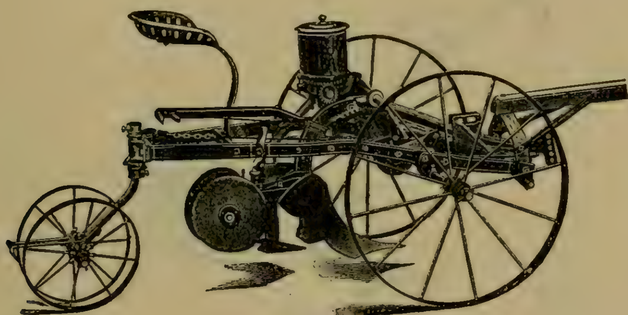


Fig. 87.

SINGLE ROW COMBINED LISTER AND DRILL.

Used in very dry soils in order to get the corn deep into the ground so as to obtain moisture.

Cedar County.

Summary of Test with Two Lots of Seed in 1907.

Number of Kernels or Stalks.	Bushels per Acre	Per cent Seed ears.	Per cent Market ears.	Per cent Nubbins	Per cent Worthless
1	32.3	3.0	75.8	14.8	6.4
1½	46.0	3.5	80.7	10.8	4.9
2	55.5	2.9	82.4	10.2	4.4
2½	65.7	2.8	85.4	9.4	2.3
3	74.8	2.0	87.7	6.7	3.5
3½	82.8	2.5	85.7	8.6	3.1
4	88.6	1.2	86.4	9.9	2.3
4½	88.3	1.6	84.2	11.2	2.9
5	95.0	1.2	81.7	14.6	2.4

Montgomery County.

Summary of Five Tests in 1906 and 1907.

Number of Kernels or Stalks.	Bushels per Acre	Per cent Seed ears.	Per cent Market ears.	Per cent Nubbins.	Per cent Worthless.
1	44.5	11.1	65.0	18.5	5.4
1½	55.8	8.5	70.9	15.9	4.4
2	65.3	9.0	72.1	14.5	4.3
2½	71.0	6.9	76.9	13.4	2.9
3	73.5	5.7	76.3	14.7	3.2
3½	73.6	3.7	74.5	18.1	3.6
4	70.8	2.8	71.4	21.4	4.4
4½	71.0	2.5	67.8	25.3	4.3
5	72.8	1.3	63.7	30.7	4.3

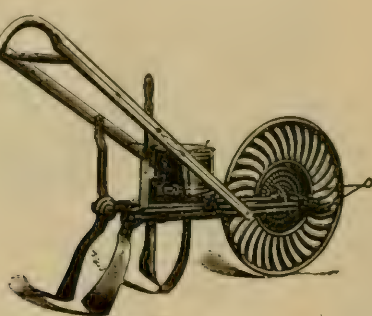


Fig. 88.
SINGLE ROW DRILL.
Used in drilling corn after the lister has opened a furrow.

Page County.

Summary of Three Tests During the Seasons of 1905 and 1906.

Number of Kernels or Stalks.	Bushels per Acre	Per cent Stand Oct.	Per cent Stand at Harvest based on 3 Stalks.	Av. Stalks per Hill at Harvest.	Per cent Suckers.	Per cent Barren.	Per cent Smutted.	Per cent Seed ears.	Per cent Market ears.	Per cent Nubbins.	Per cent Worthless.
1	43.4	91.2	30.4	.9	58.6	1.5	3.2	8.7	78.7	6.4	6.1
1½	53.2	85.9	43.0	1.3	31.1	2.9	3.3	7.4	77.5	10.1	5.1
2	60.7	88.2	58.8	1.8	17.2	2.7	2.1	8.0	80.1	6.7	5.2
2½	66.1	88.1	73.4	2.2	9.4	3.7	1.2	5.0	79.7	10.9	4.4
3	71.3	88.3	88.3	2.7	7.8	6.5	2.1	5.5	74.6	15.1	4.8
3½	71.0	86.4	100.8	3.0	5.5	8.3	2.3	3.3	71.4	18.8	6.5
4	66.3	82.2	109.6	3.3	4.3	11.6	1.5	3.2	64.7	24.9	7.2
4½	66.5	85.3	128.0	3.8	3.4	15.8	2.1	2.5	57.5	31.0	9.0
5	66.9	88.2	147.0	4.4	2.0	19.6	2.6	1.6	53.2	35.4	9.7

Taylor County.

Summary of Two Experiments in 1906.

Number of Kernels or Stalks.	Bushels per Acre	Per cent Stand Oct.	Per cent Stand at Harvest based on 3 Stalks.	Av. Stalks per Hill at Harvest.	Per cent Suckers.	Per cent Barren.	Per cent Smutted.	Per cent Seed ears.	Per cent Market ears.	Per cent Nubbins.	Per cent Worthless.
1	43.6	82.5	27.5	.8	32.5	2.5	2.5	10.6	73.8	7.5	8.1
1½	62.0	89.5	44.8	1.3	20.6	1.6	1.0	7.4	79.5	8.2	4.9
2	72.1	87.0	58.0	1.7	13.1	2.8	.8	7.6	77.4	6.2	8.7
2½	81.9	85.0	70.8	2.1	13.7	6.2	1.3	7.9	78.8	6.7	6.5
3	83.2	85.5	85.5	2.6	4.0	4.1	.8	6.0	82.0	6.9	5.1
3½	82.0	87.5	102.1	3.1	1.9	7.6	.4	3.2	79.7	11.9	5.1
4	79.7	86.3	115.0	3.5	1.5	10.5	1.0	.9	80.3	13.6	5.2
4½	85.4	84.2	126.3	3.8	1.9	12.3	1.8	1.4	71.9	20.4	6.2
5	82.2	86.2	143.3	4.3	.3	14.6	.3	.6	66.1	25.0	8.2

Henry County—1907.

Number of Kernels or Stalks.	Bushels per Acre	Per cent Seed ears.	Per cent Market ears.	Per cent Nubbins.	Per cent Worthless.
1	23.1	13.5	71.5	9.3	5.7
1½	35.8	9.3	74.9	12.5	3.3
2	46.5	8.5	79.7	9.4	2.4
2½	55.0	5.5	78.4	12.5	3.8
3	59.0	3.2	82.3	11.0	3.5
3½	60.4	1.6	77.4	17.1	3.9
4	54.6	1.5	62.8	27.8	7.9
4½	54.3	.4	58.0	35.3	6.3
5	51.3	.1	50.5	40.7	8.7

SUMMARY OF 39 EXPERIMENTS IN TWELVE COUNTIES DURING THE YEARS OF 1905, 1906, 1907.

Number of Kernels or Stalks.	Bushels per Acre	Per cent Stand Oct.	Per cent Stand at Harvest based on 3 Stalks.	Av. Stalks per Hill at Harvest.	Per cent Suckers.	Per cent Barren.	Per cent Smutted.	Per cent Seed ears.	Per cent Market ears.	Per cent Nubbins.	Per cent Worthless.
1	37.7	84.1	28.0	.8	55.0	3.2	3.9	8.7	72.1	11.0	8.2
1½	49.4	85.9	43.0	1.3	30.6	3.4	2.0	7.2	76.0	10.7	6.0
2	59.1	86.7	57.8	1.7	19.7	3.8	1.7	7.1	78.5	8.7	5.6
2½	65.6	85.7	74.7	2.2	14.3	4.6	1.3	5.2	80.3	9.6	4.9
3	70.7	84.0	84.0	2.5	8.9	5.6	1.8	4.5	79.4	10.7	5.3
3½	72.1	83.2	97.1	2.9	6.7	8.1	1.6	3.1	77.2	14.1	5.5
4	73.2	81.8	109.1	3.3	5.7	9.7	1.6	2.4	74.5	16.8	6.2
4½	73.1	81.5	122.3	3.7	4.9	11.6	1.5	2.2	69.6	21.2	7.0
5	73.4	80.2	133.7	4.0	4.0	14.5	1.4	1.5	65.9	25.1	7.6

NOTES.

Northern section

1. These summaries of all the experiments which have been carried on with the thickness of planting in the three sections of the state show that the highest yields in northern Iowa were secured where four kernels were planted per hill, or where that number of stalks were left to grow, there being an average of about 3.3 stalks per hill at harvest time.

Central section

In the central section, the largest yield was secured where five kernels were planted per hill, or five stalks were left. It should be carefully noted that the stands of corn secured in these experiments in central Iowa were lower than those secured in the northern section. There was only an average of 3.6 stalks per hill at harvest time.

Southern section

The largest yield in the southern section was secured where three to three and one-half kernels were planted, there being an average of about 2.5 to three stalks per hill at harvest time.

2. In northern and central Iowa, the largest proportion of good ears, including both seed and market grades, was secured where an average of 2.5 kernels was planted per hill, or where that number of stalks was left to develop, there being an average of a little less than two stalks per hill at harvest time.

The largest proportion of good ears was secured in southern Iowa, where an average of two kernels was planted, there being an average of a little less than two stalks per hill at harvest time.

3. In studying the results of these experiments, it should be remembered that there were only about 80 to 85 per cent as many stalks left at harvest time as there were kernels planted or stalks left at the time of the second cultivation.

5 to 10 per cent loss of stand even from good seed

In estimating the number of kernels to be planted per hill, it should be remembered that where strong seed is planted under good conditions there will ordinarily be a loss of from five to ten per cent in the stand.

4. The study of the results of these experiments would lead to the conclusion that for ordinary good conditions a farmer in central and northern Iowa, would do well to plant so as to have three good, strong stalks in every hill. In southern Iowa these results indicate that under ordinary conditions an average of 2.5 to 3 good stalks would give better results than thicker planting.

Just what number would give the best results for any one farm must be decided by the farmer himself. In general, the thickness can well be increased on rich soil, or with a small variety of corn, and decreased with thinner soils and larger varieties.

5. Notice that the proportion of stalks having suckers decreased rapidly and regularly with the increase in thickness of planting.

6. The average of all the experiments shows that the proportion of barren stalks increased regularly with the increase in thickness of planting from 3.2 per cent where there was only one stalk per hill, to 14.5 per cent where there were five stalks.

7. The proportion of stalks affected by smut was greatest where the thinnest planting was practiced.

8. The proportion of seed ears decreased rapidly and regularly with the increase in thickness of planting.

9. Notice that in the summary of all the experiments the proportion of nubbins was lowest where there was an average of two stalks per hill. The smallest proportion of worthless ears is seen to be where an average of 2.5 kernels was planted per hill, or where that number of stalks was left after the corn was thinned about the time of the second cultivation. The larger proportion of nubbins and worthless ears where the thin planting was practiced was probably due to the fact that many of the stalks produced a second small ear and that some of the many suckers had small ears on them.

More nubbins than in thin planting

Notice that the increase in the proportion of nubbins and worthless ears with the increase in the thickness of planting was greater in the southern section than in the central and northern. The increase in the proportion of barren stalks was also greater. These results show that thick planting decreases the productiveness of the stalks more in the southern part of the state than it does in the northern section.

WHAT IS A PERFECT STAND? This question is so often asked that it is here partially answered.

On Rich River Valley Soil. It is only during a season of comparatively little rainfall that the farmers on the river lowlands are able to grow a crop at all. At least three to four stalks per hill should be the standard on such land. (See foot note.)

Upland Thin Soil. At Institutes and Short Courses one quite often hears the remark that as many stalks cannot be grown to the hill now as 20 or even 10 years ago. The fact that the virgin fer-

SOUTHERN IOWA ROUGH LANDS.

These are underlaid with hardpan, and in a dry year two stalks per hill would be sufficient. A lack of plant food and the fact that the corn roots cannot penetrate the sub-soil to secure moisture, requires a smaller number of stalks per hill.

NORTHERN IOWA, LOW, UNDRAINED SOIL.

The years of shortage in early spring precipitation are a boon to the corn growers of the northern area of the Wisconsin Drift. Three stalks or even more should here be the standard, because the soil is well stocked with potential and available plant food.

tility of the soil has been drawn upon heavily for a series of years by continuous cropping, has begun to make itself evident in diminished yields. A year of heavy precipitation is the only time when a farmer whose soil is thin can think of growing three stalks per hill with success.

Growing for Show Purposes. The spirit of professionalism has to some extent entered the field of corn exhibiting. Breeders who grow samples to win for advertising purposes prefer from two to 2.5 stalks per hill, even on strong land.

This discussion has been taken up with the idea of getting at the reason for the various views upon the subject. The standard of three kernels per hill has served well up to date, but its practicability is going to be questioned in many sections before long. In order to continue its use a system of farming must be adopted which will maintain the fertility of the soil.

Missing hill means a decrease of yield

Replanting Corn. The stand of corn is frequently found to be poor, with a great many one-stalk and missing hills. This is due chiefly to poor seed, to a lack of preparation of the seed bed, to insect enemies, and to climatic conditions. A missing hill means a decrease in yield. Not infrequently a great deal of replanting is carried on, which, it may be said, is not very profitable. In the first place, the plants from the seed that was replanted will not be found to be so far advanced as those about them at the time of the first cultivation. They will not shed their pollen at the same time, and they often will not send their shoots out until so late that the greater portion of the pollen from the other stalks has fallen. This accounts for the nubbin ears which are always found to a great extent on replanted corn. When replanting is done, it is more desirable to plant with an earlier maturing variety of corn. This, of course, cannot be carried out where it is desired that the corn be kept pure, and in this case it could be done with profit only when there are from 10 to 20 per cent of the hills missing. By replanting an earlier variety than was formerly planted, the silks and tassels will come out more nearly the time the rest of the plants of the field send forth their shoots. When the missing hills are less than 10 per cent, it is not deemed advisable to replant, and should the misses be more than 20 per cent the best results will be secured if the entire field is replanted.

When to replant

Hills 9, 12, 14, 16 inches apart

DRILLING CORN. Sod land is frequently put into corn in this manner. On very fertile soil which contains sufficient moisture, the hills may be 9 inches apart. Twelve inches is more desirable, and even a distance of 14 or 16 inches produce heavy yields. Suckers are produced quite abundantly on sod land. Thicker drilling will have a tendency to eliminate this evil.

Figuring stand in drilled field

At the Illinois Station, corn checked three feet eight inches apart and plowed but one way, produced 71.7 bushels per acre, compared with 60.8 bushels where the field was drilled in rows three feet eight inches apart, with the stalks 11 inches apart in the row. This difference is accounted for by the fact that although the checked piece was cultivated but one way, it was much freer from weeds.

The number of stalks per acre in a field of corn drilled in rows three feet six inches, with stalks ten inches apart in the row, will be 14,934. If 14 inches in the row, 10,667. In figuring the per cent stand in drilled corn, step off a distance equal to 100 hills 10 or 14 inches apart, or any other number of inches, depending upon thickness of drilling. If the kernels were drilled 10 inches apart, the 100 hills would be 1,000 inches, or 83 1-3 feet. Count the stalks in this measured length. If there prove to be but 80 stalks, then the percentage of stand is 80.

Kansas the home of the lister

LISTING CORN. The lister is not a familiar implement to the farmer of central Iowa and Illinois. The western corn states, Kansas and Nebraska, and parts of Iowa and Missouri, use the lister almost to the exclusion of the planter. The lister was introduced into Kansas in 1882. In 1902 it was estimated that three-fifths of the area in corn in Kansas was listed. In these sections the soil is so loose as to allow the water level to settle very low. The winds of summer carry off much of the moisture and the storms of August and September blow down the checked or surface planted corn. Because of washing, the lister is not adapted to hilly land. On the low, tiled fields of the central states listing has proved a failure. Tests at the Illinois Station indicate lower yields and later maturity in listed than in checked corn.

Records of J.W. Robinson Towanda Kansas

After many trials on plots at the Experiment Station of Kansas, it was found that listing gave an average increase of 3.57 bushels, or 4.16 per cent per acre over surface planted corn. In 1888, during a dry season, an increase of 15 per cent was noted.

The following tables* are taken from the records of J. W. Robinson, of Towanda, Kansas. They cover a period of 22 years and take into account a crop of from 1,000 to 2,000 acres annually. In comparing the cost of handling an acre of clean ground by the two methods, listing vs. check-rowed, the figures show 75 cents in favor of the former.

*Address by Theo. W. Morse, before the Thirty-first Annual Meeting of the Board of Agriculture of Kansas.

LISTED.

Listing	$ .35
Twice harrowing	.20
Once with "Go-Devil"	.15
Three cultivations	.75
Cutting weeds	.10
Total	$1.55

CHECK-ROWING.

Plowing and harrowing	$1.10
Check-rowing	.25
Harrowing once	.10
Three cultivations	.75
Cutting weeds	.10
Total	$2.30

Preparing the surface

Preparing the Ground. As listing is not done until the time comes for the corn to be in the ground, the land usually lies idle until the first of May. Therefore, some kind of surface treatment must be given the soil. Discing early in the spring loosens the surface layer and tends to conserve the moisture. If weeds come on rapidly and grow rank another vigorous discing may be applied. Furthermore, the disc levels the last year's corn rows and splits the stubs so they are less bother in cultivating. Where listing is to follow small grain, discing the stubble in the fall conserves the moisture and prevents the weeds from seeding.

The partial failures of listed corn may often be traced to the wasteful loss of moisture in the early part of the season, because of allowing the surface soil to bake and grow up to grass.

Corn planted in a clean furrow

The Use of the Lister. The lister is simply a double mold-board plow. By arrangement of the whiffletree the distance between the rows is the same as in checked corn, although in the southwest the rows are often but 40 inches apart. The weed seeds and foul earth are thrown onto the ridges away from the rows of sprouting corn. Hence, the corn has a chance to start in a clean furrow. Many farmers recognize this when they find the corn more difficult to keep clean in a year when their lister failed to scour.

The listers which were first invented had an incomplete turn of the mold-board which left an edge of the surface of the ground sticking out instead of forming a rounded ridge of fresh earth which was less pregnant with weed seeds. Even with the best listers, ground which has not been previously disced and loosened, but rolls up in lumps, will also do the same thing.

Riding lister

Two row lister

On many large areas a combined riding lister is used; that is, a drill attachment at the rear of the lister drops the corn and two small shovels or discs cover the kernels. For doing very uniform work, through all kinds of soils, this lister is the best implement, especially on level land. A walking lister may also have this combined attachment. Often the lister is drawn alone and the drilling is done with a one-horse drill, or a two-row planter is used. A planter does not follow the listed furrows uniformly unless they have been turned with a two-row lister. The kernels are often dropped on the edge of the furrow, which gives the young plants insufficient root hold, besides making them hard to cultivate.

Double listing

Checking can be efficiently done in listed furrows, but the corn is usually not large enough to cultivate crosswise at the second plowing. Corn may be listed in ground already prepared for surface checking, but in such a case the soil is usually so loose that the lister will not scour satisfactorily. Stubble land is often listed with good results. In listing ground which has been in corn the previous year, either the old row may be listed out or the furrow may be made between the rows. Double listing—listing once early and then relisting the ridge later in the season—is a more effective way of loosening up the soil.

Furrow opening attachment

The furrow-opener attachment is rapidly gaining recognition, especially in those districts where the corn must be planted deep in order to better resist the drouth and wind. In many localities it is gradually replacing the lister. The ground is plowed and the seed bed put in proper condition by use of the disc and the harrow. An ordinary corn planter is then used with the furrow opener attachment. The corn is thus planted at a sufficient depth and may be either drilled or checked. This permits of a much more thorough preparation of the seed bed, giving the corn plant the advantage of an earlier start. With the use of the furrow opener attachment, the Kansas Experiment Station has been receiving very satisfactory results.

ACKNOWLEDGMENTS:

Many very valuable suggestions have been secured from the files of Wallaces' Farmer.

In the description of the machinery used, frequent reference has been made to "Farm Machinery and Motors" by Davidson and Chase.

King's "Physics of Agriculture" has been a source of considerable information.

The Extension Department of the Iowa State College has afforded access to much data which deals with local conditions in Iowa.

COLLATERAL READING:

Corn,
South Carolina Bulletin No. 44.
Corn,
South Carolina Bulletin No. 61.
Field Experiments with Corn,
Indiana Bulletin No. 77.
Experiments on Corn,
West Virginia Bulletin No. 29.
Experiments with Corn and Oats,
Indiana Bulletin No. 55.
Corn Culture in North Carolina,
North Carolina Bulletin No. 171.
Experiments with Corn,
Kansas Bulletin No. 64.
Corn Experiments,
Kentucky Bulletin No. 26.
Corn Experiments,
Kentucky Bulletin No. 17.
Results Obtained from Trial Plots of Grain, Fodder Corn, Field Roots and Potatoes,
Ottawa Bulletins Nos. 29, 32, 34, 36, 39, 44.
Experiments with Corn.
Kansas Bulletin No. 45.
Field Experiments with Corn,
Illinois Bulletin No. 13.
Experiments with Wheat, Corn and Potatoes,
Maryland Bulletin No. 62.
Corn,
Alabama Bulletin No. 7.
Experiments with Oats and Corn,
Indiana Bulletin No. 14.
Methods of Corn Culture,
Illinois Bulletin No. 82.
Planting and Replanting Corn,
Farmers' Bulletin No. 92.
Effects of Certain Methods of Treatment upon Corn Crop,
Nebraska Bulletin No. 54.
Field Experiments with Corn,
Illinois Bulletin No. 25.
Field Experiments with Corn,
Illinois Bulletin No. 4.
Field Experiments with Corn,
Illinois Bulletin No. 20.
Number of Kernels Per Hill,
Illinois Bulletin No. 126, 127.

Field Experiments with Corn,
Illinois Circular No. 66.
Influence of Early and Late Spring Plowing,
Ohio Bulletin No. 1.
Corn Culture,
North Dakota Bulletin No. 51.
Corn Culture,
Georgia Bulletin No. 62.
Corn Culture,
Georgia Bulletin No. 34.
Corn Culture,
Georgia Bulletin No. 51.
Corn,
Alabama Bulletin No. 3.
Corn Culture in South,
Farmers' Bulletin No. 81.
Co-operative Field Tests During 1888,
North Carolina Bulletin No. 65.
Corn Culture,
Georgia Bulletin No. 46.
Corn Culture,
Georgia Bulletin No. 58.
Corn Culture,
Georgia Bulletin No. 55.
Corn Culture,
Georgia Bulletin No. 30.
Corn Culture,
Georgia Bulletin No. 41.
Corn Growing,
Farmers' Bulletin No. 199.
Corn,
Kentucky Bulletin No. 122.
Experiments with Corn,
Ohio Circular No. 53.
Corn, Field Tests with,
Kentucky Bulletin No. 118.
Corn Experiments,
Maryland Bulletin No. 46.
Corn Experiments,
Kansas Bulletin No. 56.
Corn, Field Experiments with,
Iowa Bulletin No. 55.
Field Experiments with Corn,
Minnesota Bulletin No. 31.
Experiments with Corn,
North Dakota Bulletin No. 76.

CHAPTER VIII

CULTIVATION OF THE CORN CROP

1. CULTIVATION OF CHECKED AND DRILLED CORN.
    - A. Object of Tillage.
    - B. Harrowing Corn.
    - C. Depth of Cultivation.
    - D. Frequency of Cultivation.
    - E. Kinds of Cultivators.
2. CULTIVATION OF LISTED CORN.

CULTIVATION OF CHECKED AND DRILLED CORN

Early cultivation profitable

Thorough cultivation when the corn is young means less care thereafter. By destroying the first sprouting weed seeds, the corn is given a better chance and less moisture is lost. Furthermore, it is very essential that the corn plant never get a setback. That is, there should be no perceptible cessation of growth between the time the

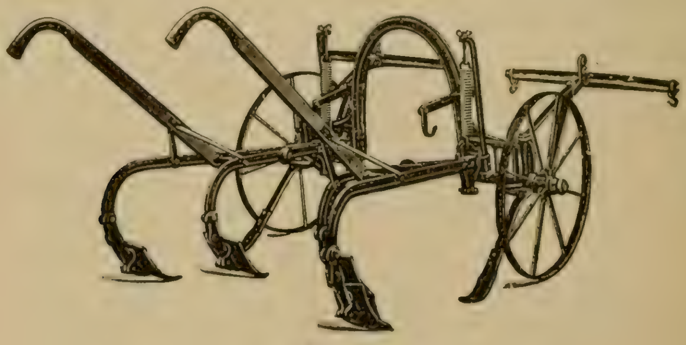


Fig. 89.
TONGUELESS FOUR SHOVEL CULTIVATOR.
Used in compact soils, and on rough lands.

plant ceases to feed upon the endosperm and the time it begins to draw its plant food from the soil. The maintenance of a healthy, dark green color and a thick, though often short stem, indicates vigor in a growing corn plant.

The Objects of Tillage. The chief objects of tillage are: (1) To stir and loosen the entire soil to a sufficient depth for the roots of the plants to freely extend themselves.

(2) To pulverize the soil and mix thoroughly its constituent parts.

(3) To develop various degrees of openness of texture and uniformity of soil conditions suitable to the planting of seeds and the setting of plants.

(4) To place beneath the surface manure, stubble, stalks and other organic matter, where it will not be in the way, and where it may be converted rapidly into humus.

(5) To destroy or prevent the growth of weeds.

(6) To start other weed seeds which have been dormant in the soil.

(7) To modify the movements of soil moisture and soil air.

(8) To assist in controlling soil temperature.

Harrowing Corn. The reasons for using a harrow or weeder before the first cultivation of corn are to kill newly germinated weed seeds; to start other weed seeds by warming the soil and admitting the air; to prevent the formation of a crust; to produce a loose surface mulch; and to get over a large area in a short time.

When and how often to harrow depends upon; first, the physical condition of the soil and seedbed.

A soil which has been plowed early and is naturally of a close grained texture, and which cements together because of beating rains, will bear a harrow without having its surface loosened at all. The harrow teeth will not move enough dirt to cover the weeds. Soil of a loose, sandy formation, the surface of which seems to break open rather than bake, can be harrowed to good advantage. The roots of the small grass around the hills of corn are soon freed so that the sun dries them out. A seed bed covered with clods or trash cannot be properly harrowed because the teeth either roll the clods on the hills or dig up lumps which tear up young plants. Old root stubs which have not been well buried in plowing, often catch in the harrow teeth and drag hills of corn out with them. The surface of sod corn land cannot be harrowed because of the loose lying pieces of turf. As a rule, however, corn on new land is comparatively free from grass the first year.

Undesirable to harrow while surface is wet

In the second place, when harrowing, the amount of rainfall and sunshine during the germination and early growing period must be considered.

During a wet time, when the sun shines but little, a harrow cultivates young grass rather than kills it. Sunlight is required to dry out the roots which are turned up to the air. Harrowing wet ground puddles the surface, instead of producing a dust mulch. On the other hand, a dry soil requires deeper tillage than that secured by the harrow. Care should be taken to note that the plants are not turgid and full of moisture when harrowed, because they snap off easily when in such condition. In the sunshine they usually bend easily and allow the harrow to pass over them without injury.

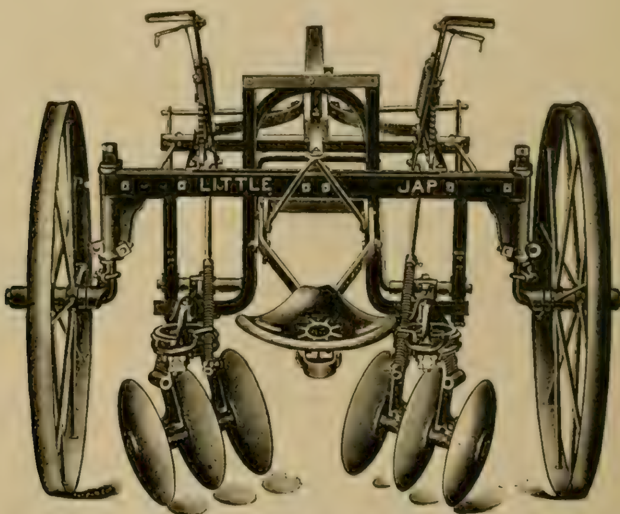


Fig. 90.
DISC CULTIVATOR.
Used especially in damp, weedy ground.

The third consideration is the size of the corn. Wallaces' Farmer advocates the following as the ideal method of planting: Thoroughly prepare the seed bed as has been previously described. Plant the corn and instead of following the planter with a harrow and harrowing it lightly crosswise, cultivate each row with the ordinary shovel plow.

Cultivating before corn is up

Set the shovels to throw considerable dirt, but not enough to ridge the rows very much. If the land is level, wait two or three days, then harrow crossways of the field. Two things are accomplished by this practice. Practically all of the corn has been cultivated once. The ground has been loosened to considerable depth. The harrow has pulverized the surface and turned to the sun many sprouting weed seeds. The whole process is more rapid and less tedious than carefully plowing weedy corn the first time. On hilly land, subject to washing, harrowing will necessarily follow immediately after cultivating the newly planted field.

When the plants are three inches in height they can be safely harrowed. Farmers on a loamy soil report harrowing corn six and eight inches high without apparent damage.

The kind of harrow is important. The teeth of the harrow should be set to slant slightly backwards. Rigid teeth tear too deeply. When raised above the surface, the harrow frame does not drag trash. A light harrow is preferable to the heavier type.

(Courtesy Janesville Machine Co.) Fig. 91.
WEEDER.
This is used when the weeds are small and the ground is in good condition.

The weeder gaining favor

The weeder, though little used in the corn belt, destroys fine grass in corn where the ground is mellow and the surface free from trash. Much younger corn can be cultivated with a weeder than with the harrow or cultivator. As the weeder is of light weight, a boy with two horses can weed a large area in a short time.

Corn should be cultivated not plowed

Depth of Cultivation. Corn should be cultivated, not plowed. The depth of cultivating corn depends first upon the size of the corn. Corn which is being cultivated for the first time has not long since begun feeding on the soil. When germinating and pushing to the surface, the sprout drew the nourishment from the endosperm of the kernel. Therefore, the roots have not spread very far horizontally or vertically. At this time the rows should be cultivated deeply and closely because it can be done without injuring the roots. There is no question but that a few may be disturbed and even cut off, but as the plant is young and the ground is moist, growth is not seriously checked. Deep cultivation should not be practiced after the first time over.

Harrowing warms the surface and conserves moisture

If the cultivator is kept from the hill and set to throw dirt to cover the weeds, rather than to uproot them, there is left in the row a compact ridge which is unfit for the corn roots to penetrate. Furthermore, the ridge is so high that by the time of the second cultivating, the weeds then growing cannot be properly covered. When a cultivator shovel passes close to a hill of corn, the loosened soil becomes warmer because of the admitting of the air. Early in the spring, the roots of corn wait especially for the soil to rise in temperature before pushing out. This loosened soil, if it dries out, will tend also to direct root growth downward, because of more moisture at lower depths. This is particularly valuable, because a shallow rooted corn plant cannot so well withstand the drying winds and lowering water level of July and August.

Deep cultivation detrimental

Deep cultivation cannot be done at any other time than the first time over. According to investigations in North Dakota, the roots of rows of corn three feet apart were interlaced at the end of 30 days after planting. The bulk of the roots were within the first eight inches of soil. Six inches from the hill the main roots were within 2½ to three inches of the surface.

Shallow cultivation best

The depth of cultivation depends also upon the texture and formation of the soil. Some types of soil contain a large amount of humus and are of a loose texture. These may be cultivated the first time with a surface cultivator. The corn soils of central Iowa and central Illinois require but one deep loosening, and produce the highest yields when tilled thereafter with surface tools. There are, however, soils of a compact, less friable nature; for example, the loess soils of southern Iowa and Illinois, which require deeper cultivation. If a beating rain follows the first cultivation, this soil will become so compact that the ordinary surface cultivator simply scrapes the ground, leaving an almost impervious sub-surface strata. As more humus is introduced into these soils, the surface cultivator may come into more practical usefulness for laying by corn.

The following table gives the result of an experiment to determine the effect of shallow and deep cultivation as carried on by the Indiana Experiment Station.

Bushels Per Acre from Deep and Shallow Culture.

Depth of Cultivation.	Average of Eight Years.
About one inch deep	42.18 Bushels.
About two inches deep	42.36 "
About three inches deep	42.56 "
About four inches deep	37.92 " *

*Average for five years.

This experiment extended over a period of eight years with the one, two and three-inch cultivations, and five years with the four-inch cultivation. It will be seen that there was a decrease in the yield when the cultivation exceeded the depth of three inches. This experiment has been corroborated by the Iowa Experiment Station and in some parts of this state by farmers who have paid special attention to this investigation.

Deep cultivation tears the roots thus lowering the yield

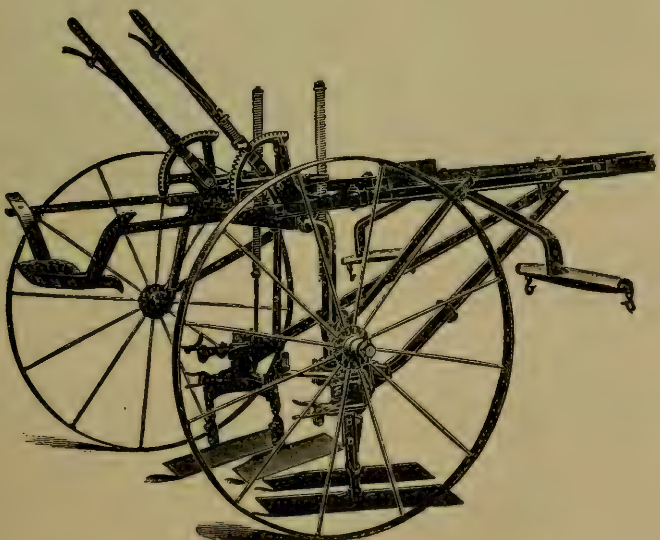


Fig. 92.
SURFACE CULTIVATOR.
These shovels are made to pulverize the surface rather than stir to any considerable depth.

According to Bulletin No. 13 of Illinois, the average of three plots for three years, 1888, 1889, 1890, at that Station, was 81.8 bushels per acre, when cultivated shallow. Three other plots cultivated deeply for the same time averaged 74.1, or an increase of 7.7 bushels in favor of shallow cultivation.

Frequency of Cultivation. The number of cultivations which a field of corn should receive during a season depends primarily upon the conditions of climate and soil. The growth of both corn and weeds is governed by the amount of rainfall and sunshine. Often in the fore part of the growing season, rainy weather will keep the teams out of the field until the grass has almost choked the corn. Clear days follow which push the corn forward so rapidly that not more than two cultivations are given to the field. A cold summer may hold the corn back so much that it is laid by after four cultivations and is yet under size.

Proper cultivation all-important

The key to the successful solution of this proposition is keen observation. There can be no set rule as to the number of times, other than that the corn should be kept free from weeds and grass, and that the surface of the ground should have the best possible mulch to conserve the moisture. Many fields suffer greatly from a lack of cultivation, either because a heavy carpet of weeds has been permitted to grow up, or because a great deal of moisture has been lost. There are, however, instances where cultivation is so frequent as to be detrimental. For example, in dry seasons when the rainfall is slight, there is nothing gained by continually cultivating the fields that already have a good dust mulch on their surface. There is such a thing possible as the surface becoming somewhat compact by lying for some time without being stirred, even though there is not much rainfall, but to keep continually cultivating corn in a dry season when there is a dust mulch already established, is only a means of stirring up the surface soil and permitting the air to penetrate deeper; thus drying it out to a greater extent than would have been the case had there been no cultivating at this time.

Cultivating may be done too frequently

There is no question but that many crops are cut short because of a lack of cultivation when the corn becomes too tall for the ordinary two-horse cultivator. The corn draws hardest upon the soil at the time when it is putting forth its silk and tassels and maturing the ear. When there is a tendency for the season to be dry, with an occasional shower, it would be very profitable to run a single-horse cultivator between the rows to keep the dust mulch established after the corn has become too high to use the two-horse cultivator.

A lack of cultivation very detrimental

At the Kansas Agricultural College, experiments were carried on to determine the advisability of frequent cultivation with the following results:

Times Cultivated During Season	Rate of Yield per Acre in Bushels			Total Average
	1891	1895	1896	
Once		23.42	37.62	30.32
Twice	68.03	30.88	44.42	47.77
Three times..............		26.45	43.77	35.11
Four times...............	76.06	20.77	48.94	48.59
Five times...............		20.51	48.27	34.39
Six times................	70.08	17.08	49.34	45.50

(Courtesy David Bradley) Fig. 93.

TWO-ROW RIDING CULTIVATOR.

Besides having four shovels to loosen up the soil, the front shanks are equipped with a short knife blade which cuts off the weeds next to the hill.

After investigating the frequency of cultivating corn for the years 1888, 1889, 1890, the Illinois Experiment Station concluded that no appreciable benefit was derived from frequent cultivation nor from cultivating after the ordinary season for cultivating was past. The soil on which this trial was made was a black, friable loam. (Bulletin No. 13, Illinois.)

Kinds of Cultivators. This is governed largely by the kind of soil, character of the land, and very often by the help which may be secured.

Fig. 94.
CULTIVATING CHECKED CORN THE FIRST TIME.
Note that considerable dirt is being stirred and the shovels run close to the corn. The shields keep the large pieces from falling on the hills.

Double row cultivators gaining in favor

In some of the more southwestern corn producing states, the double-row cultivators are frequently used and are found to be very practicable, being equipped with four gangs of four shovels each, and drawn by three horses. As one of these completes the cultivation of two rows each time it crosses the field, one man can cultivate about 15 acres a day. In many sections it is often difficult to obtain laborers when they are needed. With one of these two-row cultivators one man can practically do the work of two with single-row cultivators. The quality of the work may suffer some, however. Notwithstanding this, their use is likely to increase, especially in the comparatively level sections that are free from stumps and rocks. Most forms of these two-row cultivators are mounted on two wheels like two-horse, single-row cultivators. Very stumpy land or tall corn may necessitate the use of a one-horse cultivator.

Character of the soil determines cultivators that may be used

The kind of shovel that is best to equip either single or double cultivators with must be determined by the character of the soils, size of the corn, and size and nature of the growth of the weeds to be destroyed. Without exception, any shovel found to do good work on a one-horse cultivator can be attached to a double or two-row cultivator. For light, sandy land, sweeps are in favor. They are of various width, from six to 30 inches. The sweeps scrape along the soil at a depth of two inches, cutting off the weeds and allowing the surface soil to pass over them and fall level and flat behind the cultivator. The same result is accomplished with the double cultivator in New England where it is known as a horse-hoe or hoeing machine. This implement was originally made for tobacco cultivation, the long, horizontal blades or shears which extend toward the row from the uprights which fasten to the bean, serve well to reach under the tobacco plant and cut weeds and loosen the soil without breaking the leaves.

Four shovel cultivator too generally used

In general the four-shovel cultivator goes too deep for cultivating corn after the first time over. This is especially true if the weeds were destroyed with the first cultivation. The four shovel cultivator in fact plows the corn instead of cultivating it. Such treatment is ofen necessary to destroy the weeds, after which shallow cultivation should be practiced. This may be done by using small shovels, four to six on a side, or with the surface cultivator.

Surface should be left smooth

All forms of shovels should be so adjusted that the loosened soil will make a fine and even covering for the firmer soil beneath. Ridges left by the shovels make a larger surface for evaporation, and allow

Fig. 95.
"LAYING BY."
Cultivating the corn the last time. Inside shovels not set so deep because of the close proximity of the roots to the surface.

a deeper entrance of drying atmosphere into the soil. Some surface cultivators bear attachments for smoothing the ground as the machine passes along.

CULTIVATION OF LISTED CORN. It is an idea with many farmers of the districts where corn is checked entirely, that listing is a slack method of corn culture. In the past listing has been practiced most generally by farmers who grow large areas. Hence the methods of cultivation adopted have been those which accomplished most in the least time. This was often carried to excess, even to the detriment of the crop. Some growers harrow the ridges before the corn comes up, especially if the weeds start early. Others wait until the corn is two or three inches high and then harrow. By both of these systems, clods and corn stubs (if the old row has been listed out) are rolled into the furrow. In the former case these obstructions hold the sprout beneath the surface, and in the latter bury the little plant. In either case the weed seeds which were thrown out on the ridges away from the corn, are now returned to the furrow before the corn has had time to get ahead of their growth. Rolling with a heavy roller has some advantages in that instead of hurling the clods into the furrow, it simply pushes them down, crushing a great many. The idea of these last two methods is to level the ridge for the horses.

Harrowing corn

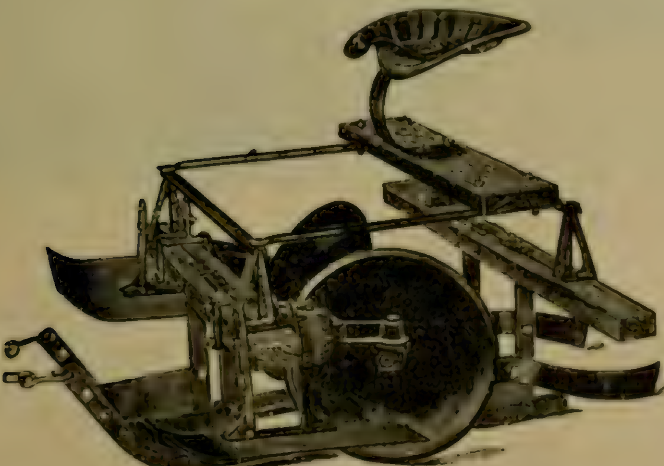
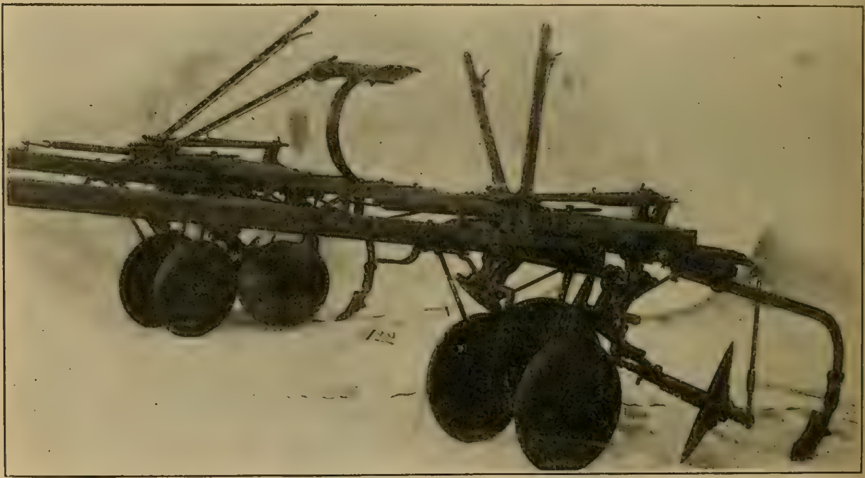


Fig. 97.
SINGLE ROW DISC CULTIVATOR WITH SLED AND KNIVES FOR LISTED CORN
This type of cultivator with varying attachments is commonly known as the "Go-Devil."

The "go-devil," as it is usually called in listed corn districts, has two heavy two-inch runners about eight inches high and 40 inches long which fit into the furrow. To the rear of these is a set of discs, two or three on each side, which may be set by a small lever placed near the seat. These discs throw dirt out of the furrow, or may simply loosen it. Two long fenders keep the corn from being covered. Such an implement, when set correctly, does very efficient work. There are a great many types of listed corn cultivators. Some have discs, some long knives. Two-row cultivators for listed corn are put up after these plans also. Some of these implements may also be used for the second time over the corn. Otherwise, the corn is often harrowed in the course of three or four days. This is a very efficient method because the first cultivation has loosened the soil.

Cultivators for listed corn



(Courtesy St. Joseph Plow Co.) Fig. 98.
TWO ROW LISTED CORN CULTIVATOR.

In certain sections the land is so very rolling that the two-row riding cultivators or one-row riding cultivators are too heavy. The four or six-shovel walking cultivator is used, either with very long shields or with a wooden or sheet iron trough dragging in the furrow. The second time over, the trough is replaced by smaller shields.

With listed corn machinery, as with all other corn implements, manufacturers have endeavored to reach perfection. The work of the two-row cultivators in northern Missouri bespeaks efficiency in ease of operation and in area covered for a given time.

In cultivating listed corn, especially where the field was only single-listed, a larger amount of dirt is moved and the shovels are set deeper in the ground. Deep cultivation when the corn is ready to lay by is less detrimental to listed corn, because the root system is much further down than in case of planted corn. Listed corn is slow in starting in the spring because its seed bed is lower down and not so warm. Many farmers become discouraged with the field of listed corn, because it looks yellow and spindling. But just as soon as it has been cultivated once, and especially after the second cultivation, the stalks begin to grow rapidly. The warm, dry weather of late summer pushes listed corn so much faster because its roots are drawing from a lower water table. This supply is most needed just when the ears are forming.

Deep cultivation less injurious to listed corn

Listed corn suffers less from drought

CHAPTER IX

THE CARE OF THE CORN CROP

HARVESTING AND STORING THE GRAIN

1. HARVESTING CORN IN THE EAR.
   - A. Stage of Maturity.
   - B. Time of Harvesting.
   - C. Methods of Harvesting.
   - D. Cost of Harvesting.
   - E. Methods of Unloading.
2. STORING CORN.
   - A. Principles Involved.
   - B. Cribs.
   - C. Shrinkage of Corn.

Fat and protein content remain constant in percentage

HARVESTING CORN IN THE EAR.—Stage of Maturity. It is a generally accepted theory that in plants of the grass family the percentage of fat increases and that of protein remains constant or decreases slightly with the advancement of maturity. Tests made at the Iowa State College show that the kernels increased in the percentage of fat from 2.18 per cent on September 14th to 4.93 per cent on November 2d. *The protein content decreased from 10.75 to 10.40 per cent between the same dates. Mature corn has a much larger percentage of carbohydrates stored in the kernel. The drying of the lower leaves and the turning of the husks from green to whitish in color, indicate the ripening of the ears. But the pith inside of the stalk holds its moisture a long time and keeps feeding the kernels. The kernels should be of a horny texture and husk well dried before being gathered.

Per cent of carbohydrates increases

*Bachelor's Thesis, Morris and Cohagen, 1907

Time of Harvesting. The season has much to do in prolonging the ripening period. A damp, cold autumn keeps the foliage green and sappy. Early drought hastens the curing of the stalk and leaves, and matures the ears. The effect of frosts is marked when the freezing is severe. Early varieties which are intended for immediate feeding may be husked before October 1st in most sections of the corn belt.

Immature, sappy corn will mold because of the large amount of moisture present. Corn husked in damp weather requires more aeration than when the atmosphere is dry and windy. To insure safe storage, October 20th to 25th is early enough. **Oct. 25 early enough**

Fig. 99.

THE COMMON METHOD OF HUSKING CORN FROM THE FIELD.

One man with team and wagon gathers two rows each trip through the field.

Method of Harvesting. Husking by hand is the chief means of gathering the bulk of the corn crop. One man, with wagon and team, will average 70 bushels per day in corn yielding 50 bushels per acre. Larger averages are made by many farmers in high-yielding fields. When no snow is on the ground and the husker is careful, very few ears are left in the field. Corn that has blown down badly can be gathered only by this method. **70 bushels per day by hand**

From time to time different patented machines have been manufactured for the purpose of harvesting corn in the ear. Most of them have proved very impracticable and wasteful. Where corn stands up well and the rows are of sufficient length to justify the use, the present cornhusker is a decided success. Besides the man to operate **Not as much waste by machinery as formerly thought** the machine and to drive the horses, (from four to six in number) two men and teams are required to haul the corn to the crib. There are some ears left, but where cattle and hogs are turned into the field during the winter and spring, little waste occurs.

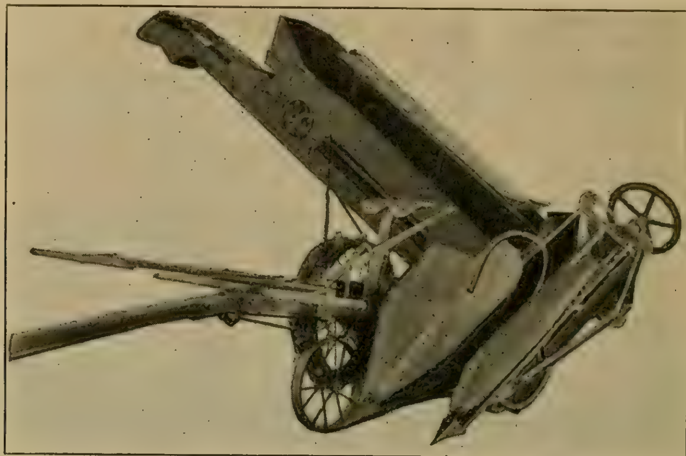


Fig. 100.
CORN PICKER AND HUSKER.
Used in larger fields, and is drawn by six horses.

2 to 5 cents per bushel

Cost of Harvesting. Not many years ago, corn growers of the central states hired men to husk their corn at two cents per bushel. Since then, the price has steadily raised until during the fall of 1906 four cents was the prevailing price in a few localities, some even paying five cents.

Very little cheaper by machinery

Owners of corn-gathering machinery report the cost per bushel between three to five cents. This depends upon the yield of the corn per acre as only from eight to ten acres can be picked daily. The use of a picker is not so much of a money saver as a time saver. Men can be hired to run a wagon by the side of the loader, who would be of little use as huskers themselves.

Methods of Unloading. The scoop shovel delivers most of the corn crop into cribs. To aid the shoveler, cribs are built with a series of doors in order that all of the corn need not be lifted so high. In some cases, where a double crib is used, an elevated driveway does away with considerable hard manual labor.

Where a corn grower has any considerable acreage to gather and store, the automatic unloaders are now almost indispensable. The power used is a gasoline engine, or more commonly the team off the husking wagon. After the wagon end gate is removed and the corn begins to fall into the hopper behind, the front end of the wagon gradually rises at the same time the corn is being elevated into the crib. A single crib may be filled from the side by moving several times. An overhead carrier is usually hung in the gable of a double crib, and chutes are arranged at intervals to transfer the corn to the cribs on each side. The time required depends upon the size of the load, the power at hand, and the pitch of the carrier. One farmer near Mason City, Iowa says that 40 bushels can be unloaded in four to five minutes. Another at Massena says he has unloaded 25 bush-

Unloaders are now used largely

(Courtesy Iowa State College)

Fig. 101.

CORN PICKER AT WORK.

Used in large fields where little turning is necessary.

els in three minutes. The fact that the husker does not have to shovel when arriving at the crib allows time to gather more corn. Ten bushels extra on an average can be so picked. One farmer reports unloading a 40 bushel load in seven minutes.

3 to 10 minutes required

STORING CORN.—Principles Involved. The principles of storing corn are:

(1) The admittance of as much air from the outside to come in contact with the corn as possible.

(2) The escape of the heated air in the crib rapidly and without interruption.

(3) The exclusion of moisture from the crib.

Stave fencing for cribs

Cribs. In the western states, where lumber is high in price and the elevators not within immediate reach, much corn is piled on the ground. As soon as the husking season is over, it is shelled and hauled to the elevators. Stave fencing has become so cheap and yet serviceable, that round cribs have been made from it which hold from 500 to 1,000 bushels. Two heavy posts are usually set in the ground about four feet apart. The fencing is then fastened to one post extended in a convenient circle, with a diameter of 12 to 20 feet and then securely stapled to the other post. A short piece as a sort of gate is left between the posts. This is easily opened at the time of shelling. The frozen ground, if cleared off well before the corn is thrown in, makes a comparatively smooth surface upon which to shovel.

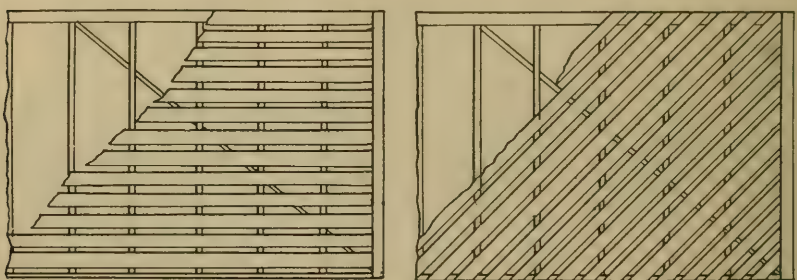


Fig. 103.
HORIZONTAL AND SLANTING BOARDS ON CORN CRIB.

Rail crib

In the east central states in the timbered sections, the familiar rail crib is no longer so often seen. The profits accruing from large fields all over the corn belt both east and west, have enabled the corn grower to build substantial structures in which to store his product. Then, too, as the farmer feeds his own crop very largely, he must be in position to keep it in good condition. Even the renter has capital enough to be able to hold back for a rising market.

Better cribs to-day

Well ventilated frame structures built on foundations of solid masonry and painted to prevent rotting have proved themselves to be of value. Different methods have been adopted to facilitate the circulation of air through the newly husked corn. Shafts at intervals through the center of the crib accomplish the required result. Tight boarding on the sides will never do. But for the best preservation of the corn, the floor should be far enough from the ground to allow free circulation of air. If the siding be put on vertically, or at an angle, there is less rotting of the studding and the rain water is carried off directly instead of being allowed to run down inside on the corn.

Cement Floor for Corn Cribs. *"I found from experience that grain, either shelled or in the ear, did not keep well on this cement floor because of the changing temperature of earth and cement, thus causing the vapor to condense on the surface of the cement. To avoid this trouble, I had to put down a wood floor over the cement, since which time my grain has been keeping perfectly. I placed on the cement joists of 2x4 stuff, wide side down, sixteen inches apart. On these was laid a hard pine floor, thus leaving a two-inch space between the cement and wood floor. Rats and mice have never attempted to harbor beneath these cribs, and I never have any fear, however great the weight, that the floor will spring and cause a leak. I would have no other kind of floor for crib or granary."

SHRINKAGE OF CORN. Because of the varying amount of moisture contained in corn at storing time, definite figures of the percent of shrinkage are not always reliable. The state of maturity and the condition of the weather at the time of gathering determine to a large extent, the water content.

Tests at Illinois. ** In tests at the Illinois Station with corn stored from November 11, 1905 to November 3, 1906, the total shrinkage was 12.9 per cent. Variations of from 9.0 to 20.7 per cent were found in trials for two years.

Tests at Illinois

Tests at the Iowa Station. ***According to tests at the Iowa State College, kernels of corn harvested September 14th, contained 41.78 per cent of water, while those gathered November 2d showed 17.83 per cent of moisture. These figures show the large amount of water stored in a crib of newly husked corn. In another test, corn gathered September 20, 1904, shrank 53.8 per cent by February 1, 1905, while ears gathered November 7th lost but 21.4 per cent in weight at the same time.

A small crib holding about one hundred bushels was built on a truck wagon. This was filled with ear corn during the husking season and careful weights taken at the dates indicated. The following table shows the results obtained:

*Nemaha County, Nebraska, I. W. P. Wallaces' Farmer, November 11, 1904
**Bulletin No. 50, Illinois.
***Thesis Cobagan and Morris, 1907. (Represents only laboratory tests)

*SHRINKAGE OF CORN BY YEARS AND MONTHS GIVEN IN PERCENTAGE.

Iowa Experiment Station.

Month	1898 1899	1899 1900	1900 1901	1902 1903	1903 1904	1904 1905	1905 1906	1906 1907	Av.	Mo. Rate
November	8.1	4.0	2.6	1.8	8.2	8.3	7.2	1.4	5.2	5.2
December	8.9	2.6	3.6	3.6	10.9	9.5	9.2		6.9	1.7
January	9.0	2.3	4.6	5.7	11.7	10.2	9.0		7.5	.6
February	10.1	2.7	5.9	6.0	12.6	10.5	11.6	3.1	7.8	.3
March	10.3	4.4	6.8	9.2	14.9	15.3	12.0	4.5	9.7	1.9
April	14.6	6.6	8.6	15.3	19.3	15.4	15.1	7.1	12.8	3.1
May	15.0	7.4	11.4	15.1	24.3	19.0	17.5	8.2	14.7	1.9
June	16.0	8.0	12.4	21.4	26.0	19.8	19.1	7.6	16.3	1.6
July	17.7	7.4	15.9	22.5	26.7	20.2	19.5	8.2	17.3	1.0
August	18.0	7.1	15.0	22.6	29.5	21.2	18.7	8.6	17.8	.5
September	19.9	7.6	14.0	24.8	30.5	20.6	19.3	8.9	18.2	.4
October	19.7	7.9	13.6	24.9	30.0	20.8	19.3	9.5	18.2	.0

Average shrink of 18.2 of 8 years of tests

As shown by above, with the exception of November, the most rapid shrinkage is during the months of April and May.

1906 will be remembered as the year of the greatest corn crop ever grown in Iowa. The yield was heavy and the corn was well matured before freezing weather. The corn contained very little moisture, as shown by the test.

Fig. 104.
PORTABLE GRAIN ELEVATOR.
Easily moved from one crib to another.

*Shrinkage begins the last of October each year and percentage taken each month. In 1901-02 corn of the previous year used but not recorded.

The crops of 1899 and 1906 will be noted as very well matured. The crop of 1903 will always be remembered as the "year of the soft corn."

Tests in Other States. *"Three joint owners of a tract comprising 6,000 acres of land, decided to make a careful test and determine exactly how much corn does actually shrink in weight when husked and cribbed under such conditions as are usually found on the ordinary farm. To this end, they erected, in the center of the tract mentioned, a double crib, 26 feet wide by 250 feet long and 10 feet high at the eaves, with a driveway 8 feet wide through the center, and a and a good, tight roof over all.

Near one end of this crib a small office was built and a set of standard scales put in. Husking began October 22d and ended December 17th. Every day while it was going on, every pound of corn that went into the crib was weighed and recorded. The quantity put in footed exactly 16,155 bushels of 70 pounds each. From November to March, the price offered for corn by local dealers was 38 cents per bushel of 70 pounds. June 1st, the price went up to 52 cents and the corn was sold, to be delivered at the elevator, three and one-half miles distant, early in July. When the time for delivery arrived, the corn was weighed as it came out of the crib, and it was again weighed at the elevator, the total weight at the two places varying but a few pounds. The corn weighed 14,896 bushels and 40 pounds when taken out, showing a total shrinkage of 1,259 bushels or a small fraction less than 7 3-4 per cent. A Kansas test

It will be seen that if these men had sold the corn immediately after husking, it would have netted them $6,138.90. By holding it until it was sufficiently cured to be handled safely in great bulk, and the lakes and other waterways were open to traffic, they realized $7,746.12 or $1,606.22 more than if they had allowed themselves to be frightened by the great "shrinkage bugaboo."

In 1893, a Farmers' Club in Pennsylvania adopted a resolution asking the members to make a test and find out by actual weight how much corn would shrink or lose weight from husking time until the next June 1st. In accordance with that resolution, ten farmers reported the shrinkage from November 1st to February 1st as 8 2-3 per cent; the shrinkage from February 1st to June 1st as 2 2-3 per cent, or from husking time to June 1st next, 16 2-3 per cent. The following year a similar test showed a shrinkage of 16.5 per cent. Test in Pennsylvania

*F. D. Coburn, Report Kansas State Board of Agriculture, 1896

Shrinkage of Old Corn. Tests at Illinois showed but .9 per cent shrinkage in the second year of storage of ear corn.

Little shrinkage the second year

Will it pay to hold corn for May prices in view of shrinkage? Figuring on the basis of the average price No. 2 (cash) corn at Chicago for a period of years from 1873 to 1906 inclusive, the following results are brought out:

The highest average price in May for this period was 47.5 cents; the lowest average 40.6 cents, or average of averages, 44.05 cents. For December for the same period the figures are 46.2 cents highest, 40.4 cents lowest, 43.4 cents average. In December a bushel of 70 pounds would be worth, on this basis, 43.4 cents. By May, according to the figures of the Iowa Station for 1904, which are representative, that bushel would have shrunken 18.2 per cent, or 12.74 pounds, leaving to be sold at that time 57.26 pounds. The May price is 44.05 cents per bushel or .63 cents per pound. .63 cents per pound for 57.26 pounds would be 36.07 cents for the bushel, which could have been sold in December for 43.4 cents. This would be a net loss of 7.33 cents on the bushel. Figuring the same shrinkage on corn in December, 80 pounds per bushel, a loss of 2.14 cents per bushel would result.

By taking a shorter, more recent period, it is found that the margin is not very much in favor of May corn, not enough, in fact, to counterbalance the shrinkage. The average price in December between 1901 and 1907 inclusive, was 50.3 cents per bushel at Chicago, that of May for the same period was 51.9 cents.

ACKNOWLEDGEMENTS

The Bachelor Thesis of Morris and Cohagan (1907) was drawn upon, it being very applicable.

In securing facts regarding the methods of unloading, the corn growers of Iowa have been very free to furnish information.

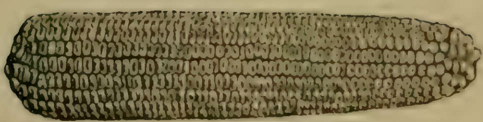
The shrinkage experiments at the different Experiment Stations have been freely quoted.

The Report of Kansas State Board of Agriculture for 1896 has furnished very practical data.

COLLATERAL READING

Corn Harvesting Machinery,
U. S. Department Bulletin No. 173.

The Shrinkage of Ear Corn in Cribs,
Illinois Bulletin No. 113.
Moisture in Corn,
Iowa (Press).
Shrinkage of Corn,
Farmers' Bulletin No. 210.
Shrinkage of Corn,
U. S. Department Bulletin No. 317.
Kansas Bulletin No. 147.



CHAPTER X

THE COST OF GROWING CORN

Very few accurate figures are available on cost of production

In the past, corn growers as a class have not kept accurate figures regarding the cost of production. Profits have accrued because of the broad margin between the cost of production and the selling price. The fertility of the soil, the cheapness of labor, and the access to larger areas, were factors which tended toward profits, no matter how small the crop. The reverse of these conditions has driven men to thinking and figuring. No such large areas are now available for despoilation in extensive slipshod methods. Labor demands almost excessive payment for the number of hours actually employed. The virgin soil no longer yields abundantly year after year without return of manure and rotation of crops.

The solution of the problem is increased yield and economy of production. Conservation of the soil fertility by feeding the crops on the farm, thus returning nearly all of the elements of plant food in an available form, better cultural methods, eradication of weeds, the use of labor-saving machinery and the breeding of the best corn adapted to the locality, will accomplish these results. Some estimates are here given regarding the cost of producing corn in different parts of the corn belt.

AMERICAN AGRICULTURIST AND ORANGE JUDD FARMER ESTIMATES

The following discussion is taken from the compilation by Myrick, in the "Book of Corn." It is here reprinted because of the thoroughness and comprehensiveness of the investigation. Each point developed is backed up by facts and figures.

Results of a day to day record

In 1897 these journals published a series of articles upon the cost of growing corn, based upon data furnished by growers who had kept detailed records of all items of cost connected with their crop in 1896. Up to that time no systematic and scientific effort to determine on any large scale the cost of production of any staple farm crop had ever been made, and most erroneous estimates of this cost were currently accepted. The method adopted to secure the necessary data was simple and effective. A large number of corn growers were induced to keep an actual day-to-day record, upon a specially prepared blank, showing the exact amount of labor and other expense bestowed upon a certain definite area, and when the season was over these records were consolidated and the results averaged.

Investigation of eight states

This investigation covered but eight states, and it was determined to carry on a second investigation which should include systematic results typical of the conditions under which corn is grown in all sections of the country. The original plan of securing actual day-to-day records was adhered to and the circulars so arranged as to secure the exact record of all expenses attached to the growing of the crop, from fertilization and preparation of the soil through the whole season's work, in the order in which it was performed, up to the cribbing of the crop. These circulars were in the hands of the growers before the first plow entered the ground, and continued in their possession until the crop was gathered.

In tabulating these individual records only those absolutely complete and perfect were used, these covering 4,051 acres, located in 156 counties of 21 states. In this area was included corn grown under various methods practiced in different parts of the country, so that the averages presented do not represent the cost under any particular method, but an average of the various methods.

What is cost?

What is the Cost? In analyzing the data secured by this investigation, the term "cost of production" is used in its popular significance, as representing the actual outlay or the amount of capital actually used up and which must be replaced before any profit upon the fixed or permanently invested capital can be secured. In the tabulations to be presented, this covers taxation, labor and labor maintenance, fertilizing material, seed, team maintenance, and depreciation of machinery and horses. Land, horses, and machinery are treated as permanent capital, and an allowance of interest on this permanent investment is not considered as part of the cost of production, but the net profits on the crop after all the circulating capital which has been used up has been replaced, is taken as the profit of production, and therefore is the interest returned on the permanent investment.

Labor and Wages. The great bulk of the corn crop is produced by the labor of the owner of the crop. Some hiring is done in stress of work, but this usually supplements the labor of the owner. In figuring labor cost, the rate of wages paid where hiring is done by the day is used, the assumption being that the owner is entitled to charge his labor at the highest local market price. By common custom in every community, there is a wage rate for labor with board furnished and another where the laborer boards himself. The difference between these two rates represents the value or cost of maintenance as determined by experience and custom. In this investigation, cost of wages and cost of maintenance of labor are figured together by making the wage basis the rate of wages per day without board. Having the number of day's labor given to each operation pursued in the growing of the corn crop and the average rate of wages per day without board, the cost of labor and labor maintenance becomes a simple matter. The average wages per day without board ranged from 60 cents in Virginia to $1.50 in Maine, averaging for the 21 states $1.10.

Rates of wages

Teams and Maintenance. The meaning of team is not the same in all districts or in all operations. It may be two, three, or more horses. To bring the various customs to a common basis, the number of horses used in any operation is reduced to a common standard of teams of two horses. As an illustration, if four horses were used to plow in a given crop, it enters into the calculation as two teams. The horse power used in making the crop may be regarded from two standpoints. Wage allowance may be made for their services on the basis of the rate usually paid where horses are hired. The second way of considering the horse power is regarding the necessary complement of horses on the farm as part of the permanently invested capital. Beyond question this is the proper method. On this basis annual cost of team maintenance and an allowance for depreciation is the proper charge against the crop. This charge may be made in two ways. The first is to ascertain the average cost per day of team maintenance, charging the corn crop with maintenance only for those days in which the team is actually engaged in the work of producing the crop. This plan would be followed upon the assumption that the horses of the farm are constantly engaged in some form of farm work, and that the cost of their keep and care each day should be charged to the work then engaged in. The objection is that horses are not employed equally day by day and their maintenance in their days of idleness must be charged to some portion of farm work.

Meaning of team

The other plan of charging for horse power, which is considered the most equitable, is to divide the annual cost of maintenance by the total acres of cultivated land in the farm. The whole cultivated area shares in their work, and should share in the cost of keeping them. In the same way, their annual depreciation should be shared by the farm as a whole.

Cost of teams

The data submitted, showing monthly feeding of hay, grain and other feed, made the average cost per month of maintenance a team of two horses $8.21, with a range from $12.91 in Massachusetts to $5.98 in Nebraska.

Horse Power and Machinery. The horse on the farm is what steam is to the manufacturer—power. Horses are therefore properly part of the permanent capital of the farm. Treated in this way, the charge for horse power in crop production is the annual cost of their maintenance and the annual depreciation of their value. The farms included in the schedule of this investigation aggregated 26,522 acres, the number of horses required in conducting the farming operations was 781, their total value being $39,525, an average of $50.60 per head. The value per farm acre of the horses necessary to farming operations was $1.49. The monthly cost of team maintenance, as shown above, was $8.21, making the annual cost of maintenance or the necessary complement of horses for the farm work $38,472, or a cost per farm acre of $1.45.

Value of horses for each acre of land

Taxation. The rate of taxation per acre of the farm is ascertained by securing the total taxation on the land, buildings, stock and implements, the fixed capital and apportioning the taxes equitably between this total farm value and the value of the corn land alone. The average rate of taxation is 28.3 cents per acre, ranging from 3 cents per acre in Virginia to 79 cents in Massachusetts. This seems a wide range, but when the value per acre of the land is considered the taxation is more equitable, being .6 of one per cent of the value in Virginia and 1.3 per cent in Massachusetts.

Rent, Implements and Interest. The average cash rental per acre of land similar to that reported upon was returned at $3.05, ranging from $1.00 in Virginia to $5.25 in Pennsylvania. The average value per acre of the corn land was returned at $47.71, and on this valuation the cash rents equal 6.4 per cent. The average rate of interest at which loans could be secured was reported at 7.1 per cent, ranging from 5 per cent in New England to 10 per cent in Texas.

Capital invested in farm implements

The quality and effectiveness of farm implements varies greatly and the amount of fixed capital invested in such machinery varies equally. From the data submitted, it appears that the average investment required to furnish implements for a 40 acre corn field was $83.59, or $2.09 per acre, ranging from 87 cents per acre in Virginia to $2.62 in Iowa. The average effective life of such implements was a fraction over ten years, thus fixing the allowance for depreciation of implements at 20.9 cents per acre. This allowance includes repairs necessary during the life of the implements.

Labor and Its Statistical Treatment. The amount and character of labor required to make a corn crop necessarily varies according to the cultural methods followed. In the 4,051 acres included in this investigation various cultural methods were used. As an average must include all methods, the total amount of labor required to perform a certain operation is distributed over the total area, although actually the labor was performed on only a part of the acreage. For example, it was necessary to remove stalks on only 1,672 acres, but the labor cost of the different operations is grouped into certain fundamental divisions of culture according to the result aimed at by the operation in question. The term "labor cost" as used in this analysis includes wages and labor maintenance, but does not include cost of team maintenance, that being included later in the tabulation as a separate item.

Removing Stalks. When corn is grown two years in succession, the first work of preparation is the removal of old stalks. Cutting up and carrying off was practiced on 784 acres, requiring 91 1-2 days of labor and 76 days of team service. The actual accomplishment was 8.6 acres per day of labor. Breaking, raking and burning was practiced on 889 acres, requiring 92 days of labor and 79 3-4 days of team service, the average accomplishment being 9.7 acres per day's labor.

Labor required in plowing

Plowing. Of the 4,051 acres, 3,491 were plowed, the remaining 560 acres being listed in. To plow 725 acres in the fall required 293 days of labor with 382 days of team service, or an accomplishment of 2.47 acres per day's labor. The discrepancy between days of labor and days of team service is of course due to the fact that more than two horses were frequently used to the plow, and in all such cases team work is stated in the equivalent of two horses. The spring plowing of 2,766 acres required 1,154 3-4 days of labor and 1,479 days of team service, an accomplishment of 2.4 acres per day's labor.

Difference in methods of putting in corn

Harrowing. The amount of work done in the way of harrowing, discing, rolling, dragging and otherwise preparing the seedbed varies greatly in local practice. Instances appear in the schedule where the field was worked seven times, while in other cases only one working was given. Of the 4,051 acres, harrowing or other similar preparation was practiced on 3,280. As only 560 acres were listed this leaves 211 acres on which planting followed plowing with no effort to prepare the seedbed. It required 496 3-4 days of labor and 668 1-4 days of team service to accomplish the harrowing, or an average of 6.6 acres per day's labor.

Listing. This method of planting is little practiced except in Kansas and Nebraska. Under the proper soil and climatic conditions it is desirable, and so far as the amount of labor required is concerned it is far cheaper than the usual practice. In this investigation 560 acres were listed, requiring 92 1-2 days of labor and 119 1-4 days of team service, the accomplishment per day's labor being 6.1 acres. Listing a cheaper method

Fertilizing. The percentage of the total corn acreage which in any year is fertilized by the direct application of fertilizing material is so small as to hardly merit consideration. Where this is done at all it is usually thus treated once in a series of years, so that the full cost of such treatment cannot properly be charged to a single crop following. The usual method of maintaining fertility is by devoting the land occasionally to some renovating crop, like clover, and when this is done it is obvious that some allowance must be made for the less valuable product of the land in that year, but what that allowance should be cannot be determined with accuracy. Maintaining fertility

In this investigation allowance has been made only for fertility directly applied, and in such cases the full cost has been charged to the crop in question. This course undoubtedly makes the charge allowed for fertilizing higher than it actually averages, but no other course seems open without the introduction of personal estimate into a calculation which is intended to be an actual record. In the schedules fertilizing was reported on some parts of 1,639 acres, requiring 635 1-4 days of labor and 483 1-4 days of team service. There were used 9,100 pounds of commercial fertilizer, costing $86.85, and 5,977 loads of home-made material valued at $2,313.95.

Planting. Planting methods included the whole range from hand dropping and hoe covering to the use of hand planters, and up through machines of varying efficiency to the best modern horse planters. As a result the efficiency of a day's labor varies widely, from .71 of an acre in New Hampshire to 12.44 acres in Nebraska. The acreage regularly planted was 3,491 acres, requiring 442 1-4 days of labor and 375 3-4 days of team service—an average accomplishment of 7.89 acres per day's labor. 7.89 acres one day's planting

1.76 acres one day's cultivation

Cultivation. The cost of cultivation differs more than any other operations, owing to the differences in implements used, and to different degrees of care and labor given the crop. The whole area, 4,051 acres, was cultivated twice; 3,991 acres were cultivated three times; 2,515 acres received a fourth cultivation, while 442 acres were given additional cultivation. To perform the total amount of cultivation given to the crop, for the record required 2,296 1-2 days of labor and 2,297 1-2 days of team service. The average performance per day's labor was 1.76 acres; this, of course, representing the total cultivation given to this breadth during the whole season. A day's labor sufficed to cultivate about 6.6 acres.

1.22 acres one day's husking

Gathering and Cribbing. Two methods are followed; first, cutting up and shocking, then husking from the shock; second, husking from the standing stalk, the stalks left standing in the field to be pastured down. In this investigation 2,976 acres were husked standing, requiring 2,438 days of labor and 2,264 days of team service, the accomplishment being 1.22 acres per day's labor, this including cribbing as well as husking. Of the crop cut up, 659 acres were done by hand, requiring 595 3-4 days of labor, or 1.11 acres per day. Husking from the shock was practiced on 651 acres, excluding 212 acres by contract, requiring 1,223 3-4 days of labor and 382 1-2 days of team service, or an accomplishment in husking and cribbing of .53 acres per day's labor.

$2.30 per acre value of fodder

Fodder. The value of fodder as a by-product must be taken from the gross cost of growing the corn crop. Where the crop is cut and shocked, the value of the fodder is an important item, but where the crop is husked standing the value of the stalks for pasturage is slight. Fodder was shocked on 945 acres, and this product was returned as worth $2,174.70 in the field, or an average value per acre of $2.30 where the fodder is cut. On the 3,106 acres, where the crop was husked standing, the selling value of the pasturage privilege was estimated by the owners at $990.60, or an average of 32 cents per acre. The aggregate valuation of fodder production by both methods was $3,165.30, or an average per acre of 78.1 cents.

Production. The total production of corn was 158,815 bushels, or 39.2 bushels per acre.

With the preceding analyses of the methods followed in this investigation, the following table is presented as a fair showing of the cost of producing the corn crop on the 4,051 acres included in these schedules.

ORANGE JUDD FARMER CONCLUSION AS TO THE COST OF GROWING CORN.

	Acres so Treated	Total Cost	Actual Cost per Acre	Av. Cost per Acre whole Area
Cutting Stalks	784	$ 108.60	$ .139	$
Breaking stalks	889	110.13	.124	.054
Plowing	3,491	1,723.48	.494	.425
Harrowing	3,280	583.86	.178	.144
Listing	560	110.46	.197	.027
Fertilization	1,639	3,275.89	1.999	.809
Planting	3,491	519.84	.149	
Replanting	1,086	108.69	.100	
Seed	4,051	332.35	.082	.082
Cultivation	4,051	2,752.44	.679	.679
Husked standing	3,106	3,120.76	1.005	
Cut by hand	730	725.45	.994	
Cut by machine	215	95.55	.444	
Husking from shock	867	1,616.95	1.865	
Taxation	4,051	1,147.78	.283	.283
Team maintenance				1.450
Depreciation of machinery				.209
Depreciation of horses				.149

Total annual investment	$5.838
Less value of fodder	.781
Actual cost per acre	$5.057
Cost per bushel (39.2 bu. per acre)	.129

Cost with Allowance for Interest on Investment. It has been previously pointed out that in determining cost of production no allowance is made for interest on capital permanently invested. The difference between the annual investment and the value of the crop produced represents the profit of production or the percentage of gain on the permanent investment. For the benefit, however, of those who desire to include interest or rent, the following table is presented, showing the proper allowance for interest on capital invested, at the rate of six per cent:

COST OF PRODUCTION WITH INTEREST INCLUDED.

Annual investment (details above)	$5.057
Interest on machinery investment	.125
Interest on value of horses	.089
Interest on annual investment	.303
Interest on value of land	2.862
Total	$8.436
Per bushel	.215

Conclusion. The tabulations which have preceded have included every item of cost of production except an allowance for annual repairs of buildings, fences and farm roads, insurance and superintendence. The allowance for these items must necessarily be a matter of opinion only. Leaving them out, the data presented show that the cost of producing a bushel of corn of the crop under record may be fairly placed at 12.9 cents.

12.9 cents cost of one bushel

OTHER ESTIMATES

In Wisconsin. The Commissioner of Statistics for Wisconsin presents the following very valuable data gathered from a great number of representative farmers of the state:

Plowing	$ .535
Fertilizing	.69
Harrowing, etc.	.23
Planting	.143
Seed	.08
Cultivation	.677
Cutting	.93
Husking	1.34
Shelling	.55
Marketing	.56
Taxation	.256
Team maintenance	.867
Depreciation of machinery	.429
Depreciation of horses	.125
Other expenses	.50
Total	$7.912
Less fodder value	3.00
Total cost per acre	$4.912
Cost per bushel (42 bushels per acre)	$ .117

Adding the allowance for interest on permanent investment, the statement becomes:

	Per Acre.
Annual investment (details above)	$4.912
Interest on machinery investment	.257
Interest on value of horses	.075
Interest on annual investment	.475
Interest on value of land	2.64
Total	$8.359
Per Bushel	.199

In Kansas. Mr. J. W. Robinson, of El Dorado, Kansas, presents the following details of the cost of his corn crops and the prices at which he has the raising of 1,500 acres arranged for in the season of 1896, and 1,200 acres more he will raise in the ordinary way with his own teams.

COST OF RAISING CORN BY CHECK-ROWING.

	Per Acre.
Plowing	$1.00
Twice harrowing	.20
Planting	.25
Four cultivations	1.20
Cutting weeds	.10
Land rent	3.00
Husking or shocking 40 bu. at 3 cents	1.20
Total	$6.95

At 40 bushels per acre, cost per bushel, 17¼ cents.

COST OF RAISING CORN BY LISTING.

	Per Acre.
Listing	$ .30
Twice harrowing	.20
Four cultivations	1.20
Cutting weeds	.10
Husking or shocking 40 bushels	1.20
Land rent	3.00
Total	$6.00

At 40 bushels per acre, cost per bushel, 15 cents.

15 cents cost of producing one bushel Kansas

From estimates of actual corn growers in every county in Kansas, the highest cost was $8.63 per acre and the lowest $4.10 per acre.

At Illinois. The Illinois Experiment Station* found the cost of producing a bushel of corn in that state in 1896 to be 16.1 cents. This is omitting rent of the land. The data was based upon estimates made by 316 farmers over the state. The lack of reliability in the report is due to the fact that the inquiry was made in 1897 concerning a crop which had already been disposed of.

16.1 cents Illinois

A very complete account of the cost of the corn crop in the State of Illinois is here given as taken from the reports of the Chicago Board of Trade:

*Bulletin No. 50.

DIVISIONS OF STATE.

	Northern.		Central.		Southern.	
	1905.	1906.	1905.	1906.	1905.	1906.
Number of Counties.	33	33	35	35	34	34
Price per Bushel.	39.0	37.0	38.6	36.5	37.0	37.3
Highest Cost per Acre.	14.10	12.40	10.95	10.95	10.65	10.65
Lowest Cost per Acre.	7.15	7.15	6.55	6.55	5.30	5.30
Highest Yield Bushels.	50	53	65	60	42	40
Lowest Yield Bushels.	30	27	32	23	20	17

INDIVIDUAL ESTIMATES OF COST

.146 Sibley Estate

Sibley Estate. There are many methodical farmers who realize the importance of knowing what it costs them to produce their crops, and such men possess data which answer the question of cost of growing so far as their own well managed farms are concerned. The Hiram Sibley estate at Sibley, Illinois, a notable example of large and well managed farming operations, has accurate records of cost of production of its crops. The manager, Mr. F. A. Warner, has submitted the following figures showing the cost of growing a crop of sixty acres of corn upon the estate:

Cost of Producing Corn on Sibley Estate, Sibley, Illinois.

Fall plowing 45 acres at $1.00 per acre	$ 45.00
Spring plowing 15 acres at $1.00 per acre	15.00
Breaking stalks on 15 acres	3.00
Discing on fall plowing, 45 acres	18.00
Harrowing	10.50
Seed corn, 9 bushels at 75 cents	6.75
Planting	12.00
Harrowing after planting	10.50
Cultivating three times	78.00
Thinning and weeding	10.00
Husking at 2½ cents per bushel	62.25
Shelling and hauling at 2½ cents per bushel	62.25
Total cost	$333.25
Taxes	20.00
Insurance and repairs	10.00
Grand Total	$363.25
Cost per bushel (41.5 bushels per acre)	.146

This cost is figured on the basis of the actual accomplishment per day's labor; labor being charged at the rate of $2.50 per day for man and team and 50 cents per day for extra horses, where used. This wage includes the board and keep of man and team.

The crop was 2,490 bushels, making the average yield per acre 41.5 bushels, and the cost per bushel 14.6 cents. The land was valued at $80.00 per acre, or $4,000 for the field, and if interest be allowed on this investment at the rate of 6 per cent, it raises the cost of the crop to $651.25 and the cost per bushel to 26.2 cents.

Standard Cattle Company.

COST OF GROWING CORN ON STANDARD CATTLE COMPANY'S FARM, AMES, NEBRASKA, 1891-1900.

	1891.	1892.	1893.	1894.	1895.	1896.
Acres.	1,825	1,825	1,325	1,792	1875	2,462
Bushels.	42,000	51,344	60,028	41,001	76,154	169,031
Bushels Per Acre.	23.0	28.0	45.3	22.8	40.6	68.6
Operating Expenses.	$8,134.20	$8,479.97	$8,966.30	$12,930.33	$17,217.48	$27,593.40
Value of Stover.	———	———	$1,312.00	$7,165.00	$4,296.00	$9,320.70
Net Cost.	$8,134.20	$8,479.97	$7,653.80	$5,765.33	$12,921.48	$18,272.70
Cost Per Acre.	$4.46	$4.67	$5.78	$3.22	$6.89	$7.42
Cost Per Bushel.	$ .194	$ .165	$ .127	$ .141	$ .170	$ .108

	1897.	1898.	1899.	1900.	Total.
Acres.	2,717	3,431	1,644	2,735	21,631
Bushels.	111,932	108,090	60,837	124,995	845,412
Bushels Per Acre.	41.1	31.5	35.9	35.0	39.1
Operating Expenses.	$22,346.00	$28,278.49	$15,275.80	$25,451.00	
Value of Stover.	$13,446.00	$10,900.00	$ 5,862.00	$10,000.00	
Net Cost	$ 8,900.01	17,278.49	$ 9,413.80	$15,451.00	$112,270.78
Cost Per Acre.	$3.28.	$5.04.	$5.73.	$5.65.	$5.19.
Cost Per Bushel.	$ .079.	$ .160.	$ .155.	$ .124.	$ .133.

SOME IOWA FARMERS' ESTIMATES

L. C. Greene, Johnson County.

On the Basis of an Acre	$11.05
Preparation of sod or breaking stalks	1.00
Plowing	1.25
Harrowing before planting	.20
Planting	.25
Harrowing after planting	.20
Four cultivations	1.40
Husking	1.75
Interest on ninety-dollar per acre land	4.50
Taxes	.50
Total	$11.05

18.5 Iowa Green Co. At 60 bushels yield per acre, the cost per bushel equals 18.5 cents; at 40 bushels, 27.5 cents.

John Sundberg, Monona County.

On the Basis of a Bushel	14 cents
Cutting stalks (man and team)	4 mills
Wear on cutter	1 "
Rake and burning stalks	4 "
Discing ground	16 "
Wear on disc	1 "
Listing for corn	10 "
Wear on lister	1 "
Planting the corn with planter	4 "
Wear on planter	1 "
Cultivating first time	4 "
Harrowing once	5 "
Cultivating three times	12 "
Wear on cultivator	1 "
Hoeing	1 "
Harvesting	40 "
Land and taxes	32 "
Wear on wagons	1 "
Fence	15 "
Axle grease and oil; some breakage	1 "
Total	140 mills

14 Cents Iowa Monona Co.

F. H. Klopping, Pottawattamie County.

Basis of an Acre	$5.60
Breaking and raking stalks	$ .17
Plowing	.80
Harrowing three times	.20
Discing two times	.30
Planting	.18
Cultivating four times	1.60
Husking corn	1.80
Interest on machinery and horses and deterioration of same, about	.45
Interest on land	.10
Total	$5.60

14 Cents
Pottawattamie Co.
Iowa

With a 50 bushel crop the cost per bushel would be 11.2 cents. A yield of 40 bushels would cost 14 cents per bushel.

Fred Woolley, Decatur County.

Field No. 1—Fall Plowed Sod.

On Basis of Acre	$10.15
Rent of land	$ 4.00
Plowing	1.50
Harrowing three times at 15 cents	.45
Discing two times at 30 cents	.60
Seed Corn	.35
Planting	.25
Plowing three times at 40 cents	1.20
Cost of husking (yield 45 bushels) at 4 cents	1.80
Total	$10.15

22.5 cents
Decatur Co.
Iowa

Yield 45 bushels, cost per bushel 22.5 cents.

Field No. 2—Spring Plowed Sod.

Add the cost of another discing and figure on five bushels less per acre in yield.

Field No. 3—Spring Plowed Stalk Ground.

Basis of Acre	$ 8.45
Rent of land	3.00
Plowing the ground	1.25
Harrowed two times at 15 cents	.30
Discing two times at 30 cents	.60
Discing once after plowing	.30
Seed corn	.35
Planting	.25
Cultivating three times at 40 cents	1.20
Husking (yield 30 bushels) 4 cents	1.20
Total	$ 8.45

25 cents
Jefferson
County

Thirty-bushel yield, cost of one bushel 22.8 cents.

W. A. Hook, Jefferson County.

10 dollars per acre, or 25 cents per bushel.

D. L. Pascal, Clinton County.

Basis of Acre	$ 9.75
Plowing	$ 1.35
Harrowing	.30
Planting	.30
Seed	.30
Cultivating	2.50
Rent	5.00
Total	$ 9.75

28.4 cents Clinton County

Add to this 4 cents per bushel for husking, the amount depending upon the yield. A 40 bushel yield at 4 cents per bushel would add $1.60 to the $9.75, or a total of $11.35. This would be 28.4 cents per bushel.

George M. Allee, Buena Vista County.

Basis of 40 acres.

40 bushels per acre or 1,600 bushels.

$3.00 cost of a day's work, man and team.

Hauling manure	6 days
Breaking stalks with harrow	2 "
Plowing (2½ acres per day)	16 "
Harrowing twice before planting (20 acres per day)	4 "
Planting (10 acres per day)	4 "
Harrowing after planting	2 "
Cultivating (6 acres per day), 3 times over	20 "
For rainy days, break downs and probable discing	6 "
Total	60 days

60 days at $3.00 per day	$180.00
Seed corn (8 bushels) at $1.00 per bushel	8.00
Use of tools, $1.00 per day for corn planter (4 days)	4.00
50 cents per day for harrow, cultivator and plow (44 days)	22.00
Breakage, hire of extra horses, use of manure spreader	8.00
Interest on wages at 8 per cent for 6 months	8.88
(Neither rent nor husking paid in advance)	
Rent ($3.25 per acre)	130.00
Husking (3½ cents per bushel, 1,600 bu.)	56.00
Total	$416.88
Stalks value	20.00
Net Cost	$396.88

24.8 cents Buena Vista County Iowa

$396.88 for 1,600 bushels, or 24.8 cents per bushel.

Fred McCulloch, Iowa County.

Forty Acres of Sod Plowed in Spring of 1906.

Nine loads of manure per acre

40 days for 1 man and 3 horses at $3.50 per day	$140.00
Plowing sod (40 acres) 2 men and 3 teams, 8 days	56.00
Discing three times, 1 man and 2 teams, 6 days	35.00
Harrowing four times, 2 teams, 6 days	30.00
Planting, 1 man and team, 2½ days	7.00
5½ bushels seed corn at $2.50 per bushel	13.75
Cultivating five times, 1 man and team, 30 days	90.00
Husking, 70 bushels per acre, or 2,800 bushels at 3 cents per bushel	84.00
Rent	125.00
Total	$580.75

20 cents
Iowa county
Iowa

A fraction over 20 cents per bushel.

Neal Brothers, Linn County.

Twenty acres of corn stalk ground.

This ground should be disced and harrowed; then plowed, following the plow with the harrow, disced crosswise to furrow and harrowed; planted and harrowed at least three times before it comes up; then cultivated four times. With good seed on good, average ground, corn raised in this way should yield from 60 to 90 bushels per acre.

This makes the ground disced twice, plowed once, harrowed six times, planted and cultivated four times, or in other words, 40 acres disced, 20 acres plowed, 120 acres harrowed, 20 acres planted and 60 acres cultivated.

1 man and 3-horse plow, nearly 3 acres per day for 7 days, at $4.00 per day	$ 28.00
1 man and 3 horses harrow 30 acres per day for 4 days, at $4.00 per day	16.00
1 man and 3 horses disc 20 acres per day for 2 days, at $4.00 per day	8.00
1 man and 2 horses plant 20 acres in 1 1-4 days	4.00
1 man and 2 horses cultivate 8 acres per day for 10 days, at $3.00 per day	30.00
3 bushels tested seed corn at $3.00 per bu	9.00
Rent on 20 acres at $5.00 per acre	100.00
For picking and cribbing at 5 cents per bushel, figuring 60 bushels per acre	60.00
Wear on machinery	10.00
Total	$265.00

22 1-2 cents
Linn county
Iowa

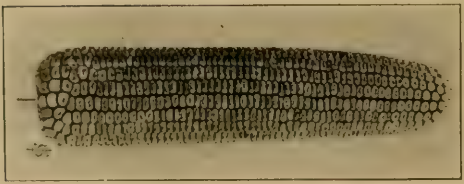
A yield of 1,200 bushels for $265.00 equals 22½ cents per bushel.

ACKNOWLEDGMENTS. Frequent quotations have been made from "The Book of Corn." The results of the test which was carried on by the American Agriculturist are very complete, though somewhat out of date at present because of the higher price of farm labor.

We wish to thank the Iowa farmers who took the pains to send us individual estimates.

COLLATERAL READING:

Corn Crop Tables of Standard Cattle Company,
Ames, Nebraska.
Cost of Producing Corn,
Minnesota Bulletin No. 97.
Cost of Farm Crops,
Nebraska Bulletin No. 29.
Cost of Producing Farm Products,
U. S. Department Bulletin No. 48.
Corn and Oats, Cost of Production,
Illinois Bulletin No. 50.



CHAPTER XI.

DISEASES AND INSECTS ATTACKING CORN

DISEASES OF THE CORN PLANT

CORN SMUT *(Ustilago mays zea).* The appearance of smut in corn fields is a common occurrence each year. The extent to which it is found it governed greatly by the favorable or unfavorable climatic and soil conditions which appear to have a corresponding effect upon both the growth of the corn plant and that of the corn smut. The damage done to the corn crop varies with the season. It is sometimes considerable. The estimated loss in Ohio on the crop of 1895 was $125,000.

Climatic conditions influence

Description. Smut seldom attacks the corn plant before it has reached a height of two or three feet. Occasionally, however, smaller plants are affected. Small patches of a whitish color may be seen swelling on the surface of the leaves, which are usually attacked first. This infection in its first development may cause the leaf to take on a reddish appearance. Early in the growth of the infected part spots will turn from a whitish to a black color, due to the formation of spores. As the plant matures the infection seems to be the greatest at the junction of the leaf and sheath.

Appears on the leaves

Quite frequently the tassel is found badly smutted, together with the greater portion of the stalk above the ear. The first joint below the tassel is probably the most common place of attack. The whole ear may be affected, or only a portion of it; but after the rudimentary ears are developed from the lower nodes the brace roots are the only points of infection. This is due to the fact that the smut spores do not penetrate any other than growing tissue. When entrance has been secured a local infection sets in, the smut masses soon appearing near the point of entrance.

Tassel frequently attacked

Brace roots last part affected

Some of the infection of the corn smut is brought about by the spores—the black powder contained within the mass—but the infections are chiefly due to the *Conidia* which are produced from the spore after germination. These are bead-like bodies which are borne at the ends of short branches of a thread which protrudes from the

Caused by spores

(Courtesy of Iowa State College)

Fig. 105.

CORN AFFECTED BY SMUT.

This mass utilizes the plant food which should have been used by the growing plant spore. These spores germinate very poorly in water, but grow rapidly in nutrient solutions such as liquid manure. A well manured soil is favorable for their production. When one of these little *conidia* is freed from the stem on which it grows and is carried by the wind, alighting upon an active growing portion of the corn plant, it soon germinates and sends out a thread-like *mycelium* which penetrates the tissues. Generally about two weeks' time intervenes between the period of inoculation and the appearance of smut spores. From this time on growth is very rapid. These smut balls often attain a size larger than an ear of corn. Should a smut ball fall to the ground and favorable conditions present themselves, the above outlined life cycle is repeated.

Smut balls contain many spores

It is thought that the early infections come from last year's spores which germinate as soon as favorable conditions are at hand. The slender threads that are put forth by the *conidium* when it alights on a growing portion, are colorless and known as the *mycelium*. They send numerous branches into the cells of the plant, which draw from it nourishment for their own maintenance. These slender threads (the *mycelium*) develop very rapidly, and soon become a dense, felt-like mass. A little later practically the entire mass is converted into small round spores.

Smut grows rapidly

Corn smut cannot be prevented by soaking the seed in fungicides, as is the case with oat smut and the stinking smut of wheat. This is due to the fact that the infection takes place after the plant begins its growth, and does not result from the spores being present on the seed. The smut of corn resembles the rust of wheat in its mode of attack. If the smut balls are all removed from the stalks and destroyed, the percentage of infection will be greatly decreased. This practice is carried on to some extent by smaller farmers. The expense incurred, however, is usually greater than the loss due to the smut.

Treating seed will not prevent smut

Loss Is In the Ears.

Experiments carried on at the Kansas Agricultural College go to show that the loss to corn plants attacked by smut is chiefly in the grain, the weights of smutted and clean stalks being practically the same, while the loss in the yield of corn amounts to about one-third, even though the ears themselves are not attacked.

The size of the ear affected more than the stalk

The following table from the Kansas Agricultural College counts the smutted stalks just as they came regardless of the place of infection:

WEIGHT OF STALKS AND EARS OF SMUTTED AND CLEAN CORN BY GRAMS.

Smutted.

Row Number	Number of Stalks	Weight of Stalks Total	Weight of Stalks Average	Weight of Ears Total	Weight of Ears Average
69	19	4,421	233	2,781	146
70	12	2,578	215	2,268	186
Clean					
	43	11,540	268	9,999	233
	53	10,684	201	11,183	211

The average weight per stalk of the smutted corn is 225 grams, while the average weight of the clean corn is 229 grams, being but little better in weight of stalk. Tht average weight of the ear on the smutted stalk is 162.8 grams, while the average weight of the ears on the clean stalks is 213.3 grams, being decided in favor of the ears on the clean stalks, representing a loss of 23.6 per cent in weight of ears for the smutted corn.*

Little difference between weights of clean and smutted stalks

Composition of Corn Smut.

CHEMICAL COMPOSITION OF CORN SMUT COMPARED WITH CORN, CORN STALK AND CORN FODDER IN PER CENT.

	Water	Protein	Fat	Nitrogen Free Extract	Fiber	Ash
Corn smut	8.3	13.1	1.4	29.6	24.7	22.5
Corn	10.9	10.5	5.4	69.6	2.1	1.5
Corn Stalk	68.4	1.9	.5	17.0	11.0	1.2
Corn Fodder	42.2	4.5	1.6	34.7	14.3	2.7

The Bureau of Animal Industry has carried on extensive experiments to determine whether or not corn smut is injurious to cattle, the opinion being more or less prevalent that it is the cause of the corn-stalk disease, and also conducive to abortion in cows. As much as 11 pounds of corn smut per day was fed to some of the animals. They seemed to relish it and the conclusion was reached that if smut is eaten by cattle it need occasion no alarm, since the evil effects which have been attributed to it do not follow.

Feeding smut to cattle

THE BURRILL BACTERIAL DISEASE. In 1889 Professor Burrill, of Illinois,** discovered a bacillus which is destructive to the growing corn plant. He describes its attacks as follows:

"The young plant is first affected in the roots, and also in full grown corn stalks after midsummer, when it manifests itself by certain discolored areas, more particularly on the leaf sheaths. An attack upon the very young plant means the dwarfing of its growth and destruction of the crop. A lessened yield and valueless fodder

*From Michigan Station.
**Bulletin No. 6, Ilinois Experiment Station, 1889.

are the only results of infection of the more mature stalk. Leaf sheaths and even the developing ear are often infected, showing a jelly-like deposition. The ear occasionally becomes a mass of rotten slime. The presence of the disease is noted to a greater extent some years than others. The prevention has not been carefully studied as yet. Destroying affected parts is the only sure way of absolute eradication. This disease is sometimes known as 'corn blight.'"

Leaf sheaths and ear attacked

CORN WILT. F. C. Stewart, of the Geneva Experiment Station, New York, has identified another bacterial disease of corn. His observations are that the plants wilt and dry up, but do not roll up as in the case of lack of moisture. Young plants die in a few days, but the older plants live for some time. The disease has been known to destroy entire fields. Dr. Erwin F. Smith has investigated this disease and named the organism *Pseudomonas Stewartii.*

LEAF BLIGHT. The infection of the leaves of corn with the leaf blight fungus is not discernible without the use of the magnifying glass. The almost round brownish spots are usually devoid of life. As yet the frequency of affected plants is so limited that no concern is felt regarding the economic importance of this fungous growth.

Of less importance

MAIZE RUST *(Puccinia sorghi* Schw). "Maize rust is found wherever maize is grown, but principally in regions of considerable rainfall. The rust does not differ materially in appearance from rusts of other grasses, particularly the *Puccinia graminis* of wheat and oats. The surface of the affected leaf and sheath displays small oblong or elliptical spots, which contain reddish brown spores. Kellerman has shown that only the *uredo* and *teleuto* stages may be included in the life cycle, although Arthur has identified the aecidial stage on Oxalis. It passes the winter in the *teleuto* stage. Though fungicides are effective, the rust is not of enough economic importance to warrant treatment. Pammel reports decreased yields of sweet maize due to the rust. The rust also occurs on sorghum and teosinte."*

Common throughout corn belt

INSECT ENEMIES

The newly planted seed, the young plant, the growing stalk, the developing ear, and the stored grain, are all subject to insect enemies. Each year pests which have heretofore been of little economic importance gain in number until they destroy whole fields. The increased acreage of corn on land which has been cropped for a number of years favors the breeding of this insect life.

Continuous cropping with corn favors breeding of insects

The most disastrous insect enemies are here described and remedies and preventives suggested.

*Page 246 of Hunt's "Cereals of America."

(Courtesy of Iowa State College) Fig. 106

PLANT APHIDS AS SEEN IN THE TASSEL OF CORN.

PLATE I.

Fig. 1 — The Seed-Corn Maggot, *Pegomyia fusciceps*, adult. Fig. 2 — The Corn Flea-Beetle, *Chætocnema pulicaria*. Fig. 3 — *C. confinis*.

OURTESY OF PROFESSOR S. A. FORBES, ILLINOIS STATE ENTOMOL

INSECTS INJURIOUS TO THE GROWING CROP

THE BLACK HEADED GRASS MAGGOT *(Sciara sp.)* Rotting seed corn lying in the ground, is subject to very destructive attacks by this black-headed grass maggot. Many maggots may infest a

Fig. 107.

BEETLE OF THE SOUTHERN CORN ROOT WORM AT WORK EARLY IN THE SPRING.

The stalk borer is also shown on the upper leaf.

single grain and consume everything but the hull. Sprouted grain is sometimes affected. Old sod land shows the majority of cases of infestation and destructive attacks.

THE SEED CORN MAGGOT *(Phorbia fusciceps, Zett.)* This maggot eats the interior out of the sprouting corn kernel. Unsprouted kernels, if softened, are often slightly attacked. The adult is a small two-winged fly, looking very much like an ordinary house fly. Definite knowledge concerning the life history is not available, but

Eats interior of sprouting kernel

Forbes, of Illinois, states that the larvae have been seen from May 17th to June 13th, pupae from June 7th to 15th, the adults emerging from June 11th to August 7th. This species hibernates as a fly. A cupful of kerosene added to a bucket of dry sand makes a mixture which, when placed in small amounts at the base of the corn plant, prevents the adult female from depositing her eggs. Kainit and nitrate of soda act in a similar way when moistened. Any injured plants should be destroyed immediately.

(S. A. Forbes, Illinois State Entomologist)

Fig. 323.
Black-headed Grass Maggot
Scaria sp.

WIRE WORMS *Drasterius elegans* . If the seed fails to come or the corn plant suddenly presents a withering appearance when from 10 to 15 inches high, it is very probable that the wire worm is present, especially if the ground was in grass the year before, or two years previous.

Fig. 108.
CORN PLANT SHOWING EFFECTS OF ATTACKS BY THE BILL BUG.
Note that the holes in the leaves are in rows.

Reddish brown color

The wire worm is of a reddish brown color, varying from yelowish to reddish. It varies in length from half an inch to an inch and a half. Its body is slender, carrying about same width throughout and bearing very few hairs. The surface is hard and crust-like. The body has 13 segments. On the three segments just posterior to the head are six pairs of short, stout legs, and on the under surface of the thirteenth segment is a single leg, sucker-like in appearance.

Eggs laid in grass lands

The eggs which produce the wire worm are laid in grass lands in the earth. The wire worm coming forth, feeds on the roots of grass. They may be found in any of our tame and wild grasses, but they are seldom found here in sufficient numbers to make a very great

PLATE II.

Fig. 1—*Myochrous denticollis.* Fig. 2—The Corn Wireworm, *Melanotus cribulosus.* Figs. 3-5—Click Beetles, adults of other Corn Wireworms; *3 Drasterius elegans; 4 Agriotes mancus; 5 A. pubescens.*

COURTESY OF PROFESSOR S. A. FORBES, ILLINOIS STATE ENTOMOLOGIST.

impression on the appearance of the grass lands. However, when the grass land is broken up and the comparative number of plants which the field contains is few, as with corn, the wire worms have to concentrate their labors more on the individual plants, and then it is that their presence is felt, the damage being done not only to the corn plants, but not uncommonly the seed is attacked and destroyed before the young plant can present itself. The wire worm attacks the corn kernel either before or after it has sprouted and not infrequently will a kernel be found into which the wire worm has made an entrance. The roots of the plant are seriously injured, the smaller roots are often eaten away, while the larger ones are bored and frequently this boring is done through the underground part of the stalk. The total destruction of the plant generally results. This larvae stage lasts for two years. The pupating occurs in July or August, and in the course of three or four weeks a reddish beetle comes forth, known as the "click beetle," commonly remembered by the clicking sound and sudden springing of the beetle when placed upon its back. The beetle may either remain in the ground during the winter or may come to the surface, passing the time in sheltered places. This is the beetle that lays the eggs from which comes the brownish colored larva (wire worm) mentioned above. Other cereals are attacked by this pest, as are also some of the root crops. It bothers wheat, rye, barley, oats, timothy, clover, etc.; and may be found attacking potatoes, turnips, beets, cabbage, onions, and many other crops.

Wire worm eats kernel, roots and stalk

Adult is known as "click beetle"

Prevention. Nothing can be done to eradicate this pest after it has attacked a plant without injuring the plant itself. Poisons of the most deadly sort have been applied to corn previous to planting without bringing the desired results. It appears that the only alternative lies in a rotation of crops. The trouble lies in the fact that the larva stage lasts two years. The second year after the plowing of the sod is when the largest damage is done to the corn field, due to the greater amount of grass that is present in the field in which the larvae can live the first year after plowing. The scanty amount of grass the second year compels the worm to center its attacks more especially on the corn. Should the sod be plowed in the fall and sown to fall or winter wheat, seeding to clover the following spring, or sowing oats in the spring and seeding to clover, a crop may be had the following fall from one of these cereals, and the next year a crop of clover may be harvested. It will be seen that in this way the larva is given the two years in which to mature and pupate. The small grain following the sod is not likely to be seriously injured. The clover

Most damage done during second year of corn

Wire worms not fond of clover

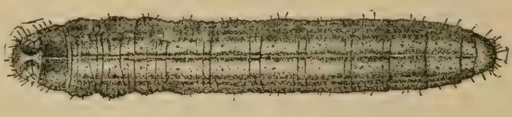
coming the second year when the pupating takes place, the ground will then be free of the larvae, and when fall plowed little fear need be entertained regarding the wire worm attacking corn the year following, which would be the third year after breaking the sod, and the crops intervening would not have seriously suffered.

When replanting is necessary, it is advisable to straddle the rows and leave the old plants standing, for if these are destroyed the worm will immediately attack the new plants and a second poor stand will result. A little later the old plants may be plowed out.

Fall plowing assists greatly in destroying the pupae, bringing them to the surface where the birds can devour them, and the cold weather will help to retard their development.

Work at night in cold wet weather

CUT WORMS. These caterpillars are exceedingly harmful at times, their damage being of a very injurious nature. They attack the young plant by eating off the leaves and portions of the stalk, often cutting the plant off close to the ground. This work is done at night. In the daytime they may be found hiding under clods or buried just beneath the surface of the ground. They have the conspicuous habit of curling up. Their larvae vary in color from a whitish to a dark brown. The skin is rather smooth, the body thick, generally marked by longitudinal lines with an occasional blotch.



(S. A. Forbes, Illinois State Entomologist)

Fig. 324.

Clay-backed Cutworm. (*Feltia filadiaria*) Enlarged.

Moth is grayish

The eggs which produce these worms are laid by grayish or brownish colored moths, and are deposited in grass lands late in the season. These eggs hatch the same fall and the young larva immediately feeds upon the roots of the grasses until winter sets in, when it buries itself in the ground, curls up and waits for the warm days of early spring. Then it again resumes its activities, which so often prove disastrous to the prospective corn crop. Often the outer rows of a corn field are damaged severely, due to the cut worms coming in from an adjoining field of grass or clover.

There is generally but one generation. However, there are a few species that have two and three broods per year. The larva has generally reached its maturity by July 1st, when it buries itself in the

PLATE III.

The White Grub; the beetle, egg, larva and pupa; enlarged two and one-half diameters.

earth and begins to pupate. The pupa is leathery brown in appearance. A grayish or brown moth appears toward the latter part of the summer.

Prevention and Remedy. As the cut worm is most destructive to corn following grass, early plowing is one of the best methods of preventing its activities. Poison can be used to good effect by mixing paris green with bran or middlings, one pound of former to 30 of latter. This may be distributed by means of a seed drill. Should the worms be in grass land bordering a corn field, the latter may be protected by poisoning fresh clover with a solution of paris green, one pound of paris green to 50 gallons of water, and scattering this along the edge of the field. In replanting corn in a field infested with cut worms late planting is advisable.

Poison can be used

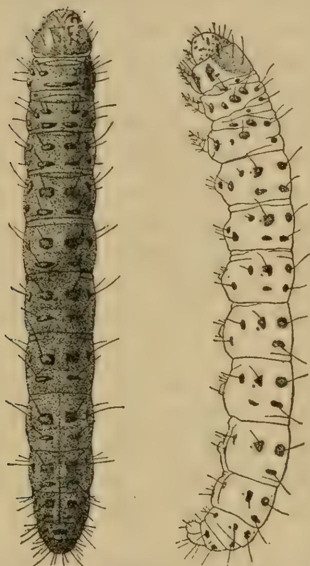
(S. A. Forbes, State Entomologist of Illinois)
Fig. 325.
Clay-backed Cutworm (*Feltia gladiaria*). Adult.

THE SOD WEB WORM OR ROOT WEB WORM. (Several Species of "Crambus"). These caterpillars average about one-half inch in length when full grown, are pinkish red or brownish, and covered with rows of comparatively smooth dark spots, from the center of each of which springs a rather coarse hair. The injury done to corn is something like that inflicted by the cut worm, except that the web worm does not sever the entire stem, but eats a groove up one side. The greedy larva feeds during the night and lives during the day in a little silk-lined tube about one inch below the surface. The larva does not pupate before winter, but hibernates in the silk-lined tube. In the spring its growth is completed. It then pupates and by June 10th the imago is dropping eggs carelessly about in the grass. These hatch in from 10 to 20 days, when the larva again appears. It is not definitely known whether the larvae change to moths and another generation is produced for hibernation, or whether the first generation grows until autumn and then hibernates.

Larva feeds at night

Prevention and Remedy. The above outline of the life cycle demands the early fall plowing of sod which is to be used for corn the next year. But if the plowing has to be left until spring the web worm will be most disturbed if this operation is postponed until after May 25th.

WHITE GRUB *(Lachnosterna rugosa)*. The white grub is a very difficult pest with which to deal because it attacks a number of varieties of plants.



(S. A. Forbes, Illinois State Entomologist)
Figs. 328 and 327.
The common Sod Web-worm
(*Crambus trisectus*)
Back and side views, much enlarged.

Eggs laid in grass lands

The eggs from which the larvae are hatched are laid chiefly in grass land, although occasionally they may be deposited in fields of corn. The adult female is a rather large, thick, short beetle, having hard wing covers of a brownish color. They are commonly seen in the early summer flying about arc-lights, and are known as "June beetles" or "May beetles." These live but a short time. The males die soon after the sexes pair. The females begin laying eggs in June, and by the first of July have practically finished. These eggs are placed from an inch to four inches deep in the ground and hatch in from two to three weeks' time.

Adult known as [J]une beetle"

The young grubs attack the roots of grass at once, and grow very rapidly during this first season. The following winter they hibernate in the same stage and live as larvae during the next summer until July, when they pupate. They exist in this state until the middle or latter part of August, when the adult form appears. The imago, or adult, usually remains right in its place of origin until early the next spring. Then it emerges as a "June beetle." The mating then begins and eggs are laid in June, completing the life cycle.

Grubs destroy the roots

The fact that the life history extends over almost three seasons makes its eradication that much more difficult. Sod is sometimes very seriously injured by these grubs. When the number of plants per acre is materially reduced, as when corn is planted on sod ground, the damage of the grubs is noticed to a greater extent. One grub attacking each hill of corn will show damage where the same number of grubs per acre on sod could not be noticed. Where the corn is

PLATE IV.

Corn Bill-bugs and larva, with injured corn plant.

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killed outright, or has a dwarfed appearance, having a yellowish tinge throughout, the indications point toward the presence of the grub. When grubs are present the roots of the corn plant will be found to be very short and stubby. The plant may be slightly bent, due to the fact that the disabled roots are unable to hold the stalk in an upright position. If the indications point to the presence of the grubs and they are not readily found, they may be discovered by digging down a foot or two from the plant. Corn of different sizes is often attacked by the grub. There are several other species of the *Lachnosterna* besides the genera *cyclocephala,* which do damage to the corn plant.

(S. A. Forbes, Illinois State Entomologist)
Fig. 329.
The common Sod Web-worm, adult. Slightly enlarged. *(Crambus trisectus)*

Prevention and Remedy. Fall plowing is a very desirable and effective means of destroying many pupae and larvae. Sod that is badly infested, having been plowed in the fall, may be almost freed from grubs by turning in hogs. The first crop of corn should be kept as free from weeds as possible in order to prevent the adults from depositing eggs for a future brood. Clover is seldom injured by the white grub; neither is the grass growing in the clover field. Potatoes, strawberries and beets are often attacked; also young larches, evergreens and tender rooted shrubs and fruit and forest trees. One or two seasons of clover will eliminate the grub sufficiently to allow the planting of corn in comparative safety.

Turn in hogs on fall plowing

CORN BILL BUG (Several species of the genus *Sphenophorus.*) Unlike the other pests of corn, the bill-bug represents the adult stage. That is, his activities are disastrous during the imago rather than larval stage. The damage done is measured by the number and size of beetles. Corn on sod land is most frequently affected.

Damage done by adult

The corn bill-bugs vary in size and color, but most of them are a dull black. Their surfaces are pitted. They are snout beetles, having a pair of minute jaws situated on the end of this protrusion. The larvae of these beetles live on the roots of grass and are frequently seen embedded in the root bulbs of timothy, in coarse sedges, and in salt grass. The larva is white, rarely found in corn fields, and is without feet, having a hard head of a brown or blackish color. Pupating does not take place until fall, the winter being passed in the adult stage, and generally about the field where they first appeared. The bill-bug does not travel far.

Beetle dull black

With the warm days of spring the bill-bug comes forth, ready to attack the young corn plant. It will generally climb the stalk and thrust its snout down in among the young leaves, often causing a very serious injury. These punctures may be noted as the plant grows as parallel holes running across the leaf. Each row of holes is made by a single puncture when the leaves are young and closely rolled together. When the stalk is young and tender the corn bill-bug will also bore into this portion of the plant. When doing this it works with head down. So intensely absorbed is the bill-bug when at work that not infrequently the plant may be removed from the field without the beetle ceasing its labors.

Works with head down

The life cycle is very simple. The eggs are laid in May and June in the roots and stems of grasses. The larvae appear in June, July and August. Pupation occurs at once and the beetles come forth in the late summer or early fall. Hibernation takes place in the imago stage.

Prevention and Remedy. Sod corn which is planted after the middle of June is rarely injured by the bill-bugs. Many farmers who have had some experience with this pest plant their sod land the last thing in the spring. There is a bill-bug, however, which is occasionally found in swampy places, that might attack the corn as late as July. All the species are much hindered in their activities by fall plowing.

CORN ROOT APHIS *(Aphis maidi-radicis).* The corn-root aphis is commonly known as the corn-root louse. Careful investigation has shown that this pest is increasing from year to year. The injury done by the aphis consists in sucking the liquid food from the growing plant. Close examination reveals no outward injury from this source, but the plant will present a dwarfed appearance, especially in certain patches in the field, sometimes on low ground. The leaves will take on a yellowish or reddish cast, the lower ones being affected first, and later the whole plant shows a lack of thrift and vigor.

Sucking insects

The adult aphis is bluish green in color. It can thus be distinguished from the grass louse, which is white with a blackish head, there being no appearance of green. The eggs are laid in the fall and the ants store them away over winter. The first hatching generally takes place in the spring before the corn is planted, the young living for a time on the roots of weeds which are laid bare by the ants. Smartweed is especially liked by the young aphids.. As soon as the young corn plant starts, the ants immediately remove the aphids from the roots of the weeds to the corn roots. The ants have been

Bluish green in color

PLATE V.

THE CORN ROOT-LOUSE, (*Aphis maidiradicis*). B, the common wingless and, A, the winged viviparous females; F, the pupa of the winged female; C, the oviparous female, occuring in autumn, and D, its egg; E, the worker of the root-louse ant (*Lasius niger americanus*).

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known to burrow hills of corn in advance and seize the winged aphids that would happen that way and bear them to their subterranean home on the roots of the corn plant. The first generation of the corn-root aphis is wingless, and is therefore confined to fields previously in corn. The second generation consists both of winged and wingless aphids. The winged aphids may travel to other fields, but they generally do not become sufficiently numerous to affect fields not in corn the previous year. It is generally November before those of the viviparous generation (those producing living young) are all dead. After this time the sexual generation is presented. These lay the eggs in the late fall ready for the ants to store away. In the spring the above outlined life history is repeated. It is estimated that each female will give birth to 12 or 15 young, although the life period of the first three generations is but 19 days. There are some 10 to 12 generations in one season.

10 to 12 generations in one season

The apparently disinterested guardianship of the ants is not entirely without profit. The aphis has been termed the "ant's cow," due to the fact that it excretes a sweet liquid called "honey dew" through the two small tubular projections situated on each side of the back near the caudal end. The ants are very fond of this liquid, which they obtain by tapping the aphids lightly on the back. The presence of ants about a hill of corn almost always means that the aphids are at work on the roots of the plant.

"Ants' cows"

Prevention and Remedy. No other crop is particularly liable to be injured by the corn-root aphis, with the exception, possibly, of broom corn and sorghum. An instance has been noted in Kansas where sorghum was badly infested. A rotation of crops is the only method by which a field can be relieved from the serious attacks of this pest. Inasmuch as no crops following corn are seriously injured by the lice there need be no fear in plowing up infested corn ground and sowing to some other cereal. Fall plowing disturbs the homes of the ants and destroys large quantities of eggs of the aphis. Clean cultivation, especially on low ground, prevents the deposition of eggs in such weeds and grasses as are commonly found in marshy places. Corn planted on ground not previously infested may be attacked by the winged generation, but no serious damage usually follows.

Clean cultivation

THE CHINCH BUG *(Blissus leucopterus).* The injury due to the chinch bug varies from year to year. Some states have suffered some fifteen to twenty million dollars in a single year. Its ravages are worse during continued dry spells, and corn plants at-

Sucking insect

tacked by it present an exceedingly wilted appearance, corresponding exactly to what might be expected from continued drought. The sap may be completely drawn out of the growing plant by this sucking insect, the result being that whole fields will be flattened to the ground. Corn is especially liked and not uncommonly attacked by the chinch bug. Beginning on one side an army of these insects may lay low an entire field.

Hibernates under rubbish

The adult, which has passed the winter concealed under old rubbish, comes forth in the spring very early. By the last of April the female begins to deposit eggs and continues laying throughout the month of May. These eggs are usually deposited at the base of young wheat plants, or of other small grains. By the middle of May the first eggs begin to hatch. The eggs being laid at no regular intervals, broods do not appear in order, but young are found in all stages of development. When it first hatches, the chinch bug is very red in color and exceedingly small. As it matures it goes through a process of moulting until the adult stage is reached at the time of the fourth moult. The adult has wings and winters over to lay the eggs the following spring. Its color varies, the head and thorax being black, and a black blotch is seen at the middle of each side. The center of the back presents a white cross. The old chinch bugs which winter over are most all gone by the middle of June. The eggs of the second generation are generally laid in the corn field at the base of any weeds or grass growing in the row. The young chinch bug of the first generation feeds upon the small grain and after the fields are harvested the corn fields are more likely to be attacked. The young of the generation feeds for a time upon the weeds and grass, then attacks the corn directly.

Red in color when young

Prevention and Remedy. The rise and fall of a siege of chinch bugs varies, the period of annual increase being longer than the period of decline. They may get more numerous continually for three or four years, and then suddenly disappear. Premises kept free from rubbish are less inviting as wintering quarters for the adult bugs which hibernate and lay the eggs the following spring. To prevent the onward march of the chinch bug, a strip about 10 feet wide may be plowed between the corn and the infested field. A part of this, at least three feet in width, should be very finely pulverized. A furrow should then be made in this pulverized strip, making the sides as vertical as possible. In the bottom of this eight-inch furrow, at intervals of 10 feet, dig holes at least two feet deep. As the line of

Tar line

PLATE VI.

The Chinch-bug; five stages of development and the egg.

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march is intercepted by this ditch the invaders fall to the bottom, are unable to climb the other side, and finally fall into deeper holes. A short log may be dragged up and down this trench by a horse, thus destroying the pests as they enter. Kerosene poured upon the bugs in the deeper holes kills them effectively. Another resort is to place a line of tar between the first trench and the corn field. If this is renewed twice or three times daily it is very effective.

When the chinch bugs are on the plants they may be destroyed by spraying with kerosene emulsion made as follows: **Kerosene emulsion**

Dissolve half pound of soap (hard or soft) in a gallon of water by boiling; then remove from stove and stir thoroughly; add two gallons of kerosene; mix thoroughly by pumping this fluid back into itself by means of a common spray pump. Before application add fifteen quarts of water to each quart of mixture. This spray should be applied before ten o'clock in the morning, if possible. Enough should be applied so that the insects will be washed off and will be seen floating in the emulsion at the base of the plant. As an economical process this cannot be recommended on a large scale.

ARMY WORM *(Heliophila unipuncta)* The army worm belongs to a large family of insects known as the *Noctuidae*. Grass lands being its natural home, it is present to a limited extent every year. The mature insects are dull brown moths, having a peculiar white spot in the center of each anterior wing, from whence comes the name "*unipuncta*" The body is about three-fourths of an inch in length in the adult. The eggs, which are usually laid in the terminal leaf sheath of grasses and grains, are small, globular, and white. Dr. Riley* found eggs deposited in strawstack bottoms, hay ricks, old corn shocks, and even two-year-old corn stalks lying on the ground in the meadow. His estimate of a single female laying from 500 to 700 eggs accounts for the rapid increase of the worms under favorable conditions. These eggs hatch in from 8 to 10 days. After feeding on anything of succulence about it, the larva is full grown in 25 to 30 days, attaining a length of 1 1-2 inches. When young they travel like a measuring worm, are dark, naked caterpillars with longitudinal stripes running the full length of the body. A very marked broad stripe on each side is characteristic. The pupa stage, which lasts about 2 weeks, is passed in rubbish on the ground. The imago or adult comes forth and begins to lay eggs again in 6 to 8 days. This, in all, gives 7 to 8 weeks for the life cycle in midsummer. There are usually from 2 to 3 broods each year in the northern states. The last brood hibernates either as larvae or pupae. The moths appear very early the next spring.

Grass lands its home

Larva 1 to 1½ inches

2 to 3 broods per year

*U. S. Department of Agriculture Report 1881-1882, P. 90-91.

Prevention and Remedy. Some bacterial diseases attack the larvae. Insect parasites destroy great numbers, yet the pest must be combated. If the worms are marching toward a field, a deep furrow in front of them will capture a great many. Holes should be dug in the furrow every 10 or 15 feet. The worms after falling into these holes may be killed by kerosene. In pasture lands, which are smooth, the caterpillars may be crushed by a heavy roller.

Color varies with age

STALK BORER *(Papaipema nitela)*. This caterpillar is very well known. It is sometimes called the "Heart Worm" because of its characteristic attacks, boring as it does into the heart of the stem. It is from an inch to an inch and a quarter long when matured, varying from a purplish brown to a brownish white in color, according to age. It may be told by the white stripes which it bears. These are five in number, one extending along the entire center of the back with two on each side. The stripes on the sides are broken, there being none on the first four segments of the abdomen. This gives it the appearance of being pinched or injured. The eggs which produce these larvae have not as yet been found, but it is commonly believed that the eggs are laid in the fall in grass land, and that these hatch during the same fall or the next spring. When first hatched, the larvae live upon the weeds and grasses which are at hand. When they attack these it is readily noticed, because the tops of the plant turn to a whitish color, due to the entrance of the larvae within the stem. The rest of the plant may remain green. This is not an uncommon sight along the roadsides. As the worm grows in size it looks for new feeding ground where it may find thicker stemmed plants upon which to feed, and in this respect it seems not to be particular. It attacks wheat, oats, timothy, potatoes, tomatoes, rhubarb, and many other woody stemmed plants.

Larva burrows within the stem

Corn is attacked generally when it is from 2 to 15 inches high. A small hole will be noticed in the corn stalk where the stalk borer entered. The burrow within the stem runs upward from this entrance varying in size with the maturing of the larvae. When the caterpillar is full grown it soon pupates generally within the last plant attacked. This commonly occurs below the opening at which it entered. The moth is rather mouse colored and flies by night.

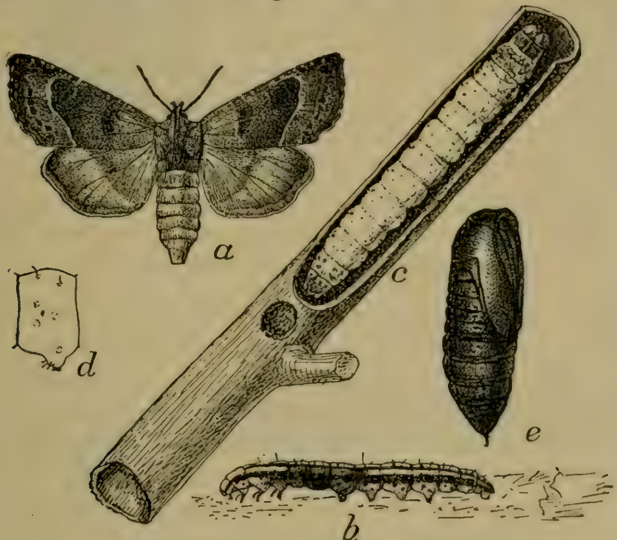
Prevention and Remedy. When a corn plant is attacked by a stalk borer, there is no remedy that can be applied that will successfully combat the intruder without doing injury to the plant itself. The place of eradication is where the larvae first appear, namely, in

PLATE VII.

The Army-worm, with pupa, moth, and egg.

RTESY OF PROFESSOR S. A. FORBES, ILLINOIS STATE ENTOMOLOGIST.

grassy places. Here they may be discovered by the tops of the grass attacked turning whitish in color and dying. This grass should be moved immediately and burned or fed to stock. It is generally the outer borders of the corn fields that are injured by the stalk borer. The damage done to the corn fields is limited. Whole fields are not attacked by the stalk borer as in the case of the other corn pests, although it is known to have destroyed 15 acres at Elmira, Illinois in a single season. In Greene County, Iowa, in 1908, a 3 acre piece of corn was ruined by the ravages of this worm.



(Chittenden, U. S. Dept. of Agriculture)

Fig. 326.

Stalk-borer (*Hydroecia nitela*) a, adult; b, half-grown larva; c, mature larva in burrow; d, side of one of its segments; e, pupa. All slightly enlarged.

THE NORTHERN CORN ROOT WORM.* This little larva, or worm, is about two-fifths of an inch long, and approaches a pin in thickness. It is white, with the exception of its head, the top of the first segment, and a spot on the last segment, which are of a brownish color.

Eggs laid in corn field

Life History.** The eggs from which this larva comes are laid in the ground, an inch or more beneath the surface, and rarely outside of the corn field. Here they remain during winter awaiting the warm days of early summer, and about the middle of June the worm comes forth in search of what is apparently its only food, the roots of the

*This investigation carried on by E. P. Humbert under the personal supervision of M. L. Bowman.
**See Eighteenth Report of Illinois State Entomologist, by Forbes.

corn plant. The corn roots are at once attacked, the larvae concealing themselves within, not burrowing through the middle of the root, but in a spiral, longitudinal direction in the woody portion which lies just beneath the outer covering. This burrowing causes the roots to decay and die. There is every evidence to lead us to believe that the corn-root worm does not live on the roots of clover, timothy, oats, wheat, barley or rye; although observations in Kansas indicate that the roots of sorghum afford a home for the larvae.

Does not live on roots of other crops

Some of the corn-root worms will have reached maturity by the latter part of June. Others will be found working in the corn roots as late as August. When the larvae have reached maturity, they leave the roots of the corn, but remain in the ground about them and begin to pupate, the worm transforming into the adult or beetle. Soon small grass-green beetles will be seen, about one-fourth of an inch in length, which come forth from the pupa and are found feeding upon the silks; also upon the pollen grains which have fallen upon the leaves of the plant, generally about the axis.

Beetles are grass green

The beetles represent the adult stage. They do very little damage to the plant, but may be seen throughout the months of August and September, and often during October. During the latter part of September and the first part of October, most of the female beetles will have buried themselves in the ground a short distance from the hill of corn. They will then deposit their eggs, which the following spring will hatch out into the corn-root worms. Seldom are the eggs deposited outside of the corn field. In fact, it may be said that the corn-root worm is dependent for its food upon the roots of the corn plant.

How Its Injury Is Noticed. The corn-root worm may be found in the corn field in spots and can be detected in the early part of the season by the appearance of the corn, showing a tendency to grow less rapidly, although it may keep green, due to the fact that the root system has not been damaged to such an extent but that some nourishment can be afforded the plant. Again, where the ground has been in corn several years, it is not uncommon to find that the entire field presents a dwarfed appearance throughout the season. It fails to produce more than nubbins, many of the stalks being entirely barren, due to the decaying and rotting of the root system, which is always the case where the roots have been attacked. In this condition, the roots are unable to support the plant with proper nourishment for maintaining the growth of the stalk, and at the same time for putting

Field presents a dwarfted appearance

FIG. A

FIG. B

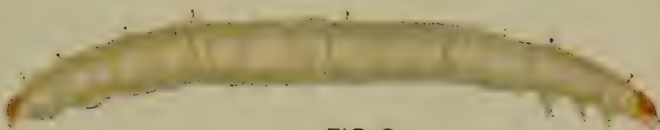


FIG. C

FIG. D

CHARLOTTE M. KING, ARTIST

PLATE VIII.

Corn Root Worm, (*Diabrotica longicornis*). A, Beetle; B, Pupa; C, Larva; D, Larva
n Corn Root.

(Courtesy Iowa State College)

Fig. 109.

Each bundle represents tour average hills of corn from ground in corn for the first, second, third and fourth years as shown from left to right.

forth an ear. Due to the lack of support necessarily brought about through the injury to the root system, the plants are very easily toppled over, and are found lying in all directions, especially after a hard rain. Should there be a brisk breeze whole fields are often laid low (See figure 118), when if it were not for the corn-root worms they would not have shown the effect in the least (See figure No. 114).

The whole plant falls over

When corn that has not been affected by the corn-root worm has been blown down, it is usually found that if the ground is firm, the corn stalk is broken some distance above the surface. The corn roots remain intact, that portion of the stalk below the break remaining in an upright position. When the corn-root worms have been working on the corn, this breaking of the stem does not occur. The whole plant falls. The stubby roots may often be seen protruding from the dirt about them, and the top of the plant endeavoring to take an upright position, as shown in (figure 116).

When the ground has been in corn but one year the damage will not be particularly apparent the year following. Quite frequently the presence of the corn-root worm is not suspected until the small grass-green beetles are found upon the plant. These beetles begin coming forth about the time, or a little before the plant puts forth its shoots and tassels, and will be found feeding on the silks and pollen. It is very common to find fields which are termed "old" and "run out" so that they will not produce corn, which are nothing more or less than lands which are suffering from the ravages of the corn-root worm.

The hills of corn as shown in figure 109 represent the average of the fields from which the samples were taken. Each bundle in the picture is composed of four representative hills from fields which had been in corn 1, 2, 3, and 4 years respectively. The 4 hills appear separately in the Figs. 110, 111, 112, 113. The great variation in the strength of the root system and the number of corn-root worms taken from hills representing ground in corn for the first, second, third, and fourth years will be noted. Each hill was secured by putting a 12 inch spade in the ground full length around the entire hill at a radius of 12 inches, after which the plants were pulled up. Then the roots were placed upon a sheet; also the loose dirt out of the hole. This experiment was begun July 26, 1906. Many of the larvae having left the roots and entered into the pupa stage, were found in the loose dirt.

The extensive development of the roots of these plants is to be especially noted in contrast with those in the following illustrations, especially in Figs. 112 and 113. It is very uncommon to find

(Courtesy Iowa State College) Fig. 110.

FOUR HILLS REPRESENTING GROUND IN CORN FOR THE FIRST YEAR.

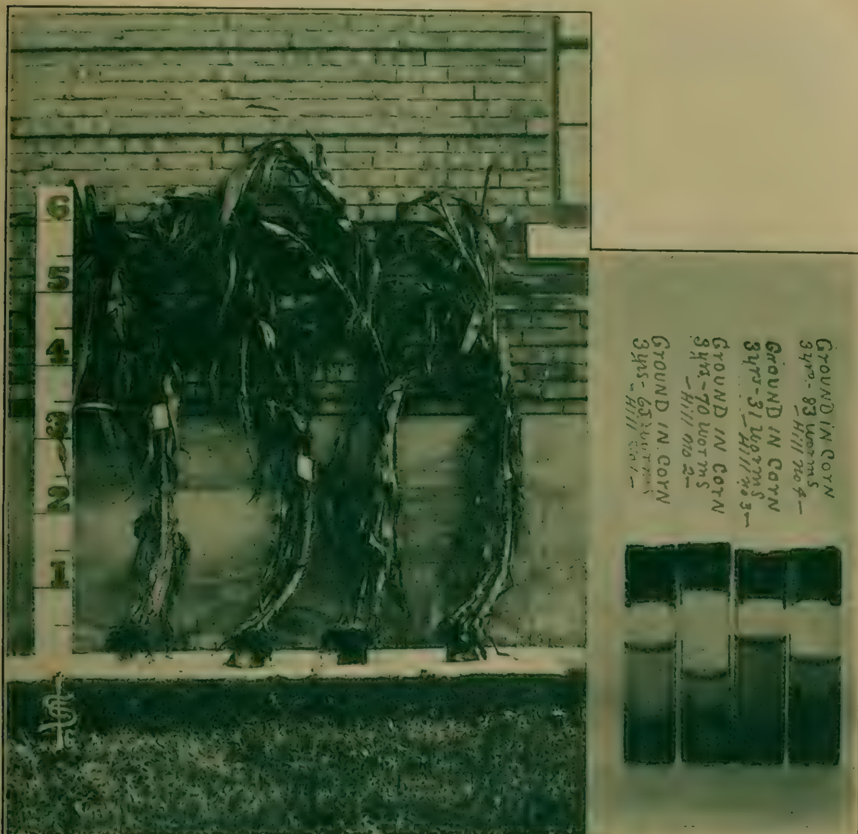
Note the extensive root development. There was one corn root worm. The ground was in clover the previous year.

Fig. 111.

FOUR HILLS REPRESENTING GROUND IN CORN FOR THE SECOND YEAR.

Note a lighter root development. Twenty-four corn root worms were taken from the four hills.

corn-root worms in ground that is in corn for the first year. The 1 corn-root worm can only be accounted for by the fact that this field was but a short distance from one that had been in corn for 4 years, a beetle having strayed to the nearby field before she had deposited all her eggs.



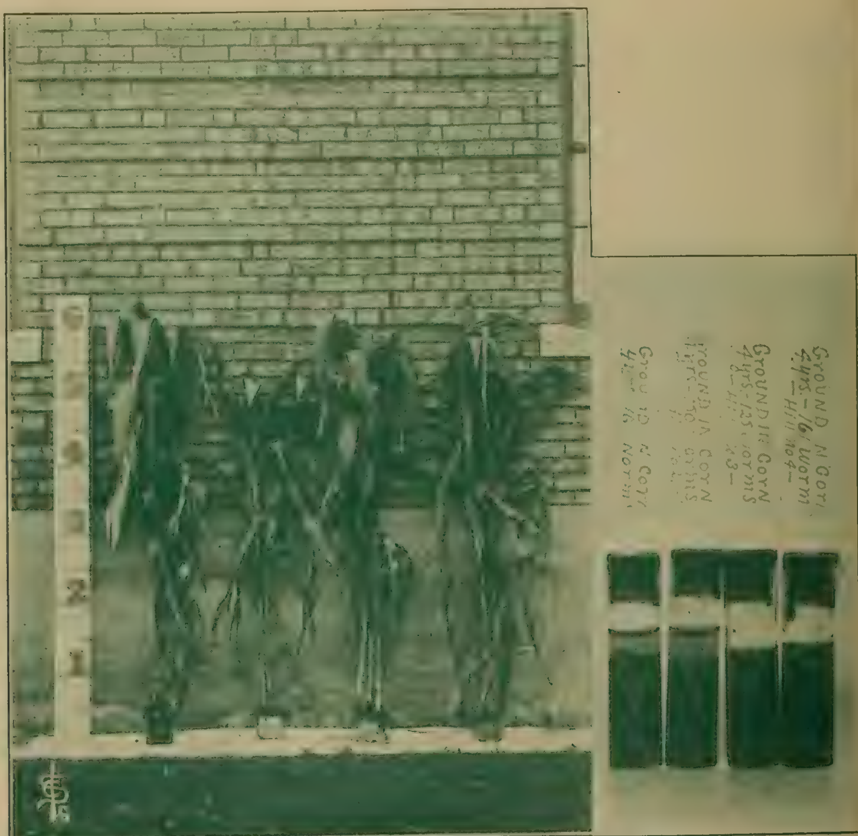
(Courtesy Iowa State College) Fig. 112.

Four hills representing ground in corn for the third year. Number of corn root worms in each hill, numbered from left to right, 65, 70, 31, and 83 worms, respectively.

It should be noted that the number of the corn-root worms is increasing very rapidly as the number of years increase that the ground has been in corn; also, the plants are getting much smaller and the extent of the root system is being very noticeably and seriously reduced.

Stalks affected have a curved position

In Figure 117 the curvature of the stalks will be noted, the root system having been sufficient up to the present time to maintain a fairly vigorous growth in stalk, but not sufficient to maintain the weight of the stalk, which is therefore bending over. The roots were



(Courtesy Iowa State College) Fig. 113.

Four hills representing ground in corn for the fourth year. Number of corn root worms taken from each hill, as numbered from left to right is 161, 150, 125, and 161 respectively. Note the stubby roots and the large number of corn root worms found in each hill. (Ground in alfalfa five years before.

found to be badly lacerated, many of them having rotted off entirely. The plants were very backward in sending forth shoots, resulting in the production of ears of inferior size.

The plants are seen to be very much dwarfed, the corn-root worm having almost completely destroyed the root system; so much so that the plants have made a very weak growth. It could not be expected that they would produce more than nubbins. The amount of nourishment which the roots have furnished these plants has been necessarily so small that even a fair sized plant has not been produced. Some of the plants present an erect appearance, because there was not sufficient weight in the stalk to cause them to topple over.

Plants are more or less barren

This shows that the best results cannot be had by continual cropping with corn. They may be obtained only by practicing a proper system of rotation. After the ground has been in corn for the second year it is subject to serious ravages by the corn-root worms, which result in a very noticeable weakening in the corn plants and a very material decrease in the yield of corn per acre, due to the lacerating and decaying of the root system.

The injury done by the corn-root worm becomes very apparent after a wind or heavy rain, especially in fields which have been in corn for 3 and 4 years or more.

Fields show effects after a rain

Figures 114, 115, 116, 117 represent ground in corn for the first, second, third, and fourth years, respectively, and also the fields from which the representative hills were taken, as shown in Figures 110, 111, 112, 113.

From 125 to 161 corn-root worms were found to the hill. The roots were badly lacerated and decayed, causing the whole plant to fall. The stubby ends of the roots could be seen protruding from the dirt about them.

Roots are stubby

Yield. It is to be expected that the yield of corn per acre would necessarily vary in fields where continuous cropping of corn had been practiced. The following contrast will be noted in the yield of corn per acre on ground in corn for the first and fourth years, respectively:

First year, from clover sod,.................72.4 bushels
Fourth year, from alfalfa sod* ....45.1 bushels

From the above it will be seen that the difference in the yield of corn on ground in corn for the first year from that of ground in corn for the fourth year, was 27.3 bushels per acre, or 60 per cent more corn in favor of the former.

Remedy.—Rotation of Crops. Nothing can be done to help corn that is attacked by the corn-root worm, but due to the fact that this worm lives entirely upon the roots of the corn plant, it is simple to combat them, a rotation of crops being sufficient. The ground which is infested with the corn-root worms which hatch out next spring will die—simply starve to death. The best results will

*Alfalfa, a legume, enriches the soil the same as clover.

Fig. 114.

The above cut shows the field representing ground in corn for the first year. Note how straight the plants are. (Ground was in clover the previous year.)

Fig. 115.

The above cut shows the field representing ground in corn for the second year. Effect of wind and rain is a little more noticeable, but only in a comparatively few plants.

PLATE IX.

The Corn Worm: light and dark individuals, pupa, moth, and egg, with injured ear of corn.

Fig. 116.
The above cut shows the field representing ground in corn for the third year.

Fig. 117.
The above cut shows the field representing ground in corn for the fourth year. (Ground in alfalfa five years before.

be had by keeping the ground in corn but for two years in succession and then rotating with small grains and legumes. By practicing a proper system of crop rotation, the ground will be more productive. This is also the very best method of combating all insect pests so injurious to our farm crops.

THE GRASSHOPPER *(Acrididac).* The injury to corn due to hoppers is usually confined to the border rows near a pasture or meadow. The grasshoppers devour the silks and eat away the husks, thus preventing pollination. The lower leaves may be consumed in some cases. The seriousness of this pest is more marked in certain years. The "grasshopper dozer" has proved a very effective means of eradication. This consists of a shallow pan filled with kerosene placed upon a sled or low wheels and protected in the rear by an upright canvas. The molested grasshoppers jumping against this canvas drop immediately into the kerosene and are killed.

Criddle mixture

*"The Criddle Mixture has proved effective for poisoning grasshoppers in Illinois and in Canada. This mixture is composed of one part, by measurement, of paris green to 120 parts of horse droppings, preferably fresh; or about a pound of paris green to half a kerosene barrel of the droppings, with a pound of salt in addition if the material is not fresh."

Feeds on the ear

THE EAR WORM *(Heliothis armiger).* The ear worm is also known as the corn worm, cotton boll-worm, tomato worm, and tobacco bud worm. It varies in color from a light green to a brown with light and dark stripes running lengthwise of the body. Its legs are dark, head yellow, body slender and nearly hairless. It is noticed most especially when feeding on the corn ear just beneath the husks. This worm may feed on the leaves by making small holes here and there. Early in the season it feeds on garden truck. The furrow made on the ear of corn begins at a round hole in the husk and extends spirally in a longitudinal direction, often reaching half way down the ear. Decay usually sets in at once and the damage is accelerated in this manner. Sweet corn is most commonly infested.

Three generations in one season

There are 3 generations in a single season. They hibernate in the pupa stage. The moth comes forth in early April and soon begins to lay eggs. Each female may produce from 200 to 300. The eggs soon hatch and the caterpillars reach their maturity in 3 weeks. Then they pupate. 3 generations go through this cycle in one season. The larvae of the first generation live chiefly on the

*Page 395 of Bulletin 95 of Illinois.

PLATE X.

The Angoumois Grain Moth: larva, pupa, moth, and egg, with injured kernel and ear of corn.

leaves and young shoots of the corn plant; the larvae of the second generation live in the tassels, silks, and young ears; while the larvae of the third generation will attack the maturing ears.

Prevention and Remedy. This pest has not as yet been successfully combated. Fall plowing destroys a great many of the pupae, in which stage hibernation occurs. Where corn follows corn such a practice cannot be followed except in a limited way.

Insects Injurious to Stored Corn.

THE ANGUMOIS GRAIN MOTH *(Sitotroga cercalella).* The adult is a small, light-gray moth, with a wing expanse of one-half inch. The eggs are of a pale red color. The larva which has a brown head, tapers gradually caudad, being covered with numerous hairs. The pupa is of a darker brown color. The moth deposits the egg on the grains of corn or wheat, either in the field or in the granary, usually the latter. The eggs are laid between the rows of corn. In 4 or 5 days the larva hatches out and lives upon the germ and starchy part of the kernel. In 5 weeks it has attained its growth. It then burrows to the crown of the kernel, makes an opening, seals it over, and pupates for a few days. The adult comes out through this opening and the life cycle is complete, requiring less than 6 weeks. The length of time depends upon the temperature. Warm spring days bring out the imagos very rapidly.

Adult light grey moth

Prevention and Remedy. The careful removal of all refuse and old corn each year during the summer will prevent the moths from having anything upon which to deposit their eggs. Carbon-bisulphide (CS_2), a colorless, very volatile liquid, is the most effective means of destruction of the moths. This should never be breathed by man or other animals, and a lighted match should never be brought in contact with the gas. In a moderately tight bin one pound of the bisulphide will effectively fumigate one hundred bushels of grain. The compound vaporizes rapidly, and being heavier than air, it soon sinks and becomes thoroughly diffused throughout the bin. If the sulphide is simply placed in shallow pans on top of the grain the results will be accomplished. Where seed is racked or hung up, the pans must be elevated above the grain which is to be fumigated. Several applications may be necessary to destroy all the moths as they appear from time to time. Grain which has been fumigated is not injurious for feeding or seeding purposes.

CS_2 as a preventive and remedy

THE GRAIN WEEVIL *(Calandra granaria).* The grain weevil has a hard body of a uniform chestnut brown color. The beetle is short, stout-bodied, and about one-seventh of an inch long. The thorax is marked with punctures arranged longitudinally. The eggs are deposited singly in the grain. The female punctures the grain with its snout and in this cavity places its egg. The larva comes forth in a few days, develops in the grain, and emerges as an adult. The life cycle requires about 40 days.

Treatment similar to that for the grain moth will eradicate the grain weevil. However, such treatment must be much more thorough.

ACKNOWLEDGMENTS.

Much of our information has been drawn from the researches of Forbes and Chittenden.

We are especially indebted to Forbes for the colored plates.

The photographs of corn affected by the Northern corn-root worm were taken from the plots of the Soils and Farm Crops Departments of the Iowa State College.

COLLATERAL READING.

Corn Bill Bugs and Root Louse,
Farmers' Bulletin No. 259.

Corn Smut,
Farmers' Bulletin No. 69.

Corn Root Worms,
U. S. Department (Bureau of Entomology) Circular 59.

Sweet Corn (Bacterial Disease of),
New York (Geneva) Bulletin No. 130.

Corn Smut,
Kansas Bulletin No. 62.

Indian Corn, The More Important Insect Injuries to,
Illinois Bulletin No. 95.

Smut of Indian Corn,
Ohio Bulletin No. 10.

The Corn Bill Bugs in Illinois,
Illinois Bulletin No. 79.

Field Experiments and Observations on Insects Injurious to Indian Corn,
Illinois Bulletin No. 104.

The Slender Seed Corn Ground Beetle,
U. S. Department of Entomology, Circular No. 78.

Insect Injuries to the Seed and Roots of Corn,
Illinois Bulletin No. 44.

PLATE XI.

The common Grain Weevils and larvæ.

OURTESY OF PROFESSOR S. A. FORBES, ILLINOIS STATE ENTOMOLOGIST.

CHAPTER XII

THE MARKETING OF CORN

1. HOME MARKETS

With the increase of dairying and stock feeding will come a corresponding increase in home consumption of corn. Tenants in general do not feed their crops on the farm. Farmers who recognize that the fertility of the soil can be maintained by keeping live stock and returning the crops to the land in the form of manure, are now raising sufficient number of hogs along with a few cattle to consume everything which is produced. Large returns in pork and beef usually accompany this practice. Furthermore, it has the advantage of being permanent and insures crops for the future.

Crops should be consumed on the farm

On the other hand, the commercial market has quoted corn at such high figures for the past two years that the cattle feeders who depend upon buying their corn have been forced to discontinue operations. This has been augmented by a prevailing state of affairs whereby the feeder usually has to pay two or three cents more than the market price in order to purchase any corn whatever. In districts where cattle and sheep feeding are carried on, the corn grower has a better market for his crop than in sections where every bushel is shipped out.

Higher marke[t] where grain is largely fed

Often where growers live within a few miles of the cattle feeder, the corn is hauled directly from the field to the buyers' cribs. A maxim of feeders is "buy when it is for sale." Renters who have little capital and must pay their rent at the first of the year, usually sell during the month of December. The man who can hold his corn, if it is of good quality, in general makes more money. *A factor of at least 18 per cent shrinkage must be considered.

Largely sold in December

The demand for corn in the towns near the grower is only a small factor. Some farmers have a regular trade with liverymen, teamsters, and feed stores. A good quality is usually desired by these buyers. Small mills which grind "chop" for consumption in the city buy a limited amount. Cornmeal mills, though located in a corn growing

Local demand varies

*18.2 per cent result of tests at Iowa Experiment Station.

section, usually buy of the elevators, because the grain is more uniformly graded and cleaned.

Local markets are quoted in the county papers. Prices are controlled by the commercial market quotations, by the people and by the supply and demand on a particular day or during a week. During the busy planting or cultivating season, when the farmers cannot leave their fields, the local corn markets often rise as much as five cents per bushel. Saturday is usually a day of low prices, because the farmers, during the slack season especially, bring in a load of corn when coming after groceries.

II. COMMERCIAL MARKETING

Twenty-three per cent shipped out

Any discussion of the subject of corn would be incomplete which did not also give some attention to the distribution of this crop. Of the total amount of corn produced in the United States in 1906 (2,927,416,091 bushels), 23.2 per cent (679,543,770 bushels) was shipped out of the county where grown. The counties of Nebraska shipped out 49 per cent of their crop, and those of Illinois, 41 per cent. The amount of corn handled each year by the elevators varies with the surplus and the demand for corn as a raw material for factories. The surprisingly large percentage of the crop of Illinois which is shipped out of the counties where grown, indicates the growing demand of the glucose factories and distilleries. The practice of shipping corn off the farm is to be severely criticised, considered from the standpoint of permanent maintenance of agricultural prosperity.

Too little is fed on the farms

The following figures show what per cent of the corn crop of the United States was shipped out of the county where grown for the years 1900 to 1906, inclusive:

1900	............22.7	per cent.	
1901	............10.0	"	(The very dry year.)
1902	............22.1	"	
1903	............18.7	"	
1904	............22.3	"	
1905	............25.0	"	
1906	............23.2	"	

As shown by the following figures, the farmers are holding their corn crop later in the season than formerly.

Percentage of Corn in the Hands of Farmers.

March 1, 1901 to 1907, inclusive.

1901	........................36.9	per cent.
*1902	........................29.1	"

*Following the year of drouth of 1901.

1903	41.6 per cent
1904	37.4 "
1905	38.7 "
1906	40.9 "
1907	44.3 "

Iowa has always been quite an extensive feeder of her crops. Although producing more corn than any of the other states, except Illinois, in 1904, there was only 21 per cent of it shipped out of the county where grown. In 1905, 24 per cent, and in 1906, 26 per cent of the corn crop was shipped out of the county where grown. **Largely fed in Iowa**

The farmers of Iowa do not depend entirely upon the fluctuation of an unsteady market at the time of harvest. Neither are they at they at the mercy or the caprice of the elevator and railway systems. That they have adequate cribbing facilities and have sufficient financial reserve, is shown by the fact that in 1905, 1906, 1907, the following percentages, respectively, of the corn crop were in the hands of the farmer; 42, 48, 49 on March 1st.

The following statement from S. J. Clausen, who operates an elevator at Clear Lake, Iowa, expresses the change in Iowa's grain movement.

"We used to have a big rush of grain from harvest until about the first of the year, but now most of the farmers have granaries and market their grain at their convenience during the year." **Farmers prepared to store the crop**

From correspondence with thirty-five elevator companies in different parts of Iowa, it was found that the greatest movement of corn was between January 1st and July 1st. In years of a well matured crop, December was also an active month.

Classification of Markets.

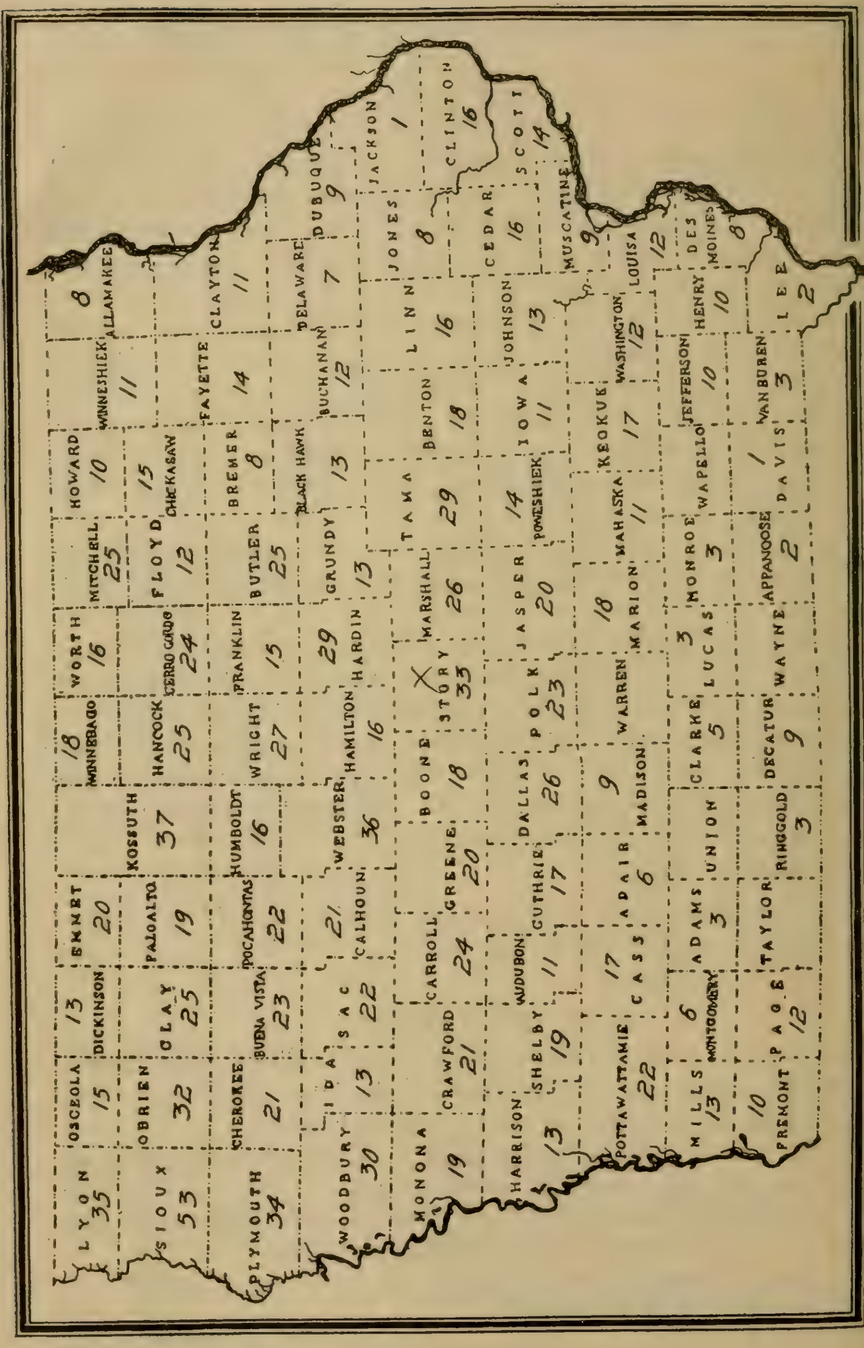
The markets which distribute the surplus corn of the United States may be classified as (1) primary, (2) terminal, (3) terminal-export, and (4) export.

PRIMARY MARKETS.

The primary market is represented by the small elevators located at railroad stations in the corn-producing districts. There was a total of 1777 such elevators in the state of Iowa in 1907.

Of this number, 220 were operated by Farmers' Cooperative organizations and 1577 were independent or line elevators. In July, 1907, the elevators listed by the Iowa Grain Dealers' Association were divided among the different railroad lines as follows:

Chicago, Rock Island & Pacific	326
Chicago & Northwestern	314
Illinois Central	137



(Courtesy of George A. Wells)

Fig. 119.

MAP SHOWING THE DISTRIBUTION OF ELEVATORS IN IOWA IN 1907.

Chicago, Great Western	109
Iowa Central	79
Minneapolis & St. Louis	65
Chicago, Burlington & Quincy (East of Des Moines River)	41
Other roads	62

Secretary Wells, of the Iowa Grain Dealers' Association, gives the following figures as the cost of operating a modern local elevator at a primary market:

Interest on cost of plant, valued at $4,000, at 6 per cent	$ 240.00
Interest on working capital, $1,000 at 6 per cent	60.00
Salary of manager or proprietor	900.00
Insurance, taxes, postage, stationery	100.00
Power	100.00
Extra help	100.00
Total	$1500.00

This, plus $200 for maintenance of property makes $1,700 per year.

About twenty per cent of Iowa's crop handled by elevators

About 20 per cent of Iowa's grain crop is handled by the elevators (according to Mr. Well's report), or 113,000,000 bushels—65,000 bushels per elevator. At this rate, the running expenses of each elevator are equivalent to 2 1-2 cents per bushel of grain handled.

Qualifications of Manager of Local Elevator. (1) The manager should be a good judge of commercial grades. Experience and observation will teach him the grading of corn as indicated by its color, moisture content, and amount of dirt present.

Must be a man of experience

(2) An understanding of the meaning of market quotations is necessary for an intelligent interpretation of market reports. Familiarity with steps in the shipment of consignments will enable him to better appreciate the need of lining cars before loading. A knowledge of railroad rates and the details of car ordering will often do away with shortage of shipping facilities at the time of a good market.

(3) Some education in regard to bookkeeping and banking will stand the manager in hand as his business grows. The margin at present on shipments of grain demands close figuring to insure profits.

Should be interested in crop improvement

(4) The manager should be the progressive man of the locality. His opinion upon the market should be respected by the shippers and farmers. His interest in the farming community should be substantial in the way of promoting corn and small grain exhibits, besides introducing new seed and advocating improved varieties.

Line Elevator Systems. Almost every town along the lines of railroad in the western part of the corn belt has a line elevator. For example; Nye, Schneider, Fowler Company have built along the Elkhorn division of the Chicago & Northwestern Railway in Nebraska, while Van Dusen holds the branch lines of the same road in South Dakota. The Updyke Grain Company owns a line of elevators parallel with the Union Pacific. On the B. & M. Ferguson buys in the principal districts.

Purchasing by elevators

These companies usually build quite large elevators to facilitate extensive storing. Cribs for ear corn are often erected near the elevator. During the husking season, farmers within a radius of several miles haul direct from the field to these cribs. In the early winter, shelled corn taken from open cribs and piles on the ground begins to come into the elevator. Corn from good cribs appears a little later, depending upon the prices and the financial condition of the grower. This corn, if it be dry and of good quality, is held in storage. Then the representative of the company, knowing how much corn they have on hand throughout the state or states, and knowing, too, how much the corn has cost, goes to the Chicago Board of Trade. Here he deals in futures, making a practice of selling on a high market and buying at a price below the original cost of the corn on hand.

Frequently deals on Board of Trade

In Iowa, there were in July, 1907, according to the Iowa Grain Dealers' Directory, 833 elevators owned by 130 companies who operated more than one elevator in the state. Twenty-one companies operated 10 elevators or more. The following companies were the most extensive owners:

Name.	Main Office	Number of Elevators.
Western Elevator Company,	Winona, Minnesota	65
Neola Elevator Company,	Chicago, Illinois	57
Huntting Elevator Company,	McGregor, Iowa	30
Nye, Schneider, Fowler Company,	Fremont, Nebraska	31
Wisconsin Northern Grain Company,	Minneapolis, Minn.	31
Reliance Elevator Company,	Minneapolis, Minn.	27

Independent Elevators. The growth of the independent or private elevator company has been marked within the last five years, especially in the western corn-growing states. Men of means in the different localities have entered into this field. Being acquainted with the growers in a given community, lumber merchants and coal dealers have erected elevators and begun buying grain. Competitive bidding with the older elevator companies places these companies in a favorable light with the farmers. There were in Iowa in July, 1907, 635

Largely with local capital

elevators operated by companies or individuals who owned but one elevator in Iowa.

Farmers' Co-operative Elevators. A Co-operative Grain Elevator Society is an organization of farmers whose object is the shipment **Purpose to eliminate profits of the middleman**

(Courtesy Younglove Construction Company)
Fig. 120.
Small Country Elevator.

of the grain grown by its members directly to the terminal markets. The purpose is to secure for the grain shipped the largest possible returns by eliminating the profit of the middleman. Each society is incorporated under the laws of the state and is governed by a Constitution and By-laws, enforced by the officers of the organization.

Iowa's first Farmers' Co-operative Society was founded at Rockwell in 1889. From a business of $220,000 in 1895, the money handled amounted to $625,000 in 1900.

The following is taken from the Articles of Incorporation of the Farmers' Cooperative Society of Rockwell, Iowa, Section 3:

Capital limited

"The capital stock shall be at the beginning of the business of this corporation, not less than One Thousand Dollars ($1,000), paid in at such beginning, and may be increased from time to time to, and not exceeding, Twenty-five Thousand Dollars ($25,000), and all increase over One Thousand Dollars ($1,000) shall be paid in from time to time on the issuance of shares of stock to purchasers becoming members. The said shares to be Ten Dollars ($10.00) each, and no member shall at any time own or have any interest in more than ten shares, and no share shall be issued to any one, except upon actual payment in cash therefor, or by note of the purchases, with security approved by the officers and directors, and such note must be made due and payable in time not exceeding sixty days and draw interest at 6 per cent. No shareholder shall have more than one vote in conducting the affairs of this Society."

Market quotations received by wire

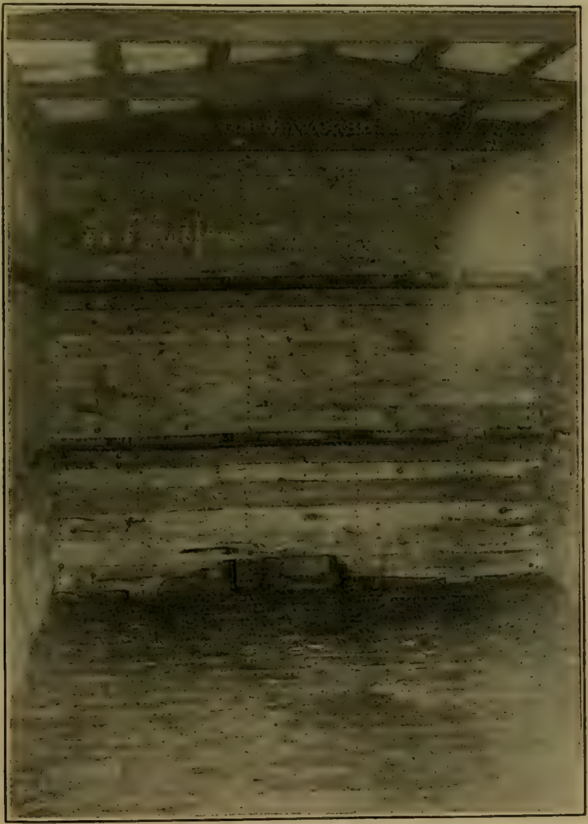
Representatives of local cooperative organizations can be as well posted each day as managers of the "line elevators." Market quotations by wire are received from all of the leading distributing and storing points. No knowledge, however, of the movement of grain enroute to market can be ascertained. A larger cooperation of all the societies in a given district is the solution of this difficulty. With the increase in the influence of the Interstate Commerce Commission, and that of the State Railroad Commissioners, a more amiable relation between farmers' organizations and transportation companies will exist. This is already manifested by a number of the railroads in their kindly attitude.

Rate per 100 lbs.

Corn Enroute to Market. In estimating the mean freight rate to Chicago, from the primary markets, rates from Illinois were taken as the lowest and from Nebraska as the highest. This average was about 16 cents per hundred pounds. A similar rate was charged for grain shipped to Minneapolis from local stations in Minnesota, North and South Dakota, and Nebraska. To Kansas City from country tributary to it, the average rate was 14 cents per hundred. At a certain time of the year, and especially in seasons of corn of low keeping quality, a car shortage occurs in the growing districts. In consideration of this point, the following paragraph is taken from the American Elevator and Grain Trade of January 15, 1907.

"The Iowa Railroad Commission recommended in January, 1907, that elevators in grain growing communities be of more reasonable capacity, sufficient to care for the products of the surrounding districts. Such increase in storage capacity would, it is believed, solve the car shortage problem. But, as George A. Wells truly says: 'There is no reason why the farmers shouldn't build bins sufficient to hold their grain and ship it when the market is the highest. They can pick that time as well as anyone else. Corn left in the field will not grade and the farmer suffers the loss. Even if additional elevators were provided, the farmers would be compelled to pay high storage charges,

Farmers should get the benefit of the best market



(Courtesy Weighing Department of Chicago Board of Trade)

Fig. 121.

Car before it has been properly lined for grain.

which would eat up their profits. But, by building bins and watching the market, they would also relieve the car shortage, which comes only because every one wants to get his corn to market at once.' "

How to Prepare Cars for Grain. Cars should be prepared for grain in such a way as to prevent, if possible, any leakage in transit, and to prevent rain or snow from reaching the grain.

Leakage

There are three causes for the leakage of grain in transit, as follows:

(1) Defective car equipment.
(2) Rough handling of equipment by railroads.
(3) Carelessness on the part of the loader.

The first two causes are beyond the control of the individual shipper, but the last named cause can be practically eliminated if the proper effort is made by the loader.

Shortage due to leakage in transit, causes all interested much concern. Shipper, receiver, line of transportation, and terminal weighmaster, all suffer directly or indirectly. Therefore, all should do their part towards eliminating this constant source of contention.

The points to be inspected in a car, arranged in order of their greatest importance, as determined by leakage statistics, are as follows:

(1) The grain doors;
(2) The sheathings;
(3) Door posts and end posts;
(4) End doors and windows;
(5) Linings;
(6) Floors.

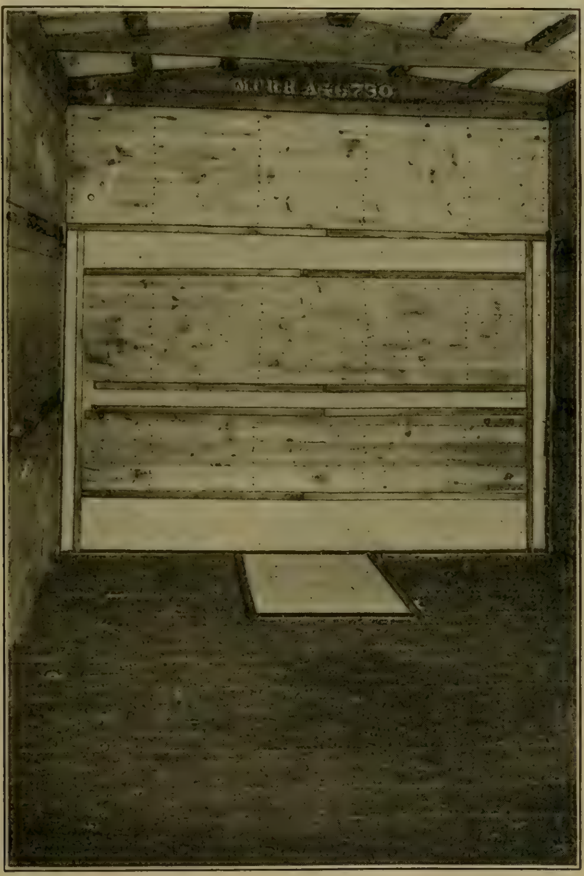
Grain doors should be strong and well braced

Be sure that your grain doors are strong enough. A safe plan is to make them stronger than you deem necessary. They should be well braced, and all braces should be nailed to each and every board. It is poor economy to scant this bracing. Where a vertical center brace is used, put a cleat on the floor at the bottom, if possible. The best and safest door of which we know, is made by placing two ordinary grain doors with the flat sides together. The object in placing the flat sides together is to prevent grain from lodging between them. Under no circumstances should a door be used which is too short for the opening. Spliced grain doors are most unsatisfactory and uncertain.

Patent doors

Patent doors, having effective lugs at the bottom, and other proper fastenings, should not be nailed to the door posts. When nailing is necessary, never use spikes, as spikes cause the mutilation of the door, when opened at the unloading point.

Single boards should be used for the top of the grain door in order that one or more boards may be knocked off by the grain inspector without loosening others and causing leakage. The jarring and jolting of cars in switching will level the grain in them; therefore, the doors and windows should be boarded above the leveling point.



(Courtesy Weighing Department of Chicago Board of Trade.)
Fig. 122.
Car after it has been properly lined for grain.

Next in importance are the sheathings. Both the side and end sheathings should be examined after the cars are loaded, and any that are loose or bulged should be securely nailed. The rocking of **Sheathings** the car in rounding curves will surely spring weak sheathings and allow the escape of grain, which the linings will not prevent. Leakage at sheathings is not readily detected unless the cars are in motion.

Examine door and end posts

Leaks due to defective door and end posts are liable to be serious. Therefore, a careful examination of them should be made before loading. When there is any evidence of weakness in these posts, the inside of the car at these points should be lined with burlap or cloth in such a manner as to prevent leakage should they give away.

Boarding end windows

End doors which extend to the floor are a source of many leaks and should therefore receive a careful examination, and if cooperage be necessary, it should be on the inside of the car. A grain door set on end will afford good protection. Always lock or cleat the end windows on the inside and do not neglect to board them high enough.

In referring to end windows when preparing cars for grain, Mr. R. C. Richards, Claim Agent for the Chicago & Northwestern Company, writes: "When you load cars, fasten the end doors inside with a cleat, since it is through these doors that robberies occur. That is the reason we want them cleated before loading with grain."

Lining the car

The lining of cars should also receive careful attention on the part of the loader, as grain lodging behind them frequently amounts to several hundred pounds; and where it lodges in pockets is often lost to the shipper. A careful cooper will pay particular attention to this point.

Floor should be inspected

In addition to the above, special attention is directed to the floors, more particularly when small grains such as flaxseed, rye and wheat are to be loaded.

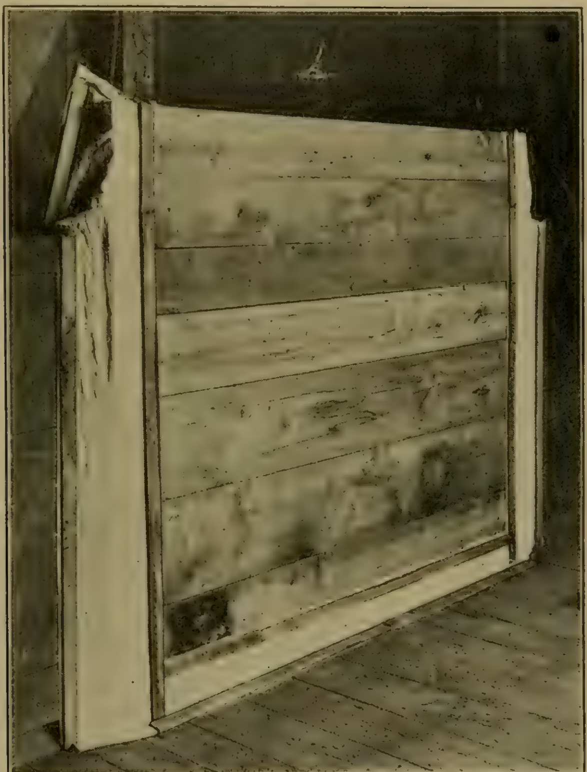
Aside from repairing large defects in a car to be loaded with bulk grain, any shipper can secure the best insurance against leakage at the least expense by lining the cars to be loaded as they are frequently and most successfully lined for flaxseed.

The cost of preparing a car in this manner varies from fifteen to thirty cents for the material, according to its condition.

Size of Cars. Box cars for the shipment of grain have capacities varying from 30,000 to 100,000 pounds. Their dimensions range from 27 feet 6 inches in length and 7 feet, 10 1-2 inches in width, to 40 feet in length and 8 feet 6 inches in width. The grain line which is placed in cars for the purpose of preventing overloading and underloading, varies in height in the case of corn from 3 feet to 6 feet 7 inches.

Measurement of car not accurate as to amount of grain contained

It is not expected that corn will weigh out according to the measurement or grain line in car. According to the Chicago Shippers' Manual, corn testing 55 pounds occupies approximately 2,090 cubic inches per bushel; settled, approximately 2,020 cubic inches per bushel. Corn testing 54 pounds, 2,130 cubic inches; settled, 2,065 cubic inches. A car 33 feet long by 8 1-2 feet wide and filled to a height of three feet with shelled corn, would contain 693 bushels. These figures are only approximate. The specific gravity of grain is constantly varying because of moisture, pressure and quality.



(Courtesy Weighing Department Chicago Board of Trade)
Fig. 123.
Car door covered with cheese cloth to prevent leakage.

The rules of the different railroads governing the quantities of grain to be loaded into cars of various capacities vary to a limited extent in minor details. The maximum amount of grain allowed to be loaded is 10 per cent over the marked capacity of the car, on practically all roads. Maxin load

The Burlington Railroad makes the following stipulation in regard to shipping ear corn:

Ear corn will be subject to the following minima, but not to exceed the marked capacity of the car.

In cars not over 28 feet in length (inside measurement), 4,000 pounds less than marked capacity of car, but not less than 30,000 pounds.

Amount per car

In cars not over 34 feet in length (inside measurement), 46,000 pounds.

In cars not over 36 feet in length (inside measurement), 56,000 pounds.

In cars over 36 feet in length (inside measurement), 66,000 pounds

To be shelled in transit

Corn Shelled in Transit. Shipments of ear corn to be shelled in transit must be loaded to full visible capacity, but not to exceed carrying capacity of car. If the weight of the shelled corn from a car so loaded is less than the minimum weight on shelled corn for the car in which the same is loaded, actual weight of the shelled corn may be accepted, if the ear corn is not loaded to visible capacity of car, the minimum weight on the out-turned shelled corn will be 30,000 pounds.

Agents will carefully examine all shipments of ear corn to see if cars are loaded to their full visible capacity, but not above carrying capacity of car, and make notation on way-bills, whether or not cars are so loaded.

Shortages and claims as viewed by the Claim Agent of a large western railroad.

Poor cars at time of shortage

"It has been my observation that most of the losses of grain are due to carelessness and insufficient coopering of cars by the shipper. When grain begins to move, a shortage of equipment usually follows. The roads are therefore obliged to furnish any kind of a car that will pass a mechanical inspection. The result is that old cars with bad doors, sides and floors are set in for the elevators, and it requires something more than ordinary coopering to make these cars safe against leakage. The shippers apparently do not realize this. They feel that if they put in the grain doors they are doing everything necessary. The fact of the matter is that a great deal of the leakage is around the center pins and over the draft rigging of the cars, and particular attention should be given to coopering such portions of the car. The railroad companies furnish grain doors and grain door lumber in abundance, and the shipper should be willing to place his labor in recoopering the car against the company's expense in furnishing the material.

Company furnishes lumber for coopering

"A great many of the leakages are caused by the weight of the grain bulging the grain doors out. These are instances where the shipper is anxious to get into the car every pound of grain he possibly can—another result of the scarcity of equipment. In such instances the shipper should take into consideration the extraordinary weight of the grain and should use enough lumber at the doors to prevent the grain doors bulging or breaking.

Too heavy loading

"A great many of the claims for grain shortages do not represent shortages at all, but merely errors in weight, which are brought about by lack of system or carelessness on the part of the shipper. Possibly he loads his car on a team track, or he may be loading two or more cars of different grades; he will frequently get a wagon load of one grade into the wrong car, and, as a consequence, one of the cars will check short—say, 2,000 pounds, while the other car will over-weigh 2,000 pounds. He puts in a claim for the shortage, but the railroad company never hears of the overage. It would be surprising to know how many cases of this kind the railroad companies actually bring to light, and it would be still more surprising if we could find out how many cases we never succeed in bringing to light."

Many shortages due to errors in weight

Suggestions As To Making Claims. In presenting claims for the loss of grain in transit, claimants who desire prompt attention should furnish the railroad companies against whom the claim is made, with the following documents and information:

First, with copy of bill of lading.

Second, with an affidavit made by the person who loaded the grain, showing the amount, date, place and number of the car into which the grain was loaded; how it was weighed and the condition of the car when loaded.

Third, the account of sales for the grain when it reached destination.

Fourth, certificate of the weighmaster at destination. If he is not the official Board of Trade Weighmaster, an affidavit from the person who unloaded the grain, showing when and where it was unloaded, seals of the car, condition of the car, and the number of pounds or bushels unloaded.

Fifth, a complete record of any investigations which have been made prior to making claim for loss, with reference to the loading, unloading and weighing of the grain.

Sixth, a statement of the number of bushels lost and value of same.

Seventh, if the claims cover damage to grain from leaky roof or other causes, they should be accompanied with all information bearing on the subject.

Much delay due to lack of information

"The mere statement of 'leaky roof' by some one at a destination is not sufficient, by any means," writes Mr. A. Kirkland, Claim Agent for the Illinois Central Railroad. "We should have more than this, and furthermore, inspectors or others should call the attention of the railroad company at destination to the discovery of a leaky roof, so that proper investigation may be made by the railroad company. The great trouble and reason for delay in the adjustment of some claims is want of information."

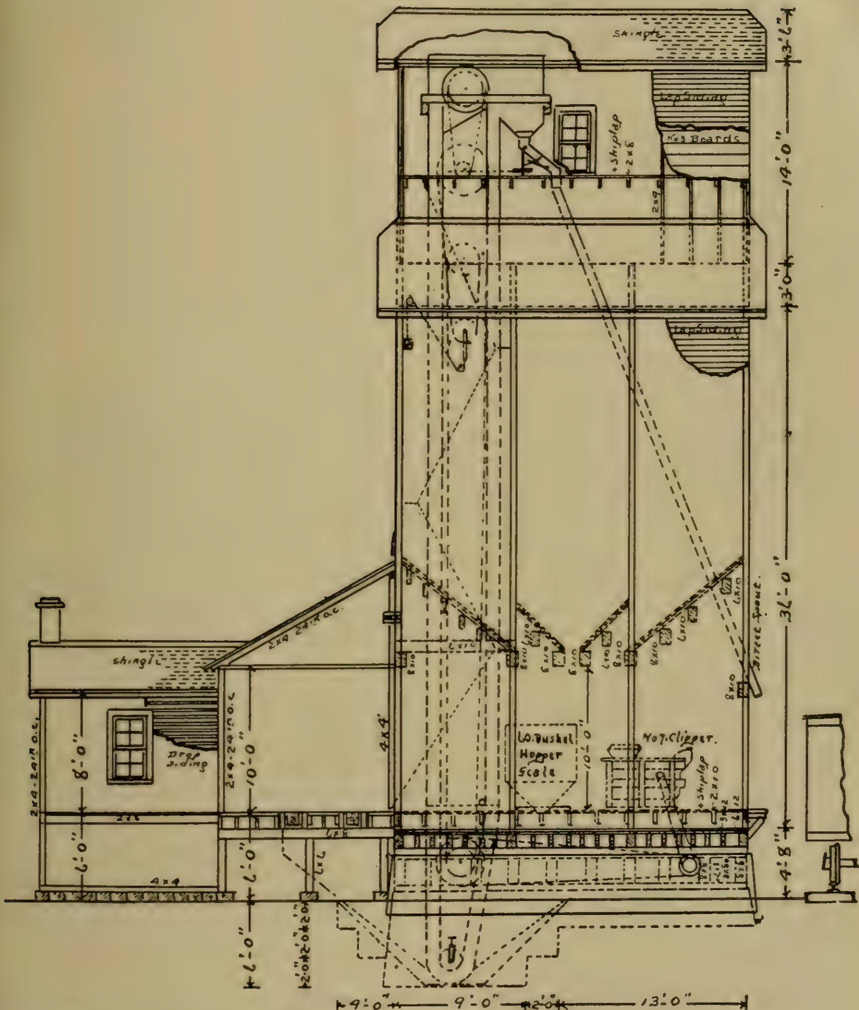
Mr. R. C. Richards, Claim Agent for the Chicago & Northwestern Railway Company, writing in the same vein, states that "if, in the presentation of claims, the claimants would furnish complete information, their losses could be promptly investigated and adjusted."

(Courtesy Weighing Dept. Chicago Board of Trade)
Fig. 124(a).
(a). Stopping leakage on the side of grain car.

TERMINAL MARKETS.

Handle large quantities of grain

Terminal markets are points of inspection, exchange, speculation, storage, and distribution. Such markets are necessary to facilitate the handling of large quantities of grain. Their growth has been due not only to increased production, but to the development of complexity in systems of distribution.



(Courtesy Younglove Construction Company)

Fig. 124.

Design of right elevation of small country elevator. Follow the course of the grain from its delivery from the wagon until loaded into the car.

RECEIPTS OF CORN AT THE PRINCIPAL MARKETS DURING 1907.

Markets	Bushels	Percent of Total Receipts Except Flax
Chicago	125,159,932	47.2
Cincinnati	9,190,142	47.6
Cleveland	5,966,357	39.7
Detroit	4,594,342	47.5
Duluth	149,365	.2
Indianapolis	6,674,800	53.4
Kansas City	14,787,900	25.1
Little Rock	4,050,000	73.4
Louisville	10,406,982	52.9
Milwaukee	6,635,435	14.3
Minneapolis	6,151,560	4.6
Omaha	18,493,200	43.2
Peoria	17,488,600	53.6
St. Louis	34,704,720	40.6
Toledo	7,438,400	42.5
Total	271,891,735	

The following table shows the comparative receipts and shipments, in bushels, for a period of 24 hours, prior to Saturday, July 18, 1908, at the principal terminal and terminal export markets:

TERMINAL MARKETS.

Markets.	Receipts.	Shipments.
Chicago	159,088	135,908
Milwaukee	4,000	3,000
Minneapolis	4,160	4,200
Duluth		
St. Louis	38,500	37,450
Toledo	8,800	9,130
Detroit	1,264	15,552
Kansas City	11,000	8,800
Peoria	67,100	25,300

TERMINAL-EXPORT MARKETS.

Markets.	Receipts.	Shipments.
New York	10,750	1,360
Boston		
Philadelphia	2,000	
Baltimore	5,219	
New Orleans	4,500	60

Chicago As a Terminal Market. Receipts of Corn at Chicago during each of the Twelve Months, 1906, 1907, in bushels.

January	8,735,964	11,488,023
February	7,940,400	13,158,362
March	6,031,912	11,324,734
April	4,146,244	7,979,002
May	7,020,249	6,393,069
June	14,764,109	19,398,650
July	8,659,513	8,569,542
August	4,676,606	5,631,622
September	13,029,866	14,619,305
October	9,065,016	13,329,138
November	6,437,419	4,137,753
December	8,389,265	9,130,732
Total	98,896,563	125,159,932

Corn Values. The following table exhibits the average highest and lowest prices for No. 2 corn (cash) at Chicago, during each month of the year. The average in cents per bushel is taken from 1873 to 1906, inclusive.

	Lowest Price	Highest Price
January	38.6	41.9
February	39.5	42.9
March	40.1	44.5
April	41.4	47.4
May	40.6	47.5
June	42.5	47.6
July	43.1	49.0
August	44.0	47.7
September	42.8	50.0
October	42.0	53.4
November	41.4	48.8
December	40.4	46.2

The following prices in Chicago for the months of 1907 show the general trend of corn values in cents per bushel:

	Lowest Price	Highest Price
January	39¾	43½
February	43	44¼
March	43	45
April	44¼	50¾
May	49½	56

June	51¾	54½
July	52	55¼
August	54	61½
September	60½	63¾
October	54¾	66½
November	55½	60½
December	57½	61½

Omaha As a Terminal Market.

RECEIPTS AND SHIPMENTS OF CORN AT OMAHA.

Years.	Receipts.	Shipments.
1904	8,833,735 bushels	7,695,050 bushels
1905	19,771,300 "	20,841,000 "
1906	20,728,400 "	19,522,400 "
1907	18,493,200 "	19,026,000 "

Beginning business as a terminal market in 1904 the volume of corn trade has increased rapidly at Omaha.

Disposition of Shipments from Omaha Market, 1907.

Destination	Corn
Chicago and Milwaukee	2,183,000 bushels
St. Louis	2,726,000 "
Mississippi River Points	951,000 "
Minneapolis and St. Paul	29,000 "
Illinois	1,987,000 "
Wisconsin	233,000 "
Middle States	1,521,000 "
Seaboard	1,670,000 "
Southeast and Mississippi Valley	3,385,000 "
Export via Atlantic	1,630,000 "
Export via Gulf	421,000 "
Interior Points	2,290,000 "
Total	19,026,000 "

A study of the above table shows that the large per cent of Omaha shipments are destined southward.

Inspection of Corn at the Terminal Markets. Carloads of corn arriving at the terminal markets are inspected and sampled by officials as follows: Chicago, by the Illinois State Board of Railroad and Warehouse Commissioners; Duluth, by the Minnesota State Board of Railroad and Warehouse Commissioners; at Milwaukee, the Chamber of Commerce appoints the chief inspector, who in turn selects his assistants.

The Steps in the Inspection. *When a carload of grain reaches the terminal yards of any railroad, it is carded by the railroad company "Grain for Inspection" and switched to tracks in the yard designated as grain tracks.

The inspector, with from one to three helpers, arrives at the railroad freight yards and the designated grain tracks about seven o'clock in the morning and begins the work of inspection. The helper first opens the door of the car and tacks on it what is called an "Inspector's Ticket." (See Figures 331 and 332). This ticket is put on the car for the inspector to make his record on when he inspects the car. This record consists of the car number, the initials, kind of grain and the grade given it. The inspector's ticket remains on the car until it is unloaded and is the authority of the elevator superintendent for unloading the car.

By whom inspected

Fig. 330.
INSPECTORS LEAVING FOR FREIGHT YARDS.

The inspector, with the assistance of another helper, follows and inspects the car, carefully sampling each and every part of the car with a "tryer." (A "tryer" is a hollow steel pipe or tube about two inches in diameter and four feet long, with a space four inches long

Samples secured with the "tryer."

*Statement of W. S. Cowen, Chief Inspector of Grain, Chicago.

Fig. 331.

BREAKING THE SEAL.

The grain inspector is seen with chondrometer in hand; by his side stands his helper with ladder and crowbar ready to open the door and remove boards if necessary, that the sampler (standing just behind him) may enter. Note the instrument on his shoulder used for taking the samples. This is called a "tryer." The fifth party standing by the cart collects the samples which are taken to the Board of Trade Building.

Marking inspector's ticket

and an inch and one-half wide, the full length of the tryer, with a closed space between these open spaces of two and three-quarter inches. (See figure 332.) This tube is fitted with a wooden plunger that fits closely inside the tube. This plunger closes the tube up tightly from top to bottom. The tryer is pushed down to the bottom of the car and plunger taken out when the tube readily fills , covering practically all the grain from the bottom to the top of the load, to see that the grain is loaded evenly. After a thorough sampling of the car, he places the grade upon the ticket above referred to. The number and initials of the car, the kind of grain and the grade given it, and his remarks for grading the grain a certain grade, is reported in a book known as a "Tract Book," which he carries with him. This process applies to every car inspected. (See Fig. 334.)

Detailed record is kept

After the inspector's work is done for the day, he makes out a report giving the car numbers, the initials, kind of grain, and grade, and remarks made on each kind of grain (these remarks being the reason given for inspecting grain a certain grade), and sends this report to the chief inspector's office. This report is then copied into the record books kept in the office of the Chief Inspector. These become the official records of the Department of Grain Inspection.

Receiver's agent

There is another man who accompanies the inspector, who is called the "Receiver's Agent." This man is employed by the members of the Chicago Board of Trade and has nothing whatever to do with this department. He takes a sample of the grain contained in the car inspected and also gets the grade as placed thereon by the inspector. (See figure 335). He also receives from the railroad a notice to the

Figure 332.
THE INSPECTOR'S TAG IS NOW PUT ON THE CAR.

consignee of the arrival of the car, and carries that notice with the sample and the grade given the grain by the inspector and delivers it on the Board of Trade to the consignee. On each railroad carrying grain into Chicago, there is a Receiver's Agent doing the work above referred to.

Car may be re-inspected

After the Receiver's Agent delivers the samples to the consignee, if the shipper feels that he has not received a fair grade on his grain, he notifies the Department of Grain Inspection and a supervising inspector is sent to the car to reinspect the grain therein; if he find that the inspector has made no error in the inspection, he sustains the original inspection. If he find an error, he changes the grade to what, in his judgment, he believes it to be, and the same is at once reported to the consignee. Should the consignee still be dissatisfied, under the rules governing this department he has a right to appeal to what is known as the "Appeals Committee," or in other words, a court of last resort in the Inspection Department. Their decision is final and cannot be appealed from.

Securing samples

Delivery of Samples. The Receiver's Agent places the samples of corn as graded by the inspector in a pushcart. The paper or cloth bags, usually the former, are labeled with the name of the firm to whom the car is consigned, number of the car, and the grade of the corn. For example, "Rumsey & Company, 43,667, No. 3 Yellow."

Fig. 333.
THE EXTRA BOARDS ARE BEING REMOVED.

Taken to the Board of Trade Building

When all the cars are inspected the bags are transferred to the morning express train which runs into the city from the terminal grain yards. During the run down town the Receiver's Agent and his helpers are arranging the bags in groups, putting all those of one company together. When the train reaches the city station, a special wagon transfers the samples to the Board of Trade Building. Business begins promptly at 11 o'clock A. M. and before that time the samples must be delivered to the table belonging to each firm represented in the morning's receipts. The tables are high set and heavily made. Each commission firm rents a table or part of one, usually a quarter or half, upon which to do business.

On the Cash Floor. The buyers for the eastern trade, exporters, glucose and distillery representatives, all assemble at 11 A. M. The examining of the samples and buying on this market is strictly cash.

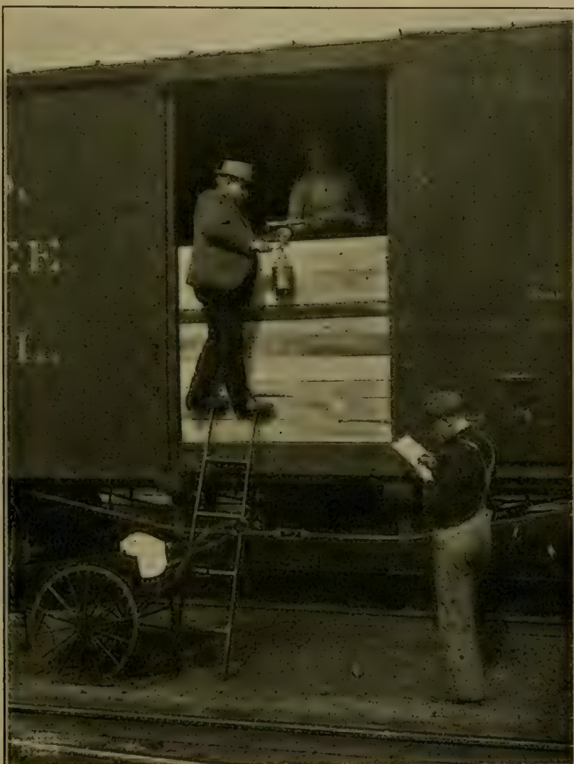


Fig. 334.

THE CAR OF GRAIN IS INSPECTED.

Samples being taken near both ends of the car as getting the weight per bushel. A detailed record is being well as opposite the door. The inspector will be seen made in the "Track Book" of each car of grain. The other two of this party (shown in Fig. 333) have gone to prepare the next car for the inspector.

Samples used on cash market

Each commission man tries to interest as many buyers as possible. He shows the samples to those who will be most interested in the grade of corn which he has on hand that particular morning. He does not try to influence the exporter to buy immature corn full of moisture, nor will he try to sell it to a warehouse man who intends storing it for any length of time.

Closing the day's business Trading ceases usually by 1:30 and the clerks in the Commission Firm's office figure up the returns of each car of corn. Mr. A., who lives at a certain town in northern Iowa, receives a letter which gives the number of bushels in the car which he shipped; the grade, the

Fig. 335.

A SAMPLE OF GRAIN IS COLLECTED.

The car number and the grade is marked on the sack. These are to be representative samples. They are taken to the Board of Trade Building and used in selling the grain on the cash market.

price per bushel, freight charges, dockage or leakage, if any, cost of inspection, commission, and a draft for the net proceeds of the sale.

Commercial Grades of Corn. The following grades are recognized and described by the Chicago Board of Trade:

No. 1. Yellow corn shall be yellow, sound, dry, plump, and well cleaned.

No. 2 Yellow corn shall be 90 per cent yellow, dry, reasonably clean, but not plump enough for No. 1. **Yellow corn**

No. 3. Yellow corn shall be 90 per cent yellow, reasonably dry and reasonably clean, but not sufficiently sound for No. 2.

No. 4. Yellow corn shall be 90 per cent yellow, badly damaged, damp, musty or very dirty.

Fig. 336.

AFTER THE CAR OF GRAIN HAS BEEN INSPECTED IT IS AGAIN SEALED.

No. 1. White corn shall be white, sound, dry, plump, and well cleaned. **White corn**

No. 2. White corn shall be 95 per cent white, dry, reasonably clean, but not plump enough for No. 1.

No. 3. White corn shall be 95 per cent white, reasonably dry and reasonably clean, but not sufficiently sound for No. 2.

No. 4. White corn shall be 95 per cent white, badly damaged, damp, musty or very dirty.

Mixed corn

No. 1. Corn shall be mixed corn of choice quality, sound, dry and well cleaned.

No. 2. Corn shall be mixed corn, dry and reasonably clean, but not good enough for No. 1.

No. 3. Corn shall be mixed corn, reasonably dry and reasonably clean, but not sufficiently sound for No. 2.

No. 4. Corn shall be mixed corn that is badly damaged, damp, musty, or very dirty.

Fig. 337.
REINSPECTING GRAIN AT THE GRAIN INSPECTOR'S OFFICE.*

Corn that is wet or in heating condition shall not be graded.

The following extract from an address of Secretary Wells** of the Iowa Grain Dealers' Association, before the members in December, 1904, shows many practical points in the grain trade:

No. 2 contract grade

"There are market conditions that affect the relative values of the different grades because of speculation and also the question of facilities for handling, storing and transportation. When a corner is being manipulated by speculation there is always a stronger demand for

*According to a new ruling the samples of grain are secured from the cars and brought into the Board of Trade Building where they are inspected.

**Now secretary of the Western Grain Dealers' Association.

the contract grade, which is No. 2 corn, than for the inferior grades, and the difference, which under normal conditions may be one or two cents per bushel and may widen to 25 cents or even more.

"To illustrate this, on July 11, 1902, during the Harris-Gates corner, No. 2 or contract grade corn sold at 88 cents in store at Chicago, while No. 3 corn sold at 73½ cents, a difference of 14½ cents per bushel, while the difference based on feeding and manufacturing or normal market values, would perhaps not have exceeded 2 cents.

"When markets are glutted and supply exceeds the demand, the corn must necessarily go into store and the buyer of such corn will certainly select only the corn that is thoroughly dry and sound, while the lower grades would be neglected. Thus, under such circumstances, the difference in value between grades would be more than if normal conditions prevailed. However, with modern machinery for drying corn, this is not so likely to occur, and will depend upon the facilities for handling of grades in the particular market in which the corn is located, and the general outlets. Low grade corn that is liable to get out of condition and is located in a market where there is no cleaning house or drying facilities, would suffer a greater discount than if located in a market with larger facilities and likewise larger demand. **Sound corn stored**

"The business of mixing grain is an important element in the terminal grain trade. Large elevator plants are devoted to that branch of the business, and it will be readily understood that for this purpose there is always a varying demand for the different grades that affect comparative values as between grades. Thus briefly stated, speculation, congestion at terminals, and mixing, affect values regardless of the intrinsic worth of the grain. It is along these lines that the grain business assumes the character of a profession, and of them the successful grain merchant must have some knowledge; otherwise his business is merely that of a freight handler at a railroad station and his income scarcely more than common wages. I know of an 8,000-bushel lot of average corn that was shelled and run through the drier in November, and the shrinkage in weight amounted to a cost of 5 cents per bushel, to say nothing of the labor. **Mixing grain**

"Volume is an important element in the grain business, and a particular grade or quality of grain must be offered in a volume sufficient to make the handling of it in its identity consistent and practical before it will be thus recognized by the trade.

"No. 2 corn is unknown to the grain trade in Iowa today, simply because of that reason; while if possibly 25 per cent instead of less than 9 per cent of the corn of Iowa were No. 2, the grain trade would **No. 2 corn scarce** be forced to recognize that grade and the farmer would receive an additional one-half to one cent per bushel, and at times more."

Cost of Inspection. The chief inspector of grains at Chicago is authorized to collect on all grain inspected, the following:

For In Inspection—

35 cents per carload; 10 cents per wagon or cartload; 40 cents per 1,000 bushels from canal boats, ¼ of a cent per bushel from bags.

For Out Inspection—

50 cents per 1,000 bushels to vessels and cars; 50 cents per carload to cars for all special inspection; 50 cents per carload to teams or 10 cents per wagonload to teams.

Brokerage by Grade. The following rates of brokerage being just and reasonable, are hereby established as the minimum charge which
Rate shall be made by members of this Association for the transaction of the business specified in this section.

For the purchase or for the sale, by grade alone, of wheat, corn or oats, to be delivered in store in regular houses, either for immediate or for future delivery, ten cents per 1,000 bushels; for the purchase, or for the sale, by grade alone, either for immediate or for future delivery, or to arrive, or in car load lots in any position, 50 cents.

Brokerage by Sample and C. I. F. The following rates of brokerage, being just and reasonable, are hereby established as the minimum charge which shall be made by members of this Association for the transaction of the business specified in this section.

For the purchase or for the sale, by sample, or by grade and sample combined, for immediate or future delivery, or to arrive or in car load lots in any position:

On corn or oats per car	$ .50
On ear corn per car	1.50

For the purchase or for the sale of all kinds of grain C. I. F. (cost, insurance, freight), for shipment by water or rail, to or from Chicago
Rate or other points, ⅛ cent per bushel in lots of 5,000 bushels or more, ¼ cent per bushel in lots of less than 5,000 bushels.

Commissions for Buying or Selling or for Buying and Selling. The following rates of commission, being just and reasonable, are hereby established as the minimum charge that shall be made by members of this Association for the transaction of the business specified in this section.

For the purchase or for the sale, or for the purchase and sale, by grade alone, of wheat, corn or oats to be delivered in store either for immediate or for future delivery, ⅛ cent per bushel.

Commissions, Buying or Selling and Accounting. The following rates or commission, being just and reasonable, are hereby established as the minimum charge that shall be made by members of this Association for the transaction of the business specified in this section. **Commission ⅛ cent per bushel**

For receiving and selling or for buying, either to be loaded or to be unloaded or to be forwarded, by grade or sample, or both, either for immediate or for future delivery, or to arrive, or in carload lots in any position; on corn or oats ½ cent per bushel; on ear corn, 1 cent per bushel. **From ½ to 1 cent per bushel**

It is hereby provided that upon transactions specified in the foregoing paragraphs of this section which are made for the account of members of this Association, or for firms one at least of whose general partners is a member of this Association, or for corporations entitled under Section 8 of this rule to members' rates, one-half of the foregoing rates shall be the minimum rates charged.

Commissions for Buying or Selling Vessel Lots—The following rates of commission, being just and reasonable, are hereby established for receiving and selling or for buying and shipping the following described property by vessels: **On corn or On corn oats ¼ cent per bushel**

On corn or oats, ¼ cent per bushel.

Additional Charges. In addition to all the rates of commission prescribed by this rule, there shall be charged all legitimate expenses incurred in handling and caring for the property involved, including storage, insurance, inspection, weighing. *Cost of sampling* shall *not* be considered a *charge* against the property.

Comparative Receipts of Different Grades.

Number of Cars of Each Class and Grade of Corn Received in Chicago.

Yellow	1906		1907	
No. 1	37	cars	1	cars
No. 2	16,596	"	12,008	"
No. 3	16,259	"	23,868	"
No. 4	4,780	"	10,190	"
				"
Total	37,672	"	46,067	"
White	1906		1907	"
No. 1				
No. 2	4,133	cars	3,199	cars
No. 3	3,585	"	7,535	"
No. 4	800	"	2,731	"
				"
Total	8,518	"	13,465	"

Mixed	1906		1907	
No. 1	4	cars		cars
No. 2	7,161	"	3,915	"
No. 3	19,159	"	22,330	"
No. 4	11,918	"	10,963	"
Total	38,242	"	37,208	"
No Grade	3,549	"	6,787	"

Arrival of different grades

In studying the receipts of these different grades by months, it is found that the largest shipments of No. 2 of all classes were made during May, June, July, August, September, and October. There was no No. 1 corn received except during these months. Almost all of the No. 4 and no grade corn arrived during November and in December, January, February, and March.

Testing Corn for Moisture.* "Expert John D. Shanahan has been making moisture tests on corn throughout the west during the past thirty days and has awakened a lively interest in the trade in that important problem, hitherto a mere matter of guesswork with most dealers, to whom, indeed, the subject had little more than an academic interest. Wichita, St. Louis, Kansas City, Omaha, St. Joseph, Des Moines, Decatur, Peoria and other places have been given the benefit of the tests with good results.

High moisture content

"The amounts of moisture found in corn at these various places did not materially vary, but everywhere there was more moisture than corn should contain that is expected to grade well or to be sent to store. At Wichita, the results of the tests were as follows, the figures indicating the percentage of moisture found:

N. E. G. Corn	20.7	Percent
No. 3, Yellow Corn	19.0	"
N. E. G. White	20.2	"
No. 3, White Corn	17.1	"
No. 4, White Corn	21.0	"
No. 4, Yellow Corn	19.8	"

At St. Louis, the tests showed the following percentages:

No. 4, Mixed Corn	18.9 to 19.9	Percent
No. 4, White	19.8	"
No. 2, Yellow	14.7	"
No. 2 and No. 3, White	17.5	"

It is said that the immediate result of Mr. Shanahan's visit to St. Louis will be the establishing of a testing apparatus in the Grain Inspector's office.

*American Elevator and Grain Trade, February 15, 1907.

At St. Joseph, the tests showed the following percentages:

No Grade Corn	21.0 to 21.5	Percent
No. 4 Corn	18.6	"
No. 3, White	16.5	"
No. 3, Mixed	17.8 to 17.6	"

"'Different grain men have used different methods of testing corn and grading it,' said one St. Joseph inspector of the tests. 'We judge by the feel, by the appearance, by the way a small quantity runs through the hand, in all sorts of ways, but a test like this would be very valuable to us.'

Methods of judging moisture

"'I wish that I had an apparatus like this in Kansas City a few years ago,' said John Winn, now State Grain Inspector in St. Joseph. 'For instance, an elevator man would put 200,000 bushels of corn into his elevator, but it might shrink 30,000 bushels before he took it out again. It sold, though, as 200,000 bushels. I experimented by taking a quantity of grain and drying it for a month in my office, and after I had made several experiments and struck off an average, I showed the grain men how I had discovered that a large percentage was lost by shrinkage. After that, they were compelled to bring in receipts for certain percentages of their grain, and we cancelled them, thus maintaining a more accurate record of the grain in elevators and protecting the buyers.'"

Heavy shrinkage

Weighing Charges at Chicago:

Grain by cargo from elevator to vessels per M	$ .12
Grain by cargo from vessels to elevator per M	.12
Grain from canal boats, per boat load	1.00
Grain in bulk, at regular transfer stations, per car load	.50

Grain Storage. In order that the terminal markets may handle and distribute promptly and economically the enormous quantities of corn which they receive, great warehouses are built for storing millions of bushels of grain. Chicago, the great distributing center for the Central States, has storage capacities for 60,000,000 bushels of grain, about equally divided between the "regular" and "irregular" warehouses. The "regular" warehouses are licensed by the Chicago Board of Trade, and the grain handled by them is subject to inspection by the State Grain Inspection Department. All grains handled by them are represented by negotiable warehouse certificates which form a collateral upon which most banks will give loans at low rates of interest. The "irregular" warehouses are not operated under the rules of the Board of Trade, but are subject to inspection by the State Grain Inspection Department.

Regular and irregular warehouses

(Courtesy Weighing Department, Chicago Board of Trade)
Fig. 125.
MODERN TERMINAL ELEVATOR.

Grain storage has not expanded with the increased production. The total storage capacity of the fourteen principal markets is 226,-000,000 bushels. Of this 181,000,000 is old wooden style construction with high rates of interest, the remaining 45,000,000 being of steel and iron. Seaboard capacities are very limited and decreasing. New York has decreased 16,250,000 bushels in the last five years. Chicago increased 2,000,000; Minneapolis, 4,000,000 bushels.

Grain must be inspected before stored

Regular Warehouses.

The following warehouses were declared regular warehouses for the storage of grain and flax seed under the rules of the Board of Trade of the City of Chicago and the regulations and requirements of its Board of Directors, until the first day of July, 1908:

Name of Warehouse.	Operated by.	Capacity Bu.
Armour Elevator, A. B. and B. Annex	Armour Elevator Company	5,000,000
Armour Elevator, C.,	Armour Elevator Company	1,000,000
Calumet Elevator, C.,	Calumet Elevator Company	1,500,000
Central Elevator, A.,	Central Elevator Company	900,000
Chicago & St. Louis Elevator & Annex	Keith Elevator Company	2,000,000
Peavy Elevator, B.,	Peavy Grain Company	1,550,000
Rock Island, A.,	J. Rosenbaum	1,250,000
Rock Island, B.,	J. Rosenbaum	1,800,000
South Chicag Elevator C. and Annex	South Chicago Ele. Co.	3,000,000
Union Elevator and Annex,	Armour Elevator Company	2,000,000
National Elevator,	Central Elevator	1,000,000
Santa Fe Elevator Annex,	Santa Fe Elevator Company	1,000,000
Grain Traders' Elevator Company's Elevator	Grain Traders' Elevator Company	1,500,000
	Total	22,500,000

Besides these, there are 66 smaller elevators in Chicago with an aggregate of 36,720,000 bushels of grain.

Rates in Chicago for 1908. On all grain and flax seed received in bulk and inspected in good condition, ¾ cent per bushel is charged for the first 10 days or part thereof, and 1-40 cent per bushel per day for each additional day thereafter so long as it remains in good condition, except in case of the "Santa Fe Elevator Annex," which charges ½ cent per bushel for the first 10 days or part thereof. On grain damp or liable to early damage as indicated by its inspection when received, 2 cents per bushel for the first 10 days or part thereof and ½ cent per bushel for each additional 5 days or part thereof. No grain will be received in store until it has been inspected and graded by authorized inspectors.

Heating of Grain in Store. The duties of an elevator superintendent extend beyond the receipt, storage, and final transmission of a certain amount of grain. In order to be able to keep the grain received in good condition during storage, and to be able further to send it out in even better condition, if possible, he should recognize as the grain comes in just what kind of treatment it will require. In locating heated grains, a "tryer" is used or the bin is "drawn." Usually large accumulations of dust should be watched for closely. In moving or changing grain in bins, the weather should preferably be dry and cool. Warm, moist air, when allowed to come in contact with moving grain, may spoil it even if previously dry.

eating due to moisture

Corn which dried on the cob in the crib on the farm or at the local elevator, shows little tendency to heat, except during the germinating time in June, when care should be taken to withhold moisture from it. "Winter shelled" corn keeps as long as cold weather lasts, but when spring opens up it should be sent to the consumer at once, as it is almost certain to heat.

orn heating shrinks heavily

Grain in a heated condition loses rapidly in weight. The Shippers' Manual of the Chicago Board of Trade for 1907 reports a single carload of hot corn shrinking 3,600 pounds. The Chicago Board of Trade Weighing Department has frequently weighed cars of hot corn on railroad track scales, day after day, the loss of weight being from 50 to 100 pounds per day per carload.

Chemical changes generate heat

Professor L. G. Michael, Chemist of the Iowa Agricultural Experiment Station, says that "the heating occurs when grain originally in a moist condition is put in bulk, thereby preventing it from drying out and consequently subjecting it to attacks of fermentative bacteria, or cells similar to yeast cells. All chemical changes of this kind generate heat which, in time, will raise the temperature to such a height that oxidation by the air sets in. The oxidation may be so rapid as to cause spontaneous combustion. The heating is due almost entirely to fermentation which attacks the starch, changing it first to alcohol and later to acetic acid. If heating is continued for any length of time a decided loss of starchy matter results from the conversion of the starch to alcohol with, of course, more or less impairment of the unconverted starch. The matter of damage through heating is one of degree, from almost no harm, through slight rises in temperature, to almost complete ruin when fermentative changes are allowed to reach any advanced stage."

Decided loss of starch

Uniform Grades. The description of the classes and grades described by the inspection departments of the different Chambers of Commerce and of the several State Railroad and Warehouse Commissions are wordy and indefinite. According to John F. Courier, Secretary of the Grain Dealers' National Association, who was a member of the

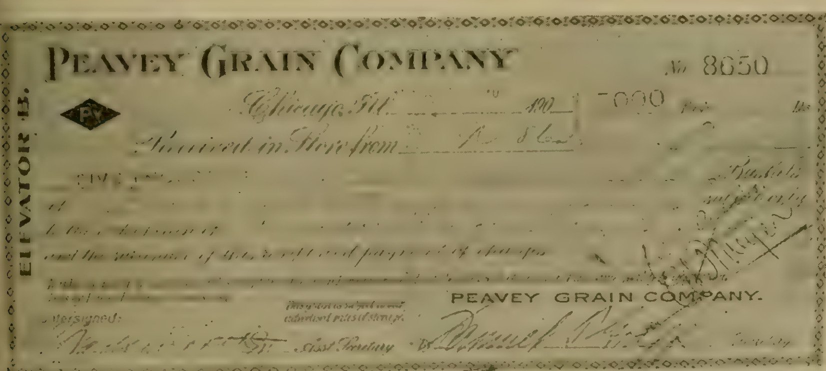
Indefinite terms

uniform Grade Congress which met in the directors' rooms of the Chicago Board of Trade, December 11, 12, 13, 1906, the word "reasonably" appeared 96 times in the stock heading of 338 titles to grades of grain. A close study of the grades as described by the various inspection boards reveals such words as "suitable," "fair," "inferior," "greater," "limited," "some," "enough" and "moderate." In themselves they mean nothing, and to different inspectors they are interpreted in varying proportions. The Uniform Grade Congress set forth grades which are described and limited on the percentage basis. Instead of stating that No. 3 corn shall be reasonably free from dirt and foreign matter, the actual percentage is ascertained.

Uniform Grade Congress

The rules of the Uniform Grade Congress fix the following maximum limits for all inspections and gradings of corn:

	Per cent of Moisture		Per cent Damaged	Per cent Dirt and Broken Grain
Grade	November-March	April-October		
No. 1	13	12	1	0
No. 2	15	14	3	2
No. 3	17	16	5	3
No. 4	20	20	10	5



(Courtesy Rumsey & Co. Through John Hill, Jr.)
Fig. 126.
WAREHOUSE RECEIPT.

Federal Inspection. The subject of federal inspection of grain did, during the Congressional Session of 1906, absorb the interests of the grain trade. We print herewith a statement made by Senator McCumber, of North Dakota, before the senate committee on Agriculture and Forestry, January 25, 1906, because it set forth the advantages of federal inspection.

Sen. McCumbe on Federal inspection

Injustice of the Present System. 1. Grades and inspections are made by inspectors who owe their positions to the influence of the large elevator companies and their allegiance to the parties responsible for their appointments.

Chief inspector appoints deputies

2. The chief inspector appoints all deputy inspectors. If an appeal is taken from the act of the deputy for improper grading or for any other cause, such appeal is decided by the chief inspector. The chief inspector, who is responsible for the efficiency of his deputy, cannot very often overrule him without subjecting himself to criticism for his deputies.

3. The great terminal elevator companies have lines of elevators along every railroad through the states. They arbitrarily instruct their buyers to what grade the grain is entitled. They, of course, protect themselves against possibility of loss.

Adverse to the farmer

4. Every year, when the crop begins to move, the graders at the terminals have adopted a rule that all questions of doubt shall be resolved against the producers. The result is that about two-thirds of the crop of the farmer has been purchased at a grade lower than that to which it is entitled. As the season advances, the grade is raised. This, of course, raises all of the grades in store and held by the elevators, and which were purchased at a lower grade. All questions of doubt in grading are resolved against the producer.

5. The report of the State Grain and Warehouse Commission of Minnesota, for instance, every year shows that the number of bushels of the higher grades taken in is only a small percentage of the higher grades shipped out from the terminal elevators, and that the lower grades received are many times over the lower grades shipped out, thus defrauding the producers of many millions of dollars every year.

Mixing grades discredits our market

6. In addition to this, we have our mixing elevators at the terminal. They will mix 1,000,000 bushels of No. 1 Northern and have the same reinspected and graded all as No. 1 Northern. This grain is then shipped—say to Liverpool. The foreign purchaser receives the bill of lading, accompanied by the certificate of the grain inspector, showing the grain to be No. 1 Northern. He gives it a chemical analysis, compares it with Canadian No. 1 Northern, and finds that the American No. 1 Northern is far below the same grade of Canadian wheat. This discredits all of our honest grades of wheat in the foreign market, and the only person who reaps a benefit is the mixer.

Purchaser in full control

7. The producer of grain, the farmer, has no voice whatever in determining, directly or indirectly, the personnel of the force which passes upon the grade and quality of every bushel of grain he sells,

while the purchaser of the grain controls absolutely the personnel of graders and inspectors. This injustice must be apparent. The producer has no means of securing any redress in case of combination, corruption, or inefficiency of the inspectors and graders.

8. It often happens, as I am credibly informed, that for the purpose of breaking corners in the gambling deals of the wheat pit, millions of bushels of grain are given false certificates to meet a shortage. In the end, the producer pays for the losses resulting from false inspection or certification losses. At present, every grain market has its own system of grading and inspection, and no two systems are exactly the same. The result is that the same kind and quality of grain shipped from the same field, entering markets of different states, is graded differently and named differently, creating confusion and generally loss to the producer.

No two systems the same

9. Under the present system of inspection, all carloads of grain arriving at the terminals are docked a certain number of pounds per bushel to cover dirt, undeveloped kernels, or any foreign matter in the grain. As all this can be removed, and is removed in the elevators, it should not affect the grading. It is, however, often excessive, and while the farmer pays the freight on it, but gets nothing for it, the purchaser often sells it for a very good price.

How National Inspection and Grading Will Remedy Present Injustice. 1. Under national inspection all inspectors will be free from political influence. They will owe no allegiance to buyer or shipper. Their decision will be free from bias. Their grading will be under rules and regulations adopted by the Agricultural Department. They will have as a guide all of the experimentation and accumulated knowledge of the Department, acquired by years of study and investigation and laboratory work on grains.

No allegiance to buyer or shipper

2. Proper provision will be made for reinspection in case of complaint, in place of the present system of appealing from the deputy to the principal, whose interest generally demands that he shall sustain his deputy.

3. Owners of elevator lines could not instruct their buyers under a national system not to give above a certain grade. The difference would be immediately apparent as soon as the same grain was inspected at the terminals, and they could not long do business under such instruction when it became publicly known that the local grades were below the terminal grades.

A fairer deal to producer than under present system

4. There would be no inducement by the national inspectors to resolve every doubt in favor of the purchaser and against the producer,

whereby such purchaser, as is now the case, would secure one-half to two-thirds of the crop at a grade lower than that to which it was entitled.

Grades will not be determined by purchaser

5. Under national inspection, it would be impossible to ship out three times as many bushels of the higher grades as are taken in the the terminal elevators. Under the present system, the buyer, by controlling the personnel of the Board of Inspectors, practically determines what grade he will buy in at and what grade he will sell out at. The Department inspectors would apply the same test on grain received as shipped out.

6. If the shipper mixed his grades, such mixture would have to be again inspected and graded by the Department, and such grain could not be sold in the market under a false certificate. This would give confidence in our American standards and facilitate our export business in wheat, corn and flax the same way that our meat inspection has facilitated commerce in meat.

Shipper may better protect his interests

7. The producer of North Dakota or South Dakota, for instance, has not the slightest voice in determining the personnel of the political inspectors of his grain in Minneapolis, Duluth, Superior, or Chicago, where he must sell it, nor can his voice be heard as to the proper system of inspection or grading. Under national inspection, he can be heard. Through his representation he is brought in touch with the Department, which must listen to his complaint or suggestions, and if they are well founded, will seek to apply a proper remedy. In addition to this, an inspector, if found incompetent, may be discharged, or removed to another section of the country where he might be competent.

More fair

8. Under national inspection, it would be almost impossible to secure false certificates as to grades to assist in gambling deals on the Board of Trade.

Dockage unjust

9. Dockage should have nothing to do with grades. A sufficient amount is deducted by the buyer to cover not only the amount of poor wheat and any dirt or foul stuff, but also to cover expense of cleaning. While this dockage is a total loss to the producer, and worse than a loss, because he is compelled to pay freight on it, it is a gain to the purchaser, for, while the purchaser pays nothing for it, he sells it to be ground into cattle feed, or grinds it himself and sells it to good advantage.

Change could be readily made

Feasibility of National Inspection. 1. The change from State and Board of Trade inspection now in vogue, to National inspection and grading, would be most simple. The Department could, over night, take the present force of inspectors and make them national inspectors.

It could then work off the incompetent as occasion required. These inspectors would be new men only in being free from political influence or personal fealty.

2. Inasmuch as national inspection and grading would cover only grains raised in one state and shipped into another, or grains shipped from one state to a foreign market, and would not include grains raised in a state to be used wholly therein, the present number of inspectors could be greatly reduced.

3. There would be no difficulty in fixing grades. The Department would naturally accept all present commercial grades and would, of course, modify them only as experience demanded. The modification, therefore, would be made without the slightest injury to commercial contracts or interest.

4. The bill makes provision for sales by samples and without the use of grades where such may be the custom, or where any purchaser desires to so purchase. But, of course, all exports should be graded.

5. The present charges for grading and inspection range from 50 to 75 cents per car. At 50 cents per car, there would be raised far more than sufficient to cover the expense of Government inspection and grading. My own belief is that it could be reduced to about 25 or 35 cents per car.

Reduce expense of grading one-fourth

6. There are about 8 species of wheat raised in the United States, each with its own name and each graded by numbers. The bill provides that such grades and species should be recognized in the beginning and should be modified only as experience should demand.

Objections to Federal Inspection. Geo. A. Wells, Secretary of the Western Grain Dealers' Association, points out the following difficulties that might arise from federal inspection:

Needs men of practical experience

"(1) Would a federal grain inspector be more competent in exercising his personal judgment than the board of trade or state inspector, grain inspection being largely a matter of personal judgment no positive scientific basis having yet been established?

"(2) Considering the fact that grain does not change in condition, as by the absorption or evaporation of moisture, etc., would not the same difficulty involved in such changing of conditions exist under federal inspection?

"(3) Suppose a country grain dealer bought No. 3 corn from a farmer, and when it arrived at market it inspected No. 4, both inspections being federal, would the Government 'make good,' or would it be considered as merely performing a 'governmental function', with no liability for damage?

"(4) Could the foreign buyer hold 'Uncle Sam' responsible for delivery of grain of the quality represented by the government seal of inspection?

A dual system with double cost

"(5) Federal inspection could have jurisdiction only with interstate grain, while the present systems would no doubt still be maintained, thus making a dual inspection with a double cost and endless complications.

Unlimited authority unwise

"(6) The McCumber bill gives the Secretary of Agriculture practically unlimited authority in the establishment of the proposed federal inspection of grain. Is this advisable?

"(7) Do we want a system established, that if it should prove impracticable, cannot be removed, but that would cost the farmers of the state a vast amount of money?

"(8) Is it not a fact that there is an element of competition in the present system of inspection that accrues to the benefit of the farmer, and that this would be removed by the federal inspection?

Must be consistent in claims

"(9) If in a general sense the profits in the present system of handling grain as between the farmer and the consumer are not excessive, how is 'Uncle Sam' going to give the foreign buyer more value for his money and at the same time give the farmer more money for his grain?"

Opinions of Boards of Trade. In order to obtain the views of the men who are daily interested in the grain business, a number of the Boards of Trade, located at the terminal and the terminal-export markets, were asked for a statement. The Boston Chamber of Commerce stands bitterly against federal inspection, because it believes it to be impracticable. When a car of grain reaches an elevator, it loses its identity and the inspection certificate is worthless. They state further that it guarantees nothing to the producer and does not protect the consumer.

The Board of Trade of Chicago is not in favor of federal supervision.

Boards of Trade in general not favorable to federal inspection

Baltimore Board of Trade states that such a measure would be interfering with State rights.

Milwaukee Chamber of Commerce is against it because the federal authorities do not know local specific conditions.

The Board of Trade of Duluth, Minnesota, was not dissatisfied with the work of the State Inspectors in Minnesota, but because part of their warehouses and elevators were located in both Minnesota and Wisconsin, there was a feeling that more stable condition of affairs could be brought about through federal inspection.

Arguments raised by the more southern markets, St. Louis, New Orleans, and Kansas City, were based principally upon impracticability. Grain must be handled rapidly at certain times of the year and the question of Government supervision being adequate is raised.

The most urgent need of federal inspection

The most urgent need of federal inspection is in the corn which leaves the terminal-export markets. This will be considered later.

TERMINAL-EXPORT MARKETS.

The principal terminal-export markets are New York, New Orleans, Baltimore, Galveston, Boston, San Francisco, Philadelphia, and the Canadian ports on the St. Lawrence. In 1905, New York, New Orleans and Galveston transferred over 50 per cent of the total exportations from storage to vessels.

EXPORTS OF CORN FROM 1899 TO 1902 INCLUSIVE, FROM THE PRINCIPAL ATLANTIC AND GULF PORTS ONLY.

	1899	1900	1901	1902
New York	39,683,000	43,256,000	22,749,000	2,918,000
Boston	17,424,000	14,092,000	11,058,000	779,000
Philadelphia	29,231,000	33,364,000	16,355,000	2,045,000
Baltimore	46,002,000	42,118,000	25,370,000	3,844,000
New Orleans	20,266,000	22,966,000	12,827,000	1,571,000
Montreal, Portland, St. John and Quebec	16,581,000	13,812,000	5,584,000	300,000
Newport News	14,588,000	9,372,000	3,567,000	1,212,000
Norfolk	5,938,000	4,185,000	2,281,000	396,000
Galveston	6,637,000	3,302,000	128,000	757,000
Other Ports*	1,600,000	1,450,000	278,000	38,000
Total	197,950,000	187,917,000	100,197,000	13,860,000

EXPORTS OF CORN FROM 1903 TO 1907 INCLUSIVE, FROM THE PRINCIPAL ATLANTIC AND GULF PORTS ONLY.

	1903	1904	1905	1906	1907
New York	21,840,000	9,807,000	27,628,000	20,570,000	21,750,000
Boston	7,118,000	4,264,000	10,934,000	3,950,000	5,668,000
Philadelphia	10,491,000	5,908,000	8,062,000	9,151,000	6,422,000
Baltimore	19,461,000	8,474,000	14,954,000	24,110,000	19,358,000
New Orleans	13,828,000	5,111,000	20,410,000	18,388,000	7,550,000
Montreal, Portland, St. John & Quebec	9,243,000	4,554,000	8,754,000	4,813,000	4,674,000
Newport News	3,723,000	1,191,000	2,929,000	3,524,000	1,242,000
Norfolk	818,000	579,000	1,386,000	820,000	355,000
Galveston	4,386,000	3,408,000	10,278,000	10,332,000	6,609,000
Other Ports*	171,000	478,000	810,000	1,154,000	1,127,000
Total	91,079,000	43,774,000	106,145,000	96,962,000	74,755,000

Exportation From Southern Ports Increasing.

It will be noted from the above table the exportation of corn from the southern ports is steadily increasing. Railroad facilities in the Mississippi Valley are more efficient now than in earlier years. The

*Other Ports, includes Charleston, Pensacola, Mobile and Port Arthur.

states in the so-called semi-arid region are growing more acreage and the product can be more cheaply transported to Galveston or Port Arthur than east to the Atlantic. However, during 1906, Chicago, which is usually classified as a terminal market, but which in recent years has developed an export trade, shipped direct from its docks by lake, 2,907,151 bushels. Detroit is also a large terminal-export market, as are Toledo and Buffalo.

Much of the corn is damaged

The exportation from the southern ports accounts for much of the corn being spoiled when it reaches the European markets. The climate is warmer and the degree of humidity much higher on the Gulf Coast; hence corn stored and shipped from these ports enters the vessel in condition favorable to heating. Within the last year the government has taken steps to inspect all corn before it is loaded, to insure against shipment of grain which is damaged.

Drying Export Corn.

In some instances 10 per cent was classed as damaged

*"For several years, complaints have frequently been made as to the condition in which our export grain, especially corn, arrives in European ports. During the past spring, a representative of this Bureau (Plant Industry) visited the principal grain-holding ports of Europe and made careful inquiries to determine how far these reports were founded on fact and how far they were colored in the interest of the purchaser on the other side.

"It is to be regretted that many cargoes of corn from the United States have arrived in European ports in damaged condition. In Rotterdam, nearly 10 percent of our corn received last season was damaged. The same condition exists in other ports and has seriously injured the reputation of corn from the United States. The result has been an increased European trade in corn from the Argentine Republic, our only important competitor.

"The trade in Argentine corn has grown, both because it is sold in London by tons, and because it stands shipment better than corn from this country on account of its hard, flinty character.

Artificial drying

"Our softer dent corn is nevertheless preferred in all the European markets, and the maintenance and increase of our export trade are dependent only upon its being shipped so that it will arrive in uniformly good condition. As deterioration of corn during ocean transit is directly dependent upon the amount of moisture it contains, there is an easy and practicable remedy for the present condition in artificial drying. This has been successfully tried at New Orleans and the necessary machinery is now being installed in Baltimore and Boston. Thus

*Year Book of the Department of Agriculture for 1905, page 170.

far, practically no attention has been given to determining just how dry grain should be in order to stand shipment under varying conditions on board steamships and at different seasons of the year."

Freight Rates from Terminal to Terminal-Export Markets. Corn is usually shipped from "Terminal" markets to "Terminal-Export" markets. The freight rates vary according to the route and methods of transportation. In 1900, the rate for corn by river from St. Louis to New Orleans was 10 cents per sack of 100 pounds. Corn shipped from Chicago to New York by lake and canal cost in 1906, .0551 cent per bushel exclusive of Buffalo charges for transferring from lake steamer to canal boat. By lake and rail, .02572 cent per bushel covered the entire cost of transportation between the same points. Because of more rapid transit, shipment by rail entirely cost .0952 cent per bushel, during the same year. A freight rate of 13 cents per 100 pounds is charged from Chicago to Boston, 12 cents to Montreal, Quebec, and Portland, 12 cents to Philadelphia and 11½ cents to Baltimore, Norfolk, Virginia, and Newport News.

Vary according to route and method of transportation

EXPORT MARKETS.

The falling off in exports of agricultural products, and especially wheat and wheaten flour, continues to be a marked characteristic of the export trade. The percentage of the total domestic exports which agricultural products formed was in 1907 but 48; in 1905, but 55.4 per cent against 69.73 per cent in 1895; 72.96 per cent in 1885, and 76.95 in 1875.

Agriculture products not keeping pace with manufactured products in export trade

Comparing 1905 with 1895, the exports of manufacture show an increase of practically 200 per cent, and those of mines, forests and fisheries, an increase of more than 100 per cent each, while those of agriculture have increased only 50 per cent in the same period. The steady decline in the percentage which agricultural products form of the total exports is due, says the Secretary of Agriculture, to the increase in the exports of other products, especially manufactures, rather than any material decrease in the products of agriculture as a whole.

Production has steadily and rapidly increased. Exportation has fluctuated, being governed largely by the surplus. Its decrease or lack of growth need not be viewed with timidity, because of the increased home consumption.

Amount of Corn Exported.

TOTAL EXPORTS OF CORN FROM UNITED STATES.

Year.	Amount.	Percent Crop Produced.
1900	213,123,412	10.30
1901	181,405,473	8.62
1902	28,028,688	1.84
1903	76,639,261	3.04
1904	58,222,061	2.59
1905	90,293,483	3.66
1906	119,893,833	4.43
1907	86,368,228	2.95

It will be noted that in any year the percent of the corn crop which is exported is very small, and that the United States is decreasing in the exportation of corn is shown very clearly by the low percent (2.95) in 1907, following the heavy crop of 1906.

The following table shows the exports of corn from the United States from 1867 to 1899 inclusive:

		1870,	2,140,487	1880,	99,572,329	1890,	103,418,709
		1871,	10,676,873	1881,	93,648,147	1891,	32,041,529
		1872,	35,727,010	1882,	44,340,683	1892,	76,602,285
		1873,	40,154,374	1883,	41,655,653	1893,	47,121,894
		1874,	35,985,834	1884,	46,258,606	1894,	66,489,529
		1875,	30,025,036	1885,	52,876,456	1895,	28,585,405
		1876,	50,910,532	1886,	64,829,617	1896,	101,100,375
1867,	16,026,947	1877,	72,652,611	1887,	41,368,584	1897,	178,817,417
1868,	12,493,522	1878,	87,192,110	1888,	25,360,869	1898,	212,055,543
1869,	8,286,665	1879,	87,884,892	1889,	70,841,673	1899,	177,255,046

The following table shows the amount of corn exported from the United States during the one year at the end of each decade:

1790,	3,929,214	1820,	9,638,453	1850,	23,191,876	1880,	50,155,783
1800,	5,308,483	1830,	12,866,020	1860,	31,443,332	1890,	62,622,250
1810,	7,239,881	1840,	17,069,453	1870,	38,558,371	1900,	75,693,734

Countries Purchasing Export Corn. The following table indicates which countries buy most of the corn exported from the United States:

Year	To Great Britain	To Continental Europe	To all Other Countries
1899	91,374,000	103,980,000	2,596,000
1900	91,412,000	93,059,000	3,446,000
1901	49,631,000	47,556,000	3,010,000
1902	6,020,000	6,250,000	1,599,000
1903	42,871,000	44,137,000	4,071,000
1904	21,286,000	20,522,000	1,966,000
1905	48,661,000	54,663,000	2,821,000
1906	37,933,000	55,538,000	3,341,000

Among the continental nations, Germany and the Netherlands are the largest purchasers, receiving in 1904, 23.5 and 11 percent respectively of the whole corn exported from the United States. Belgium and Denmark are quite extensive buyers. Canada has always drawn largely upon American corn, but not so heavily within the past five years as formerly. The British West Indies buy extensively and the demand in the Islands is yearly increasing. Until 1906, British South Africa imported American corn, but in that year Rhodesia exported a local surplus to England.

Germany and Netherlands large purchasers

Prices of Export Corn. From 1896 to 1900, the average price of corn sold for export was $.369 per bushel. From 1881 to 1907 inclusive, a period of 26 years, the average price was $.529 per bushel.

Price per bushel

Monthly Price of Export corn as it Left the Port at time of Exportation.

1906,	July	$.574	per bushel.
"	August	.57	" "
"	September	.545	" "
"	October	.546	" "
"	November	.524	" "
"	December	.502	" "
1907,	January	$.498	per bushel.
"	February	.506	" "
"	March	.516	" "
"	April	.528	" "
"	May	.574	" "
"	June	.594	" "
	Average	.539	" "

Import Duties. The import duties in the countries using the major part of corn exported from the United States are as follows:

Country.	Foreign Unit.	Equivalent in America.
France,	3francs per quintal,	$ .579 for 220.46 pounds
Germany,	3 marks per quintal,	.714 for 220.46 pounds
Spain,	2.25 pesetas per quintal,	.434 for 220.46 pounds
Sweden,	3.70 kroner per quintal,	.99 for 220.46 pounds
Belgium,	Free,	
Russia,	Free,	
England,	Free,	

European Distributing Points.

Principal distributing ports of Europe

Liverpool, London, Glasgow, Hull, Manchester, Hamburg, Bremer, Christiana, Copenhagen, Rotterdam, Antwerp, Havre, Marseilles, Genoa and Naples, are the principal distributing points of Europe.

Export Freight Rates.—American grain destined for foreign markets is sold "C. I. F." (cost, insurance, freight), the marine insurance

Highest rate in January, lowest in June.

and ocean freight being included in the cost. The rates on corn and wheat from Boston to Liverpool averaged 3.42 cents per 60 pounds for the year 1906; from New York, 3.11; from Baltimore, 4.03; New Orleans, 6.86; Galveston, 6.60. A study of the rates from month to month shows them to be the highest in January and the lowest in June. A severe criticism has been made of this tendency of ship owners, because it tends to hold the American surplus back until late in the season.

American grain discriminated against

American Trade Certificate in Export Trade. During the last few years American grain has been discriminated against rather severely. This discrimination has been a united action of the grain-handling interests in Europe, which from their letters seems justifiable. They have taken a very fair view of the situation and seem willing to co-operate with the American exporter in removing the trouble.

The following letter was read by Hon. Alse J. Gronna, Representative from the State of North Dakota, before House Committee on Interstate and Foreign Commerce:

"London Corn Trade Association,
Exchange Chambers, 28 St. Mary Ave.,
London, January 20, 1908.

"Mr. President,—

"I am instructed by the European International Committee on American Grain Certificates to communicate to you the following facts:

Trade certificate not popular in Europe

"There has been for some years past, a general consensus of opinion among European buyers of grain that the operation of the present system of certificating grain for export is increasingly unsatisfactory and that whatever may be its merits for the purposes of domestic trading, it no longer gives to European buyers the confidence and protection which is necessary in a trade where the only guaranty for reliable quality and condition in exchange for buyer's money is a paper certificate. Formerly, buyers in buying from the United States of America were able, as they still are in their dealings in grain with other exporting countries, to recover from shippers any damage they sustain owing to defects in quality or condition; but since the introduction of the certificating system, this is no longer possible. Even after its introduction, indeed, until comparatively recent times, it was seldom found that any serious abuses arose and, trusting to their belief in the reliability of the grading system, buyers were willing to continue trading with America on less favorable terms than they demanded elsewhere; but, whether from increase of individual competi-

Does not protect purchaser

tion, or what is probably more important, the rivalry between the older ports and their smaller and more recently established competitors, there seems little doubt that the standard of grading has been lowered, either temporarily, or in some cases permanently, in order to attract business from interior points. We in Europe feel that the burden of such departure from the more reliable and stricter method in force formerly, has been borne chiefly by European importers who, being far away, have no power of protecting themselves against errors or worse in the grading methods of recent years. The result is that American grain suffers as regards price when in competition with grain from other countries.

Grading methods not popular

Robert A. Patterson,
Chairman European International
Committee on American Grain Certificates.

"President United States of America,
White House, Washington, U. S. A."

A Criticism from Another Source.

"Het Comite van Graanhandelaren te
Rotterdam,
Rotterdam, February 20, 1907.

"Representative J. A. Gronna, Esq.,
Washington, D. C.

"During the last Berlin Grain Conference held January 29th and 30th of this year, by delegates of the German, Holland and Scandinavian grain trade, the McCumber bill and the other bills of similar character introduced into Congress, were one of the chief subjects on the program. During many years, already, the American Grain Inspection certificates have been very unsatisfactory and immense losses were caused to the buyers on this side by the careless inspection of American grain shipped for export. It has been said by American opponents of the bills mentioned above that the fixing of grades on better and higher standards would injure the export trade, and that the European buyers will not buy anything but the grades which have always been shipped and to which they are accustomed.

Grain inspection certificates very unsatisfactory

"Many important firms in the importing centers on this side have absolutely given up importing American corn, taught by the experience of several years, when a single parcel of this article, certified No. 2 mixed, sail mixed, etc., and still showing 30 to 90 per cent damage on arrival, caused a loss greater than the small gain made on many shipments together. They prefer to buy from Argentina, Russia and the Danube. A better inspection, however, and certificates which give suf-

Some firms refuse corn from the U. S.

ficient guaranty that the grade has really been given in accordance with the grain's quality and condition, will induce these firms to take up the importation of American corn again.

"We don't object to the export of inferior grain, but to the fact that the grades are not given according to the condition of the grain, so that the certificates are entirely unreliable. Perhaps some buyers on this side want the inferior grain, but those who deal in the better qualities want to be sure that when they pay a better price for the higher grade, the certificate gives them the guaranty to get this grade.

Certificates unreliable

"As soon as grades all over the United States are uniform, and as soon as certificates of inspection will be reliable, the importation of American grain will certainly increase after the sharp decline which it has experienced.

"Uniform Government inspection will bring a higher standard of export grain, induce the European importer to buy American grain more freely again, and consequently benefit the honest American exporter at the cost of his dishonest competitor. It will greatly purify the trade and make an end to an unbearable situation.

Yours truly,

Het Comite van Graanhandelaren te Rotterdam,
Rotterdam Corn Trade Association,
A. Coan, Sr., President,
H. Van Randeryk, Secretary."

ACKNOWLEDGMENTS. The local elevator men on the railroads in Iowa have been very prompt in answering inquiries concerning local conditions.

The reports of the Secretary of the Iowa (now Western) Grain Dealers' Association have been drawn upon freely. Mr. Wells has willingly co-operated with us in every interest.

The Farmers Co-operative Society of Rockwell, and the State Co-operative organization, have been very faithful in their attention to our inquiries.

We have quoted many practical points directly from the Shippers' Manual, edited by H. A. Foss, Weighmaster of the Weighing Department, of Chicago Board of Trade.

W. S. Cowen, Chief Inspector of Grain at Chicago, has outlined the steps in the inspection of a car of grain when it reaches Chicago.

The Boards of Trade of the principal markets have offered many valuable suggestions in rendering their opinions.

COLLATERAL READING. The Annual Reports of the Boards of Trade of the principal terminal and terminal-export markets. These may be secured by application to the secretaries of the respective boards.

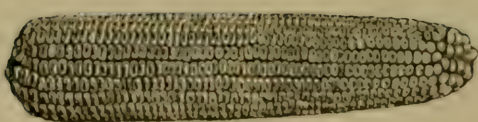
Shippers' Manual, issued by the Chicago Board of Trade.

The Book of Corn, by Herbert Myrick.

Examining and Grading Grains, by Lyons and Montgomery.

Year Books of the Department of Agriculture.

Reports of the Bureau of Commerce and Navigation.



CHAPTER XIII

BOARDS OF TRADE

THEIR ORGANIZATION AND BUSINESS METHODS

The large grain and provision markets have established Boards of Trade. Their purpose and operation are here outlined, taking the facts from the Chicago Board of Trade, which is the largest and most important in the United States.

Founded Mar. 13, 1848

THE BOARD OF TRADE OF THE CITY OF CHICAGO. On the 13th of March, 1848, thirteen men, representing the commercial interests of Chicago, organized the Board of Trade of the City of Chicago and laid down the fundamental principles and policies which have made this Exchange the greatest of its kind in the world, as well as a model for all similar exchanges since formed here and elsewhere, and have given this city premiership among the world's grain and provision markets.

What the founders of this institution aimed to accomplish and what it has stood for during nearly two-thirds of a century of its corporate life, was thus enunciated in the Preamble of the Rules and By-laws:

Preamble and purpose

"To maintain a Commercial Exchange; to promote uniformity in the customs and usages of merchants; to inculcate principles of justice and equity in trade; to facilitate the speedy adjustment of business disputes; to acquire and disseminate valuable commercial and economic information; and generally, to secure to its members the benefits of co-operation in the furtherance of their legitimate pursuits."

So comprehensive and satisfactory is this expression of commercial, ethical and civic ideals, that it has never been found necessary to modify it in any particular, and it stands today as when it was first voiced, the fundamental article of the organic law of the Chicago Board of Trade.

Charter members had faith in Chicago

The charter members of this commercial exchange had been engaged in the infant trade of the city from the time of its incorporation. They were enthusiastic believers in the future, full of courage, hope, and determination to live up to the opportunities which they saw around them on every hand awaiting development. These men had deep and abiding faith in the city which they had helped to found. They were men of sagacity and their foresight had in it the quality of intuition. They perceived that this city, situated on the peerless waterways of the Great Lakes and adjacent to the limitless fertile plains of the Mississippi Valley, was destined to be not only a commercial metropolis, but also a dominant force in the markets of the world. At that time, Chicago had a population of less than 30,000, the state of Illinois had only 157,000 people, and the United States had not yet attained a total of 13,000,000 population. Today, the population of Chicago is, in round numbers, 2,400,000; of Illinois, 5,500,000; of the United States, 90,000,000. Chicago was further removed from New York than we are now distant from the antipodes. Her transportation facilities were of the most meager sort and communication was by the slow-going stage, the infrequent sailing vessel or the laboring post-rider.

Mission of the Chicago Board of Trade

If the "manifest destiny" of Chicago was to be worked out, it was necessary that there should be an organized effort to attract trade, to facilitate the transaction of business, and to reduce the hazards of commerce by building up a body of principles which should have the force of law, insuring righteous dealings between the buyer and the seller and banishing chicanery and deceit from the code of trading. Such was the mission of the Board of Trade of the City of Chicago.

But the objects of these founders of Chicago's greatness were broader than mere self-interest. They grappled with large public problems from the very outset, striving in all possible ways to facilitate profitable dealings with the farms of the Central Valley and the mills of the East, seeking to connect Chicago by telegraph with the eastern markets, and in many other ways fostering commercial advancement.

General Assembly of Illinois enacted a special charter in 1850

There is the best possible evidence of the energy with which the little voluntary organization prosecuted its work for the benefit of the city and its citizens; for, in the year after the first meeting in South Water street, the General Assembly of the State of Illinois enacted fostering laws relating to Boards of Trade. In 1850, the Legislature enacted a special charter for "The Board of Trade of the City of Chicago;" and nine years later, when events had proved that the grants thus conferred were inadequate for the proper working out of the mission of the institution, the General Assembly enacted a new charter law, giving the corporation the right of perpetual existence and clothing it with very broad power and authority to regulate the trading practices and commercial conduct of the affairs of this market.

Grain inspection inaugurated in 1858

Directly in line with the policy expressed, the Chicago Board of Trade introduced in 1858 the system of grain inspection which, as much as any other one thing, has contributed to the prestige of Chicago. This inspection system is still in force substantially as it was when devised by the administration of 1858, and it has been accepted as the model for virtually all the grain markets of the country, if not of the world.

Present Board of Trade building dedicated 1885

Prior to the enactment of the special charter of 1859, the Board had been restricted in its powers and limited in its resources, despite the financial assistance afforded by the city council; but when the new charter was granted, the membership quickly increased to 725 and the treasury soon showed a comfortable surplus. Outgrowing rented quarters, the Board determined to erect an exchange building at La Salle and Washington streets. This first fixed abode of the Board was occupied in 1865 and remained until the fire of 1871 laid it in ashes. Within a year, the structure was rebuilt and was the center of the country's grain trade until 1885, when the present Board of Trade building was dedicated.

1726 members in 1908

*Today, with a membership of 1726, the Chicago Board of Trade is recognized as the dominant factor in the determination of the prices of grain and provisions. More than that, it is universally recognized as the most potent force extant for the maintenance of those principles of business morality and justice which its founders embodied in the preamble of sixty years ago. Its quotations are unquestioned, its statistics unimpugned; its certificates of inspection, weights, and grading unchallenged; and the word of its members as good as gold anywhere and at any time.

9:30 a. m. to 1:15 p. m. except Saturdays 9:30 a. m. to 12 m.

Hours for Regular Trading. "No trade or contract for the future delivery of grain or provisions shall be made, or offered to be made, by any member or members of this Association, in the exchange room of the Board nor in any of the public streets, courts or passages in the immediate vicinity thereof, or in any hall, or exchange hall, or corridor in any building located or fronting on such streets, courts or passages on any business day, except from 9:30 o'clock A. M. to 1:15 o'clock P. M., or upon any Saturday except from 9:30 o'clock to 12 o'clock M. nor on any day or that part of a day on which the Board shall hold no business session; it being the object and intent of this rule that all such trading which may tend to the maintenance of a public market shall be confined within the hours above specified."

Terms Used in Trading. Like every other business occupation,

*July, 1908.

(Courtesy of Chicago Board of Trade) Fig. 127.
CHICAGO BOARD OF TRADE BUILDING.

the daily exchanges of communication employ certain terms and phrases peculiar to its needs and operations.

"Futures," commodities bought on contract for delivery, which may or may not be actually made at a later date.

"Settlement" price, a convenient price made upon a given date (usually about the same as the price on the market on that date), by which settlements of contracts which are not delivered are made.

"Delivery" price, a price fixed upon a given date (usually about the same as the price on the market on that day), by which the financial settlements in regard to contracts actually delivered are made.

"Short" trading refers to the practice of selling grain which a trader does not actually possess, but contracts to deliver it in the future. It is sometimes called "fictitious," because it does not at the moment represent grain on hand.

Sign language very accurate

The Sign Language of the Pit Traders. The visitor sitting in the gallery of Exchange Hall during a flurry in the grain pits on the floor rarely fails to express wonder that there can be any orderly and certain transaction of business in such a hurly-burly. But the trader in the middle of the excited throng sees in the turmoil, only the fierce determination of his fellows to buy at the cheapest or to sell at the highest possible price. As to the intentness of any man in the pit at that moment, the practiced trader has no doubt whatever. Articulate speech is not only impossible, under such circumstances, but useless. The eye is quicker than the ear; and the signals given with the hand or by a gesture of the head mean as much as a telegram to the person addressed. Rarely does a mistake occur in this sign language trading.

Sign manual simple

The sign-manual of the pit trader is simplicity itself, and with a very little practice anyone can become adept at it; but it calls for natural aptitude to be a master of the strategy and generalship demanded of a good broker. Corn having sold at 48 cents, for instance, a trader catches the eye of some one opposite in the pit who has 50,000 bushels to sell, and partly by telepathy, partly by a motion of the clenched fist, signals that he will take the "50 wheat" at 48. The seller, in reply, holds up his right hand with the index finger extended horizontally, indicating that he wants 48½ cents. The buyer motions acceptance and signals back ⅛. The two traders note on their cards "Sold 50 at ⅛, Jones" and "Bot 50 at ⅛, Smith." After they leave the pit they meet and check the operation.

The hand being held horizontally, the clenched fist indicates the price in even cents. Each finger represents an added eighth of a cent up to five-eighths; the extended hand with the fingers close together means three-quarters and the thumb only, signals seven-eighths; but the whole hand displayed vertically means 25,000 bushels, each finger counting 5,000 bushels; whether offered or being bid for, is shown by a slight motion of the hand to or from the trader making the signal. The official reporter stationed in the pit sees all the signaling, and partly by observation and partly on information given him by the traders, notes the latest price and gives it to a telegraph operator at his side to be "put on the ticker." Thus the price of grain is made every moment of the session and transmitted to all the markets of the world. When understood, the chaos of the pit becomes an intelligible language even to the nonparticipant.

Each finger represents 5000 bushels

The latest price is put on the ticker

OMAHA GRAIN EXCHANGE. The Omaha Grain Exchange was organized in the autumn of 1903 and incorporated and commenced business about February 1, 1904. At that time Omaha was not a grain market; only a stopping place for grain in transit. The organization of the Grain Exchange brought about an adjustment of freight rates whereby grain produced in Iowa and Nebraska could be merchandised at Omaha and reshipped.

Feb. 1, 1904

The Omaha Grain Exchange has a membership of 166 with a paid up cash capital of $83,000. Elevators have been erected in Omaha and vicinity with a capacity in excess of 6,000,000 bushels.

166 members 1908

SPECULATION IN THE GRAIN TRADE. Boards of Trade were originally and primarily established for bringing together buyers and sellers of cash products. Out of this a speculative trade in grain has developed; that is, contracts are made for future delivery of grain. The producing territory of the United States is so extensive and the system of distribution of the agricultural products so complex that the element of speculation enters largely into its operation. It is impossible to define where speculation begins and business risks end. Reasonable speculation is such speculation as cannot seriously or permanently affect the resources or positions of the persons indulging in it. Intelligent speculation is such speculation as is indulged in only after a thorough investigation and study of the subject of the speculation. Reckless and plunging speculation, which is prompted by no motive except greed, guided by no thought except chance, usually leads to downfall and is the kind tabooed by the Boards of Grain Exchange.

The speculators of the corn and wheat pits are the distributors of the nation's farm products. The Industrial Commission in its report to Congress on January 15, 1901, found that these men did the work on a closer margin of cost than the producer could do it. The risks of distribution are shifted by both producers and consumers upon the distinct class of speculators known as distributors. If the risk of distribution fell upon the farmer, it would increase materially the risks of capital required and thus raise the rate of interest. He would have to pay as a producer, because increased risk always raises the rate of interest. This would increase the cost of production and consequently tend to reduce consumption by rise of price to consumers. Such rise of price beyond a certain point would reduce the volume of trade. Consumers cannot shoulder the burden of distribution because they would soon be neglecting their occupations which make them heavy purchasers.

The speculator is a distributor

The existing system of speculative grain trade is essentially the essence of the specialization of industries and pursuits of the American industrial fabric. It is the fundamental division of labor between the development of agricultural and manufacturing resources. This separate commercial class is in position to inform itself as to all the factors, past, present and prospective, affecting the course of prices. But the distribution of the domestic surplus is not all. The world-wide service to society of feeding the consumers of another continent, involves so many risks and so much capital that only those who are familiar with conditions in both worlds can afford to attempt it.

This commercial class is well informed

FUTURES. It is difficult to realize the vast volume of business transacted on the Board of Trade and Produce Exchanges of this country. To one who hears only of speculation and manipulation, the Exchanges seem to be founded for no other purpose than to provide facilities for speculation. Speculation is the sensational feature of the trade, and the newspapers devote the most space to that class of news, for the reason that it is sensational. But speculation is a mere incident of the grain and cotton trade, and grew up after the exchange had been established for the purpose of bringing buyers and sellers of cash property together at one common point.

Speculation sensational feature of grain trade

As the volume of cash transactions increased and facilities were provided for storage of products at market centers, contracting for future delivery developed gradually. At first these contracts were irregular as to quantity, time of delivery and grade of goods, but they slowly assumed uniformity and the Exchanges, recognizing their validity and value, regulated them by rules. It was not until early in the 60's that these "future-delivery" contracts became general in the grain trade and the Chicago Board of Trade dignified them by adopt-

Future deliveries first used in '60

ing rules to govern and enforce them. The system gradually developed and brought about wonderful changes in the methods of merchants and millers.

Prior to the establishment of trading for future delivery, as now practiced on the Chicago Board of Trade, every grain dealer was a speculator in cash grain, with all the uncertainties of the markets to contend with. Today he is a merchant working on an assured margin of profit, by reason of his ability to protect himself by sales for future delivery on the Chicago Board of Trade. This is illustrated in a simple manner. The grain dealer at ————, Iowa, buys 10,000 bushels of ear corn in January of the farmers and stores it in his corn crib. It will not be fit to shell and ship until the following May. He orders his commission merchant on the Chicago Board of Trade to sell 10,000 bushels of corn for May delivery. The commission merchant makes the sale and reports back the prices. The dealer has thus secured his profit, although it is five months before he can deliver the corn in Chicago, that length of time being required for the corn to cure. He in turn pays the farmer cash for his corn, who can then pay rent on his land and buy machinery for the spring work. Now, the dealer has made what the public call a speculative transaction, viz., a trade for future delivery on the Chicago Board of Trade, and yet he is the very opposite of the speculator. Suppose he had not sold the corn for May delivery, but had taken all the risk of chances in the market for five months, no one would think of calling him a speculator, and yet that is exactly what he would be.

Secures the grain dealer

Millers and grain dealers throughout the world trade in "futures" in Chicago, in order to avoid speculating in their business, on exactly the same theory as the dealer at ————, Iowa, sells May corn in Chicago, against the ear corn in the crib at home. If you can find a miller with 1,000 or 10,000 barrels of flour on hand that had not been sold, you will find that he has wheat "futures" sold (usually in Chicago) to the extent of about five bushels a barrel. As soon as he can sell the flour he will buy back the "future." He may sell the flour at 50 cents a barrel less than it cost to grind it and yet he will not lose a cent. On the contrary, he will save his manufacturing profit at 10 to 25 cents a barrel, for his sale of the wheat "future" has protected him. Wheat and flour prices move together, and when he sells his flour at 50 cents a barrel loss, he at the same time buys back the wheat "future" at 10 to 12 cents a bushel profit—the wheat has declined in the same proportion as the flour. Or, the miller may reverse this operation and buy wheat "futures" and sell flour which he has not on

Millers use this method of security

hand, to be shipped sixty or ninety days hence. He either receives the cash wheat on the "future" when the contract matures, and grinds it into flour to fill his sale, or he buys other wheat better suited to his requirements and sells out the "future" as fast as he acquires the necessary "spot" wheat. In the meantime, wheat prices may change 25 cents a bushel without disturbing the miller, who, when he purchased the wheat "future" and sold the flour, had secured his margin of profit. Ask any miller why he trades in "future" and he will tell you it is done to avoid speculating in his business.

Used by exporters also

The grain dealers and exporters who carry stocks of grain or make sales of grain to be shipped in the future, are in the same position as the miller. You will find them constantly buying and selling "futures" in order to avoid speculation in their business. The packer and provision merchant resort to contracts for future delivery for the same purpose.

In eyes of law futures are legitimate

All of these transactions in "futures" made by millers, grain dealers, and packers are the same as the transactions ordinarily known as "speculative transactions," and at the same time they are made in the matter of their execution and settlement they are in every way identical. If a speculator desires to buy 5,000 bushels of wheat for May delivery, he buys it at the same place and in the same manner as does the miller who wants the wheat to grind. Both transactions are subject to the same rules and customs. Both parties must be prepared to receive and pay for the property at the maturity of the contract and, in the eyes of the law, the contract of the speculator is as legitimate as that of the miller.

The trading in futures has been criticised by those ignorant of its great aid to agriculture and commerce from the day when the increase of yield of farm products in the West and South made it necessary to buy and sell for delivery at a future time, in order to facilitate the carrying and distributing of the farmers' surplus crops at a minimum of cost and risk for the months intervening between harvests.

Why and How Futures are Settled Without Delivery. The strongest weapon in the hands of those opposed to futures has been the argument that every purchase and sale for future delivery is not finally consummated or settled by the actual delivery of the property on the contract at maturity.

Delivery is made in lots of 5000 bushels

All contracts for future delivery on the Board are made in the same manner and are exactly similar as to quantity or unit. Except in wheat and flaxseed, where there is a small volume of trade in 1,000-bushel lots, the unit is 5,000 bushels. Thus, if the broker "A" buys from broker "B" 25,000 bushels of corn for May delivery, he has really bought five 5,000-bushel lots, and both parties would so enter the transaction on their books. Delivery must be made in lots of 5,000 bushels and settlement can be effected for 5,000 bushels or any number of 5,000 bushel lots up to the total amount of the contract. The same holds true in all transactions. When a trade of 100,000 bushels is reported, it means twenty lots of 5,000 bushels each. A broker may receive orders from five clients at the same time to buy May corn. Clients "A" and "B" and "C" order 10,000 bushels each; client "D" 15,000 bushels and client "E" 5,000 bushels, aggregating 50,000 bushels. The broker steps into the corn pit and bids for 50,000 bushels, buying it all of one party. He then divides the purchase among his clients; "A," "B" and "C" each get two 5,000-bushel lots. "D" gets three 5,000-bushel lots and "E" one 5,000-bushel lot. The party of whom the broker bought has really sold him ten 5,000-bushel lots and so enters it on his books; although at the time the trade was made, it was spoken of as a 50,000-bushel trade. This is a feature of the trading which must be clearly understood by the student before he can grasp the system of settlements.

50,000 bushels the same as ten 5000 bushel lots

All contracts being uniform as to quantity, they are substituted one for the other, and members of the Board acting as commission merchants do not try to preserve the identity of the contracts made for any particular clients. In place of doing so, and for the privilege of substituting similar contracts, they guarantee to their clients the fulfillment of the contracts, a course not usually adopted by agents when acting for principals. The right to substitute contracts is the consideration for the guarantee.

Identity of contracts not preserved

We will now take five imaginary commission merchants, Brown, Jones, Smith, Day and Lee. They all receive and execute orders for the purchase and sale of grain for future delivery on the Board of Trade. Their clients are millers, exporters, eastern dealers, buyers of grain at western points, speculators, and investors. The clients send orders from day to day as their business requirements or desire to speculate may dictate. Some of these orders are to buy, some to sell. We shall assume that they are all in corn for May delivery and that the contracts are entered into in January. Brown receives an order to buy 5,000 bushels of May corn. Stepping into the corn market or pit, he buys the quantity ordered of Jones, one of the other commission merchants. If either Brown or Jones elects, there is but one way to settle this contract; that is, by actual delivery by Jones to Brown some time in the month of May. Or, if Brown does not sell 5,000 bushels of May corn, settlement would be impossible, except by Jones procuring the actual corn and delivering it to Brown in the month of May. In other words, both parties to the contracts must first have a purchase and a sale of May corn, and secondly, must consent to a settlement before any contracts can be closed, except by delivery.

But there is a third and more essential condition which must exist before the first two are of consequence, and they are not sought nor considered until it is discovered that this third condition exists. It is the all important reason for settlement without delivery and is the mere fact that delivery would be idle and unnecessary. Therefore only such contracts for future delivery are settled without delivery of the actual grain, as the parties to the contracts may agree to settle after having discovered that delivery would be an idle form.

When Delivery is Unnecessary. When a purchase and sale (there must be both a buyer and seller) for future delivery is made on the Chicago Board of Trade, it must be made with the intention on the part of the purchaser to receive and on the part of the seller to deliver the commodity. Subsequent events may render delivery unnecessary and settlement before the maturity of the contract desirable without jeopardizing the legality of the contract. But this cannot be foreseen and the buyer and seller must calculate to be prepared to receive and deliver the cash commodity at maturity of the contract.

Two parties

Brown, having bought in January 5,000 bushels of May corn of Jones, as previously stated, enters the transaction on his books, and in the usual course of business Jones would deliver him the actual corn some time in the month of May. But a week later Brown received an order to sell 5,000 bushels of May corn, and stepping into the corn pit offers the grain for sale, and Jones buys it from him. Now, we have Brown and Jones in the position of having bought of and sold each other 5,000 bushels of May corn. Brown, who originally bought of Jones, has now sold to Jones, and Jones, who originally sold to Brown, has now bought of Brown. Suppose it were illegal to settle future contracts, except by the delivery of the actual grain, where would Brown and Jones be? Which one would make the initial delivery of the grain? Each would say to the other when May arrived, "Deliver me that 5,000 bushels of corn I have bought of you, so that I can deliver it back to you and thus settle your sale to and purchase from me and my sale to and purchase from you," and each would answer the other, "When you deliver me the corn you have sold me, I will deliver it to you." Could a more absurd condition exist in

It is absurd for each to sell the same grain to the other the business? Yet this is exactly the kind of a transaction that gives rise to the criticism that "futures" are settled without delivery.

Brown and Jones have no trouble in settling this contract. If Jones sold the corn to Brown at 45 cents a bushel and subsequently bought it of him at 46 cents a bushel, he has a loss in the transaction of 1 cent a bushel, or $50.00, which he pays to Brown immediately and the contracts involved are settled.

We will now go one step further and note a more complicated settlement, which will involve more than two brokers.

In the month of January, Brown buys of Jones 5,000 bushels of May corn; on the following day, Jones buys 5,000 bushels of May corn of Smith. The purpose of these transactions is that in the month of May, Smith will deliver 5,000 bushels of corn to Jones, who in turn will deliver it to Brown, thus fulfilling the contracts. But, if in the course of business extending over the period between January (when the contracts above mentioned were made) and May (when the contracts mature), it should so happen that Smith should buy 5,000 bushels of May corn from Brown, the three brokers would be in the same position that Brown and Jones were in on the first transaction referred to, where each had the corn bought and sold to the other. To make this more clear:

Three parties

Brown has bought of Jones.
Jones has bought of Smith.
Smith has bought of Brown.

Each has bought of the other

Putting it another way:

Brown has sold to Smith.
Smith has sold to Jones.
Jones has sold to Brown.

It will be noticed that, no matter how you put these transactions, they begin and end with the same party, and it would be the same in case any of the brokers delivered corn, for it would come back to him who delivered it, after passing through the hands of the other two. Assuming, for example, that Smith delivered the 5,000 bushels of corn, it would pass from one to another as follows:

Each has sold to the other

Smith delivered to Jones.
Jones delivered to Brown.
Brown delivered to Smith.

So that Smith would get back the corn and the delivery would have accomplished only the settlement of the contracts as among the three parties. If each of the three parties received and paid for the corn and in turn delivered it out and received a check for it, as they would have to do in this case, and assuming the average price to be 45 cents, each party would collect and pay out $2,250; in other words, they would handle $4,500. So that the aggregate received and paid out would be $13,500 to settle these three transactions in which the difference might be a very small sum. But the delivery spoken of would not occur for the simple reason that Smith would wait for Brown to deliver the corn to him so that he (Smith) could deliver it to Jones, while Brown would wait for Jones to deliver the corn to him so that he (Brown) could deliver it to Smith.

It will be seen that delivery on these contracts is not only unnecessary, but also impossible, except by borrowing the cash corn for the purpose of going through an idle form.

Before showing how these trades are finally settled, we will carry the illustration a little further. The case of Brown, Jones and Smith can be extended so as to involve a large number of brokers. It is frequently discovered that as many as twenty brokers are in the same position in one transaction as Brown, Jones and Smith were; that is, they must settle without actual delivery, as every one of them has it bought and sold and each is waiting for the party he has bought it from to deliver it to him. If they should fail to investigate and discover the true state of the trades, every one of the twenty brokers would default on his contract by reason of their all waiting for an impossible or at least, improbable delivery.

To escape the possibility of becoming involved in trades that would result in default, to facilitate their business by discovering and settling these unnecessary contracts, and to collect and pay all differences on these closed contracts, every broker in Chicago who trades in futures, employs a clerk whose duty it is to watch the transactions closely and see that they are settled immediately, in case it develops that delivery on the contract is unnecessary for the reasons just described.

Where necessary all trades for future delivery are settled by actual delivery

Every trade for future delivery made on the Chicago Board of Trade (unless the seller defaults on the contract, and defaults are very rare), is finally settled by the delivery of the commodity contracted for, except such trades as get into a position that renders delivery unnecessary, as in the cases already set forth.

Having noted "when delivery is unnecessary" and settlements are effected by the payment of the differences between the contract prices, we will now give a short explanation of how deliveries are made; for on all contracts for future delivery, there is an actual delivery (defaults, which are rare, excepted), unless it develops that delivery is unnecessary.

How Deliveries are Made. Deliveries on contracts for future delivery of grain, flaxseed and provisions entered into on the Chicago Board of Trade, are made by warehouse receipts for the commodities in warehouses declared "regular" by the Board. Deliveries of grain and flaxseed are made in lots of 5,000 bushels (except a few in wheat and flax in 1,000-bushel lots), provisions in lots of 250 packages and 50,000 pounds.

All contracts upon which delivery is unnecessary are eliminated as fast as they are discovered, so that when the month of delivery arrives, it finds only the contracts open upon which delivery must be made. Sellers begin to deliver the commodities on the first business day of the month at 8:30 A. M., and oftentimes deliveries are very frequent throughout the month.

Where deliveries are unnecessary such trades are eliminated as soon as found

Warehouse receipts deliverable on the contracts are negotiable and great care is necessary to prevent their loss. If it were not for the manner in which the deliveries are made, the parties to the contracts would be subjected to great loss and annoyance by reason of lost or misplaced warehouse receipts and unnecessary clerical expense.

Experience and necessity have developed an almost perfect system of delivery, which eliminates all danger of loss of warehouse receipts and simplifies the work. At 8:30 A. M. on the first business day of each month, deliveries are made by notice on the Exchange Hall of the Board of Trade. Every party having grain, provision, or flaxseed contracts open for that month must be represented. Those traders having commodities to deliver hold the receipts in their offices, but they hand notices to the parties to whom they have made sales, notifying them to call and pay for the property and get the warehouse receipts. The party receiving the notice either holds the notice and sends a certified check to the party making the delivery, who then turns over the warehouse receipts to him, or if he has a contract of sale with some other member, he passes the notice by endorsement to the third party, who can, in turn, do the same thing; so that a notice of delivery may go through twenty-five or thirty hands, until it finally reaches a party who, for some reason, desires possession of the commodity. This last party then pays for it and all the intermediate parties settle by receiving or paying the differences between the contract prices—in other words, the profits and losses in the trades.

Deliveries are made 8:30 a. m. to 9:15 a. m. on first business day of each month

This system of delivery saves the paying out and collecting by each party of the full value of the commodity delivered, as well as the

Warehouse receipts are used

Fig. 128.
EXCHANGE HALL OF CHICAGO BOARD OF TRADE.
(Courtesy of Chicago Board of Trade)

passing of the warehouse receipt from office to office. Thus, deliveries that would involve immense sums of money and two or three days' time are consummated in forty-five minutes by paying for the property once.

After the first delivery day, deliveries can be made by warehouse receipts from office to office each morning, but in the afternoon of each business day, deliveries are made by notice in the Exchange Hall, the same as on the morning of the first business day of the month. The delivery notice is a complete description of the receipts and the contract on which they are to be delivered. Any person to whom the notice is delivered can procure the receipts by holding the notice and sending a check for the value of the commodity to the party issuing the notice. Every notice is back to the office of the issuer within an hour after deliveries close, accompanied by a certified check, and the warehouse receipts are surrendered to the party thus paying for them.

Volume of such deliveries beyond comprehension

The volume of these deliveries is at times beyond comprehension. In making an investigation of one lot of 1,200,000 bushels of wheat, sent out by a firm on notice, it was found that the 240 notices of 5,000 bushels each had passed through an average of twenty hands before they finally lodged and were paid. Thus, contracts for 24,000,000 bushels of wheat were settled by delivery of this lot of wheat in forty-five minutes (the delivery runs from 8:30 to 9:15 A. M.).

As there were between five and ten millions of bushels of grain delivered that morning, the contracts settled by delivery were evidently between one hundred and two hundred million bushels. If that volume of business should be carried from office to office, it would have involved much time, labor, expense and delay, all unnecessary. Every person receiving the notice had absolute control of the disposition of the warehouse receipts during the time the notice was in his hands; for it passes from hand to hand and can be stopped by any party who receives it.

Settlements, and Settlement and Delivery Prices. Contracts settled for the reason that delivery is unnecessary, must be uniform in all respects. If only two parties are involved, the settlement is very simple; the one having a loss in the transaction, pays it to the other who has a profit. But when more than two parties are involved, the collecting of profits and payment of losses are more complicated and difficult of explanation, although differing not the least in principle. The parties having losses pay, and the parties having profits collect them, and in every settlement, whether it involves two or twenty parties, the losses equal the profits.

To illustrate this, let us use an imaginary settlement involving five brokers. The settlement is of 5,000 bushels of May corn and might occur any time after trading in that "future" becomes general.

Five parties

Brown has sold to Jones at 46 cents.
Jones has sold to Smith at 44 cents.
Smith has sold to Day at 47 cents.
Day has sold to Lee at 43 cents.
Lee has sold to Brown at 48 cents.

A little figuring shows that Jones, Day and Brown have respectively 2 cents, 4 cents, and 2 cents a bushel loss, aggregating 8 cents a bushel, in their transactions; while Smith and Lee each have a profit —Smith of 3 cents and Lee of 5 cents a bushel, a total of 8 cents a bushel, equal to $400 on 5,000 bushels. When it is discovered that the trades are in the position indicated and delivery is unnecessary, and all the parties agree to settle the transactions, the next step is to transfer the $400 owed by Jones, Day and Brown, to Smith and Lee.

Settlement price is the average price for the day

An extremely simple method in doing this has been in vogue for twenty years. Each day a "settlement price," or more properly a "figuring" price is fixed. It has nothing to do with the real settlement of the contracts, being a mere convenience. In settling this 5,000 bushels of May corn, as among the five brokers, the settlement or figuring price for the day on which the settlement is made will be used as a figuring basis. Taking 45 cents as the settlement price, we get the following result:

SETTLEMENT 5,000 BUSHELS MAY CORN.

SETTLEMENT PRICE 45 CENTS.

Sales.		Loss.	Profit.
Brown			
to Jones	at 46 cents	Jones 2 cents per bushel	
to Smith	at 44 "		Smith 3 cents per bushel
to Day	at 47 "	Day 4 " per bushel	
to Lee	at 43 "		Lee 5 " per bushel
to Brown	at 48 "	Brown 2 " per bushel	
	Total	8 cents per bushel ($400.00)	8 cents per bushel $400.00

You will notice that in the case of Day, who has a loss of 4 cents a bushel ($200.00) to pay, he has the corn bought of Smith, who has a profit of 3 cents a bushel ($150.00) to collect; and he (Day) has sold it to Lee, who has a profit of 5 cents a bushel ($250.00) to collect, and the question would arise immediately as to which of these parties Day should pay his $200.00 loss to, if it were not for the figuring price. Day's clerk figures that having bought the corn of Smith at 47 cents and sold it to Lee at 43 cents, he must settle on a basis of 45 cents with each, which he does by paying Smith down to 45 cents, which would be 2 cents a bushel ($100.00), and paying Lee up to 45 cents, or 2 cents a bushel ($100.00). Thus Day has paid his loss direct to the parties to the contracts with whom he had the trades. All the other parties to the contracts pay and collect to this common price, so that each pays his whole loss or collects his whole profit in a systematic and simple manner.

Profits and losses are in this way reckoned systematically

Jones, who has bought of Brown at 46 cents and sold to Smith at 44 cents, pays each to 45 cents, 1 cent a bushel in both instances. Brown, who has sold at 46 cents to Jones and bought at 48 cents of Lee, pays Lee 3 cents a bushel ($150.00) and collects 1 cent ($50.00) of Jones. So that each party settles with the parties with whom he originally made the transactions, on the basis of an imaginary figure which is every day fixed at about the average price for the day.

The using of the "settlement" or "figuring" price has the effect of enabling each party to the settlement to settle direct with the two parties with whom he has made the transactions, on the same basis that he would settle with them in case of a settlement wherein only two parties were involved. It simply reduces the transactions to the same basis as a trade wherein the purchaser had sold back to the seller, at the "settlement" price and the seller has bought back of the purchaser at the "settlement" price. In other words, it works out the same as if Jones, who had bought it of Brown at 46 cents sold it back to him at 45 cents and paid his loss of 1 cent a bushel ($50) to Brown, and then having sold it to Smith at 44 cents bought it back of him (Smith) at 46 cents, another loss to Jones of 1 cent a bushel ($50), which he pays to Smith, and so through the whole list of persons interested in the settlement as follows:

Brown sold to Jones at 46 cents... Jones sold to Brown at 45 cents...	Brown collects 1 cent of Jones.
Jones sold to Smith at 44 cents... Smith sold to Jones at 45 cents....	Smith collects 1 cent of Jones.
Smith sold to Day at 47 cents..... Day sold to Smith at 45 cents.....	Smith collects 2 cents of Day.
Day sold to Lee at 43 cents....... Lee sold to Day at 45 cents........	Lee collects 2 cents of Day.
Lee sold to Brown at 48 cents...... Brown sold to Lee at 45 cents......	Lee collects 3 cents of Brown.

	Loss
So that Brown, whose loss is 2 cents a bushel, has paid Lee 3 cents loss and collected of Jones 1 cent..............	Net 2c
Jones, whose loss is 2 cents a bushel, pays 1 cent to Brown and 1 cent to Smith	Net 2c
Day, whose loss is 4 cents, pays 2 cents to Smith and 2 cents to Lee	Net 4c
Total..	8c per bu.

It will be noticed that Smith and Lee have collected respectively 3 cents a bushel ($150.00) and 5 cents a bushel ($250.00) direct from the parties with whom they had the trades, although in no case is the loss of any one of the debtors the same as the profit of either Smith or Lee. In every case in which a settlement is made in place of an unnecessary delivery—and no agreement can be made except on that basis—the result will always be the same, the losses equalizing the gains.

Delivery on contract may be made at contract price or delivery price

Delivery Price. Deliveries on contracts, when the warehouse receipts are passed from office to office, are paid for at the price of the contract as originally made between the brokers. When delivery is affected by the "delivery" notice, as explained heretofore, it is made at a "delivery" price fixed each day, as in the case of the "settlement" price, and the commodity is figured, for the purpose of delivery, at that price. The party receiving the commodity pays for it, not at the price at which he bought it, but at the "delivery" price. If the "delivery" price is less than the price of the contract on which he received it, he pays the difference to the party from whom he bought, but if it (the delivery price) is in excess of the purchase price, he collects the excess or difference from the party from whom he has bought it. This plan is followed by each party who received and delivered out the "delivery" notice; they use the delivery price as a figuring price and pay the difference in exactly the same manner as they would when using the "settlement" price in case of settlement without delivery.

Even the party sending out the notice receives payment at the delivery price and he collects of or pays to the person to whom his sale was made and who first received the "delivery" notice from him, the difference between this contract price and the "delivery" price. The "delivery" notice may be passed through any number of brokers and the contracts settled at the delivery price. The following morning, the brokers pay and collect the differences between the price at which they originally made the purchase and sale and the "delivery" price.

The "delivery" price is like the "settlement" price, a mere figuring basis for the convenience of the traders. Neither has the slightest relation to the real transaction, or its settlement or delivery; but after settlement is agreed to, or delivery made, they furnish a simple, systematic, economic and uniform basis for the payment of balances due to or payable by the brokers, without changing the result one iota. If there were neither "settlement" nor "delivery" prices fixed, the business would be handled exactly the same as it now is, with the exception that the payments of balances would have to be made in a cumbersome and unsatisfactory manner.

BUCKET SHOPS

A bucket shop is an establishment nominally and ostensibly for the transaction of grain, cotton, or stock exchange business. This transaction is a mere pretense. The bucket shop exercises no commercial function and is devoid of every commercial feature. The proprietor with or without the consent of the patron, takes one side of every deal that is made in his place, the patron taking the other. No article is bought or sold in the public market and charges or commissions are exacted for no services rendered. The market quotations posted in an up-to-date bucket shop are similar to those posted in a legitimate broker's office. The broker posts them for the purpose of showing what the market has been on the exchange, as a matter of information. The bucket-shop keeper posts them as the terms upon which its patrons place their bets. The margins deposited with bucket shop proprietors by the patrons, are nothing but the patrons' stakes to the wager, and are appropriated by the proprietor when the fluctuations of the price on the exchange, whose quotations are the basis of the bet, reach the limit of the deposit.

Bucket shop is a pretense

Difference between broker and bucket shop keeper

ACKNOWLEDGMENTS. Much of this chapter has been taken from "Gold Bricks of Speculation," by John Hill, Jr. His discussion of "Futures" could not be improved with the extent of our knowledge. We wish here to express our appreciation of the very clear and forceful way in which Mr. Hill describes the operations in the trading.

Secretary George F. Stone and President Hiram Sager, of the Chicago Board of Trade, have taken special pains to settle points of technicality.

Rumsey and Company and E. W. Wagner and Company were courteous in answering inquiries.

Secretary E. J. McVann kindly outlined the History and Development of the Grain Exchange of Omaha.

COLLATERAL READING:

Gold Bricks of Speculation, By John Hill, Jr.
Speculation Not a Fine Art, By E. W. Wagner.
Reports of the Boards of Trade of the several principal markets.

CHAPTER XIV

THE COMMERCIAL PRODUCTS OF CORN

The Commercial Products of Corn May Be Classified as Follows:

1. THOSE DERIVED FROM THE KERNEL.
   - A. By mechanical and milling methods.
   - B. By mechanical and chemical processes.
   - C. By fermentation.
2. THOSE DERIVED FROM THE COB.
3. THOSE DERIVED FROM THE PLANT ITSELF.
   - A. From the stalk.
   - B. From the leaves.
   - C. From the husks.

PRODUCTS DERIVED FROM THE KERNEL

Germ and hull are removed from modern corn meal

BY MECHANICAL AND MILLING MEANS.—Corn Meal. The early American mill stone produced a coarse meal from corn. This form of meal contained hull, endosperm and germ. Rancidity often resulted from the presence of an excess of oil. Hence, as soon as the milling of corn meal for commercial purposes was developed, the elimination of the germ was found necessary to facilitate storing and shipping. In this process, heavy rollers are used which are set far enough apart to allow a kernel to pass through flatwise. Very sharp, but slight steel projections neatly peel the germ from the kernel, which has previously been softened and hulled. From the rollers, the entire mass is passed into water. The germs rise and are taken off and thoroughly dried. The remainder of the kernel is ground into different grades of corn meal. The classification of corn meal is made according to color, white or yellow; and graded by its structure into coarse, medium and fine.

Classes of corn meal

Some companies at the present time, put out a "whole meal" during the winter months for a select trade and where it is to be consumed shortly after being manufactured. Very few people understand the real value of this form of meal as compared with the commercial form commonly found upon the market. Whole corn meal includes the germ, which contains 82 per cent of the entire oil content of the kernel, thus adding considerably to the food value.

Corn Meal as a Food. Corn or maize meal is prepared as food in many different ways. In Ireland, it is made into a sort of porridge called "stirabout," or in the more expressive phraseology of America, "mush." In Northern Italy and South Tyrol it is prepared in a similar way, but with the addition of cheese and other ingredients. Maize meal or corn meal is made as above stated, by removing the hull and germ. A white and yellow meal is prepared, the former in greater quantities because its color is more attractive to the purchaser. In food value, however, there is no difference. Fine maize meal is more gritty than wheat flour, but when mixed with the latter, its presence can hardly be detected. The comparative cheapness of maize flour is an inducement to millers to adulterate wheat flour with it, and this is already being done to some extent in America and France. Flour so adulterated yields fewer loaves than an equal quantity of pure wheat flour, and the bread produced is more moist than wheat bread and has a tendency to be sodden. An addition of 10 per cent of maize flour is calculated to mean a reduction of five loaves on the sack. Owing to the absence of gluten, this meal cannot be used to make ordinary bread, but it is often baked into cakes of various sorts. The "johnny" (corruption of journey) cakes of North America are unleavened and are made of a rather coarse maize meal. Similar cakes constitute the "tortilla" of South America and Mexico. The following is the composition of the "johnny" cakes, analysis by Atwater and Wood:

Used to adulterate wheat flour

Composition of "Johnny" cake

Water	38.0	per cent.
Proteid	8.5	"
Fat	2.7	"
Carbohydrates	47.3	"
Mineral Matter	3.5	"

Comparing this with white bread, we find the nutritive value to be greater in the case of the "johnny" cake.

An anlysis of wheat bread by Dr. Robert Hutchinson, of the London Hospital, is as follows:

Water	40.0	per cent.
Proteid	6.5	"
Fat	1.0	"
Starch, Sugar and Dextrine	51.2	"
Cellulose	.3	"
Mineral Matter	1.0	"

Sometimes the maize meal is leavened with yeast and subsequently baked in iron vessels. In this form, it is known as "pone." In Ireland, baking powder is used or the maize meal is mixed with flour and so converted into loaves. One-third of its weight of good flour is sufficient to enable fine maize meal to form good loaves. The color of the bread is always rather dark, however, even if the proportion of wheat flour be increased to one-half.

Exportation. Our export trade in corn meal amounts to a great deal at the present time. During the ten years from 1898 to and including 1907, the following amounts with values appended, were shipped to foreign markets:

766,880 barrels exported in 1907

Year.	Barrels of Meal.	Value.
1898	827,651	$1,766,068
1899	791,488	1,775,868
1900	943,782	2,148,410
1901	896,877	2,065,432
1902	348,034	1,046,643
1903	451,506	1,382,127
1904	590,774	1,691,669
1905	371,565	1,113,295
1906	543,794	1,623,397
1907	766,880	2,313,410

For the year 1904, the following countries were the chief importers of corn meal manufactured in the United States according to the Government Statistical Report on Commerce and Navigation for that year.

The total number of barrels exported to all foreign countries for 1904 was 590,774. Of this, British Africa took 32.79 per cent; West Indies, not including Porto Rico, 27.3 per cent; the United Kingdom, 21.32 per cent; the Dominion of Canada, including Labrador and New Foundland, 9.675 per cent.

The above figures give an idea of the countries using most of the export corn meal. It may seem strange that so much goes to South Africa. It may be interesting to know, in this connection, that plain corn cake constitutes the chief food of the South African Kaffirs employed in the African mines.

Milling By-Products. The by-products from this system of milling, consist of the germs and hulls. The larger manufacturers press the oil out of the germ and then sell the "germ-oil meal" for stock feed. But, as the majority of corn meal mills are in the smaller towns in the western part of the corn belt, this process is little practiced. A mixture of the unpressed germ meal with one-third its weight in whole oats, is fast becoming a popular horse feed with draymen and breeders. The combination of the corn hulls with the germs makes an inexpensive stock food.

During the year 1904, 14,014,885 pounds of corn-oil cake in the form of large pressed slabs were exported to European markets, the total value of which amounted to $169,921.00. Of the total number of pounds exported, Belgium took 55,000 pounds; France 9,379,685 pounds; Germany 2,105,000 pounds; Netherlands 1,166,000 pounds; Sweden and Norway 950,200 pounds; United Kingdom 329,000 pounds; and the Dominion of Canada (British Columbia) 30,000 pounds.

14,014,885 pounds of corn-oil cake exported in 1904

Hominy, Cerealine and Samp. The first of these, or whole lye hominy, is generally put out as the whole kernels minus the hull. It is treated with a solution of alkali, which serves to loosen the coat of the kernel. When the hull or coat has been removed, the remainder of the kernel, including the endosperm and germ, is thoroughly washed to rid it of the alkali which was used to loosen the hull and to take out a large per cent of the oil.

In hominy the hull is removed

In the preparation of whole lye hominy, a choice white variety of corn is demanded because the white corn makes an attractive and more desirable dish. Hominy mills often pay from one to three cents per bushel more for choice white corn of a hard, flinty texture. Soft, immature, starchy, or discolored corn is not used by hominy mills.

White variety used

Cerealine and samp, which are preparations of corn to be classed as hominy, are made from the hard, horny portions of the kernel. For the manufacture of these products, the manufacturers demand a hard, flinty, long-kerneled white corn, as this gives the desired color, and the large kernel will usually yield a larger percentage of the horny portion. Starchy, immature, or soft corn is not desired at any price. Hominy mills are willing to pay a premium of from three to five cents for the most desirable corn. Mixed colors in corn are not wanted.

Immature and soft corn undesirable

The process of manufacturing consists, first, in running the shelled corn between rollers so that it is cracked open. It is then rolled and rubbed by means of machinery in order to remove the germs and the white, starchy portions. In the whole-lye hominy, the germ is not removed, but the treatment with the alkali and the heating to a high temperature prevents the oil which remains in the kernel from becoming rancid. Since the cerealine and samp receive no alkaline treatment, the germ must be removed mechanically.

Corn is first cracked

Germ is removed

The chemical composition of hominy and cerealine as given by Dr. Robert Hutchinson, is as follows:

	Hominy	Cerealine
Water	11.9 Per cent	10.6 Per cent
Proteid	8.2 "	9.4 "
Fat	0.6 "	1.0 "
Carbohydrates	78.9 "	78.6 "
Mineral Matter	0.4 "	0.4 "

Both of the preparations above discussed are of a high nutritive value and admirably adapted for making puddings, etc. In this capacity, it is used considerably in the Orient. In our own country, it is usually served by cooking in milk, much the same as sweet corn.

Almost pure starch

Corn Flour, Maizena, Oswego. Corn flour, maizena and oswego are prepared from maize by washing away the proteid and fat by means of dilute alkaline solutions, so that little but starch is left. Church states that corn flour contains only 18 grains of proteid in every pound, and a sample of "Brown and Ralston's" corn flour, according to Dr. Robert Hutchinson, contained but a mere trace of nitrogen in the form of proteid.

The following is an analysis of maizena, as given by Klemperer in Leyden's "Handbuch der Ernahrung Sterapie," page 298:

Water	14.3	per cent.
Proteid	.5	"
Carbohydrates	84.9	"
Mineral Matter	.3	"

These preparations must therefore be regarded simply as agreeable forms of starch, well adapted for food, provided they are taken along with some proteid and fat carrier, such as eggs or fatty meats. Such starchy preparations, however, cannot be considered as economical, no matter what the source, because they are a very unbalanced ration.

Easily digested

Maize, as we have considered it in any of the forms discussed, is a highly nutritive cereal. It also has the added advantage of being very well digested in the human body. Experiments show that 90 per cent of its dry matter is absorbed, as compared with 82 per cent in the case of wheat. Of the protein of maize, but 19.2 per cent escapes absorption; in wheat, about 20 per cent is lost.

Economical food

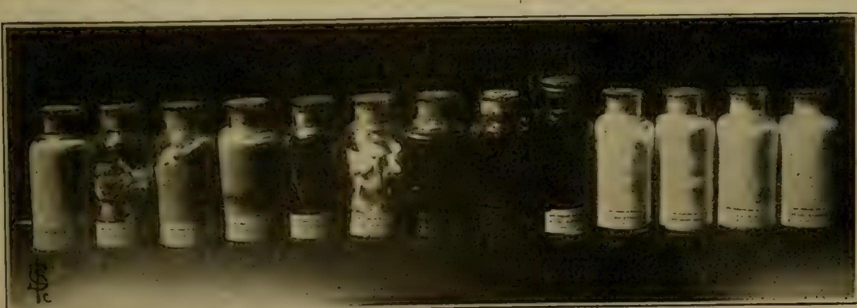
Maize is an economical food. It has been calculated that when maize and wheat are both selling at the same price per bushel, the same amount of digestible matter in each is purchased for the same expenditure of money. In wheat, however, there would be 2½ pounds more protein, and in maize 2½ pounds more carbohydrates. The fuel value in each case is almost precisely the same.*

In view of the above facts and the growing scarcity of wheat, it behooves the lower classes of our country and the hordes of Europe to adapt themselves to the use of this cheaper and simpler form of food stuff. **A food for the lower classes**

Corn Crisp, Corn Flakes. Another corn product, commonly called "Corn Crisp" or "Corn Flakes" is made from white corn grits, which are first seasoned with sugar and salt. They are then steam-cooked, dried, and passed through powerful rollers which flake each grit. These flaked grits are placed in an oven where they are toasted. The method of serving is common to all.

Corn which is used for this purpose is usually not of a high grade. It is more generally of a No. 3, or even No. 4 grade. Corn Flakes are very bulky as put up for commercial consumption, and represent rather an expensive article of diet. They do, however, contain considerable nutriment in the form of carbohydrates, although very low percentage of ash and protein. **A high grade is not usually used**

One of the most extensive manufacturing plants in the country, engaged in the manufacture of this product, is operated at Quincy, Illinois, by the Postum Cereal Company, Limited, of Battle Creek Michigan. This plant annually utilizes 42,000,000 pounds of corn. The type of corn desired is a white, flinty variety. No by-products are put out for stock feeders, as in the case of the starch factories. The outlet for this corn product is found chiefly in the central and western states. The export trade which has been lately established is principally with Great Britain. The amount exported at the present time is inconsiderable.



(By courtesy of Iowa State College.) Fig. 120.

COMMERCIAL PRODUCTS OF CORN.

*U. S. Department of Agriculture, Division of Chemistry, Bulletin No. 50.

CHEMICAL AND MECHANICAL PROCESSES. Taking up the separation of the grain into its different by-products, we find that the first step in this process is the separation of the kernel into three parts; the outer covering or bran, the germ, and the solid portion, made up of the starch and gluten.

Separated into three parts

The corn, which is purchased in the shelled form, is first cleaned and fanned to remove refuse matter and then steeped in a warm solution of sulphurous acid which dissolves the soluble, glutenous matter, thereby, to a certain extent, freeing the germ and making the starch and insoluble gluten mass chalky and easy to grind. From this steeping process, the corn is run through the mills which simply tear it apart, thus liberating the germ from the rest of the mass. This mass is then run into a separator in which the mixture is kept at a certain density, due to the free starch held in suspension. Owing to the density of this mixture, the germs float to the top and are skimmed off. The remainder of the mass, being heavy, sinks to the bottom and is drawn off from that point. From there, it goes to fine mills which complete the grinding.

Germs come to top

This mass, which consists of pulverized starch, gluten, and fiber, is then sieved over silk, and the fiber thus separated is kept at hand, awaiting the addition of pure gluten. The mixture which goes through the silk is sent to long runways, and on these the starch settles; whereas, the gluten, due to its lighter specific gravity, floats off. This gluten, plus the fiber, plus what is called "steepwater," which is the dry material dissolved from the corn in the original steeping process, constitutes our commercial gluten feed.

Bran is sieved out by silk sieves

The gluten which is first separated contains some starch and is again passed over the starch tables and a second grade of starch obtained. The gluten, after passing through powerful presses, which remove most of the water, is then dried and put on the market as "gluten meal," which sells for about $38 per ton.

Gluten floats off

Most of the gluten meal and the corn bran, as indicated in a preceding paragraph, are mixed and ground together in about the proportion in which they occur in the grain, being marketed in this form as gluten feed at from $19 to $25.50 per ton.*

The germs being dried out and finely ground, are steamed and the oil extracted by pressure, about 90 per cent being removed. By treating the germs with naptha, a larger per cent of oil is drawn out, but the germ meal remaining, is less palatable for stock. After being allowed to settle, the oil is drawn off into barrels. Sometimes it is

Germ oil is pressed out

*Corn Products Mfg. Co., July 27, 1908.

filtered. This oil sells for from 4 to 5 cents per pound. It is used for manufacturing paint, for lubricating oil, and for making rubber. This rubber, produced by vulcanizing the oil, is of a coarse texture and mixes readily with India rubber, being useful where wearing qualities rather than elasticity are required. Sole rubber, buffers, and solid rubber buggy tires, are made chiefly of the rubber from corn. Lighthouses have been successfully lighted with corn oil. A refined quality of corn oil is used in place of olive oil for salad dressing and preserving. Much corn oil is exported annually to those countries which manufacture olive oil. In 1906, 3,833,251 gallons of corn oil, valued at $1,177,206, were exported from the United States.

Corn Bran is mixed with gluten meal and sold as gluten feed

The extracted germs are marketed in the form of thin slabs, known to the trade as "corn oil cake," or are ground and sold as "germ oil meal." Exportation of this product in 1906 amounted to 48,420,942 pounds, valued at $605,346.00. Great Britain and Germany are the exclusive purchasers of corn oil cake, the breeders of the Islands relying upon it almost entirely as a concentrate. In the American market, germ oil meal sells for from $18.50 to $25 per ton, its value as a feed being less than that of linseed oil meal. Corn bran, after being subjected to a thorough washing to remove the starch, is dried, and if not mixed with gluten meal, sold as a separate product at from $15 to $22 per ton. It is bought by feeders and mixed with other heavy concentrates to lighten the rations.

The amount of the above products which a bushel of shelled corn will produce is about as follows:

Starch	36	pounds.
Gluten meal	7	"
Corn bran	5	"
Germ oil meal	2.7	"
Corn oil	1.8	"

Starch settles out

From the "green starch," as it first comes from the settling troughs is made a number of other products. Dextrin, which is formed by heating starch to 280 degrees Fahrenheit in the presence of dilute nitric acid, is used extensively in the manufacture of paste and mucilage. Fine fabric, paper box, and glue manufacturers make large use of different kinds of dextrin. The postage and revenue stamps of the United States government derive their adhesive power from this corn product. A granulated gum which competes strongly on the market with gum arabic, is manufactured from dextrin.

For converting starch into glucose, dilute hydro-chloric acid is now very generally used, although for certain products, sulphuric acid in mixture with a limited amount of nitric acid is used. The operation is conducted in a steam heated, closed copper converter, under a pressure of 30 to 40 pounds per square inch. High pressure reduces the amount of acid and length of time required. Syrupy glucose can be produced in from ten to thirty minutes by such a process, but solid starch sugar requires a longer time. As the syrupy liquid comes from the converter, the sulphuric acid is neutralized with chalk or marble dust and the hydrochloric acid with soda.

Starch changed to glucose

"Mixing Glucose" or grape sugar is the largest single product derived from starch conversion. Pure glucose syrup has little flavor and is but one-half as sweet to the taste as beet or cane syrup. Hence, 10 per cent or more of the latter are blended with the former, the result being what is known as "Korn King Syrup" or "Karo," or products of a similar nature known by different names. Corn syrup and "70" and "80" sugars sell for 2¼ cents per pound. Jelly glucose is the basis for manufactured jellies, the flavoring being the evaporated juices of different fruits. Fancy fruit preserves are put up in glucose. Apothecaries and soft drink dispensers use glucose very extensively in compounding. Four kinds of crystallized glucose are made into cake frostings and other delicacies by bakers and confectioners. Candy factories annually utilize carloads of the crude glucose. Grape sugar is only two-thirds as sweet as cane sugar, but because it costs less an anhydrous kind is used by brewers to increase the alcohol content of beer. Cheaper grape sugar plays a part in the tanning of leather. 189,655,011 pounds of grape sugar valued at $3,489,192, were exported from the United States in 1906. This product even enters Europe and the territory where the sugar beet is extensively grown.

Glucose syrup

Fruits preserved in glucose

Corn starch has long been a well known product in the American home. In one form or another 66,574,881 pounds of starch valued at $1,490,797 were exported from the United States in 1906. Laundry starch is now made largely from corn, potato starch being seldom used for such purposes.

Corn starch

Pearl starch is used by cotton and paper manufacturers in stiffening. A refined product is bought by the baking powder companies. The commercial grades of pearl and powdered starch sell for about 2 1-4 cents per pound.

Used in textile mills

Flourine, a corn flour, consisting principally of starch, is used to a limited degree as an admixture to bolted wheat flour, with no detrimental effect. Textile mills run colors in some fabrics with starch after it has been freed of all trace of acid. A limited amount of dried starch and sugar feed, together with starch feed (wet), are the principal by-products in the immediate conversion and refining of starch.

For the manufacture of the products discussed, with the exception of hominy, the companies generally buy No. 3 and No. 4 corn—more often the latter. We may safely say that these companies furnish a means of handling millions of dollars worth of corn that would have been almost valueless upon the market for any other purpose. The Corn Products Manufacturing Company of Chicago, alone, handle from thirty-five to forty millions of bushels of No. 3 and No. 4 corn annually.

FERMENTATION PRODUCTS. The corn is first cleaned by screening and fanning and then run between rollers and crushed. The hulls and germs having been removed, the remaining portion of the corn, which consists largely of starch and gluten, is ground and cooked in large tanks to dissolve the starch.

Three steps in making alcohol

It is then taken to the fermenting tanks where about 10 per cent of barley malt and yeast are added, with 40 gallons of water per bushel of grain. The mass is allowed to ferment. The starch is first converted to sugar by the action of the enzymes in the malt, and then the sugar is converted to alcohol.

The liquid portion, consisting of water and alcohol, is drawn off and heated in large evaporating tanks. The alcohol, having a lower boiling point than water, is driven off first. It is then condensed by directing it over coils filled with cold water.

The residue left in the fermenting tanks, after being washed to remove all the alcohol, is taken to powerful presses and as much as possible of the liquid matter is removed. This liquid portion is used by cattle feeders, who frequently have large feeding establishments located near the distillery. The cattle do best when stanchioned all the time. In front of each row of cattle runs a long trough in which the distillery slop is placed. The cattle drink large quantities of the slop, which, with the exception of a very few pounds of hay to lessen the scouring effect of the slop, constitutes their only feed. "Inasmuch as a bushel of Indian corn weighs 56 pounds, the total weight of fermentable matter therein, in round numbers, is 39 pounds. The weight of the alcohol which is produced under the best conditions is little less than one-half of the fermentable matter. Therefore the total weight of alcohol which would be yielded by a bushel of average Indian corn would be, in round numbers, about 19 pounds. The weight of a gal-

Feeding catt[le] distillery slop

lon of 95 per cent alcohol is nearly 7 pounds. Hence, 1 bushel of corn would produce 2.7 gallons.

Cost of making denaturized alcohol

"If the average price of Indian corn is placed, in round numbers, at 40 cents a bushel, the cost of the raw material—that is, of the Indian corn—for manufacturing 95 per cent industrial alcohol is about 15 cents a gallon. To this must be added the cost of manufacture, storage, etc., which is perhaps as much more, making the estimated actual cost of industrial alcohol of 95 per cent strength made from Indian corn about 30 cents per gallon. If to this be added the profits of the manufacturer and dealer, it appears that under the conditions cited, industrial alcohol, untaxed, should be sold for about 40 cents per gallon."*

Distilled spirits from corn enters into the manufacture of smokeless powder. Fusel-oil (amyl alcohol) forms a part of Bourbon whisky. American perfumes and Cologne are based on corn alcohol as a solvent for the aromatic compounds introduced.

PRODUCTS DERIVED FROM THE COB

One ton of cobs equals as fuel one-third ton of hard wood

About the most valueless thing on the farm, so far as manurial value is concerned, is the corn cob in its cob state. In parts of Iowa, where the corn is shelled on a commercial scale, the cobs are hauled to the fields to be used as a fertilizer and for the addition of humus. Furthermore, it is claimed that they are valuable as a soil holder and conserver of moisture. The most value may be obtained by burning them as a summer fuel. One ton of corn cobs is worth about one-third as much as a ton of dry, hard, wood. Their cost, of course, depends upon the scarcity of wood and coal and the amount of corn grown. As a manurial product, they are valuable chiefly for the potash and phosphorous they contain. Chemical analyses show corn-cob ash to consist of about 50 per cent of potash (K2O).

Missouri the home of the cob pipe

In parts of Missouri, chiefly in the vicinity of St. Louis, there is a great demand for corn cobs to be manufactured into the famous "Missouri Meerschaum" pipes. Near Washington, Missouri a very large type of corn is grown, which has cobs that may be easily utilized by the manufacturing plants. The firm of Hirschl and Bendheim, located at St. Louis, is probably the largest concern doing that kind of business in the United States. They pay about $25 per thousand pounds for selected cobs. According to the above firm, the output of cob pipes for one year in the United States amounts to about half a million dollars. The export trade of this product, which is chiefly with England and her possessions, amounts to very little.

*Farmers' Bulletin 268.

"Corn Down," which is secured by chaffing the cob in the manufacture of cob pipes, and in cleaning out the shelled corn used in the various mills, is used in upholstering and in padding mattresses. "Corn down"

PRODUCTS DERIVED FROM THE PLANT ITSELF

FROM THE STALK. A good quality of paper is produced from corn stalks at a cost of $25 to $26 a ton. Paper from wood pulp or rags costs from $66 to $75 a ton. Over $100,000 has been spent in the perfection of machinery for the handling of this material. A recently patented threshing machine separates the stalks from the leaves, delivers the stalks bound in bundles, ready for shipment, and the remainder of the plant into the barn ready for stock. The stalks are sent to a depithing plant, where the casing of the stalk is removed, leaving the soft pith ready to be rolled into ordinary paper. The coarser pith is manufactured into stiff box-board. Corn stalk is depithed

The New Corn Product. The Naval Department of the United States Government has conducted extensive experiments with corn pith for use in vessels, and the results have been so satisfactory that it has been adopted and specified for use in the construction of all new vessels. A number of European nations, also, have adopted it, and others have commissions for the investigation of the material, looking to its adoption. Pith as a packing for war vessels

This extensive use of corn pith means a market for a product which has been almost entirely wasted heretofore. After the pith has been removed, the shell or the balance of the stalk is ground up into a sort of meal known as the "New Corn Product." While this is perhaps of little value to the Iowa corn grower, yet it is of value to the manufacturers engaged in the extraction of the pith used in the manufacturing of ships. Immense quantities of corn stalks are used to secure the pith for one battleship.

By digesting cellulose in nitric acid, or a mixture of nitric and sulphuric acids, a nitrate is formed commonly known as guncotton. Nitro-glycerin and this guncotton form smokeless gun powder. Corn stalks are rapidly becoming an important source of the cellulose used in these operations. Pyroxylin varnish, a liquid by-product in the manufacture of cellulose, has many practical uses. Guncotton also made from cellulose

FROM THE LEAVES. The leaves, outer shell of the stalk, and other refuse remaining from the manufacture of cellulose, are ground finely and sold as stock feed. Tests at the Maryland Experiment Station proved it to be higher in digestible nutrients than corn fodder. A like product, except that it is the by-product of the paper factory, is also put upon the market, the coarser parts being baled. Highly digestible

Stock foods of different nutritive values result from the use of the by-products of the stalk and leaves. After grinding this refuse matter very finely, it is mixed with dried blood, molasses, distillery and glucose by-products, sugar beet pulp, and apple pomace.

FROM THE HUSKS. Corn husks furnish packing for horse collars and are used in the manufacture of cheap hats in the South. Coarse door mats of lasting quality are made in the North. Husk ticks for beds are used in bunk houses by construction companies, when contracts happen to be in the corn growing districts.

ACKNOWLEDGMENTS.

We wish especially to express our appreciation of the assistance rendered by G. M. Moffett of the Corn Products Manufacturing Co., of Chicago.

Van Camp Packing Co., of Indianapolis has furnished much data in regard to hominy manufacture.

Hirschl and Bendheim, of St. Louis co-operated with us in securing data concerning the cob pipe industry.

COLLATERAL READING.

Studies of Corn and its Uses.
Illinois Bulletin No. 9.

Indian Corn as a Food for Man.
Maine Bulletin No. 131.

Report on the Value of a New Corn Product.
Maryland Bulletin No. 43.

CHAPTER XV

COMPOSITION AND FEEDING VALUE OF CORN

THE GRAIN AND BY-PRODUCTS

PHYSICAL STRUCTURE.* Dr. C. G. Hopkins, of the Illinois Experiment Station, has made a very satisfactory mechanical analysis of the corn kernel. He divides it into six different parts, as follows:

Corn kernel divided into 6 parts

1. **Tip Cap.** This is a small cap covering the tip end of the kernel and serving as a protection to the end of the germ. It consists of material somewhat resembling the cob. Occasionally in shelling corn the tip cap remains attached to the cob, leaving the tip end of the germ uncovered, but nearly always sticks to the kernel.

2. **Hull.** This is a very thin outer covering of the kernel. It consists largely of carbohydrates, especially fiber or cellulose, although it also contains a small percentage of other constituents.

3. **Horny Glutenous Part.** This part lies immediately underneath the hull. It constitutes a second covering of the kernel. For short it is called "horny gluten," although it is, of course, not pure gluten. However, it is the richest in protein of any part of the corn kernel.

4. **Horny Starchy Part.** This part lies next to the horny gluten, on the back and sides of the kernel. For short it is called "horny starch," although it is not pure starch, as it contains considerable amounts of other constituents, especially protein. In an examination of the kernel with the unaided eye, the horny glutenous and the horny starchy parts are not readily distinguished from each other, the line between them being somewhat indefinite and indistinct. Considered both together, these two parts constitute the horny part of the kernel.

5. **White Starchy Part.** This part occupies the crown end of the kernel above the germ, and it also nearly surrounds the germ toward the tip end of the kernel. For convenience, this material is called "white starch," although it is not pure starch. In some kernels the horny starch extends nearly or quite to the germ, near the middle

*Bulletin No. 87, Illinois Experiment Station.

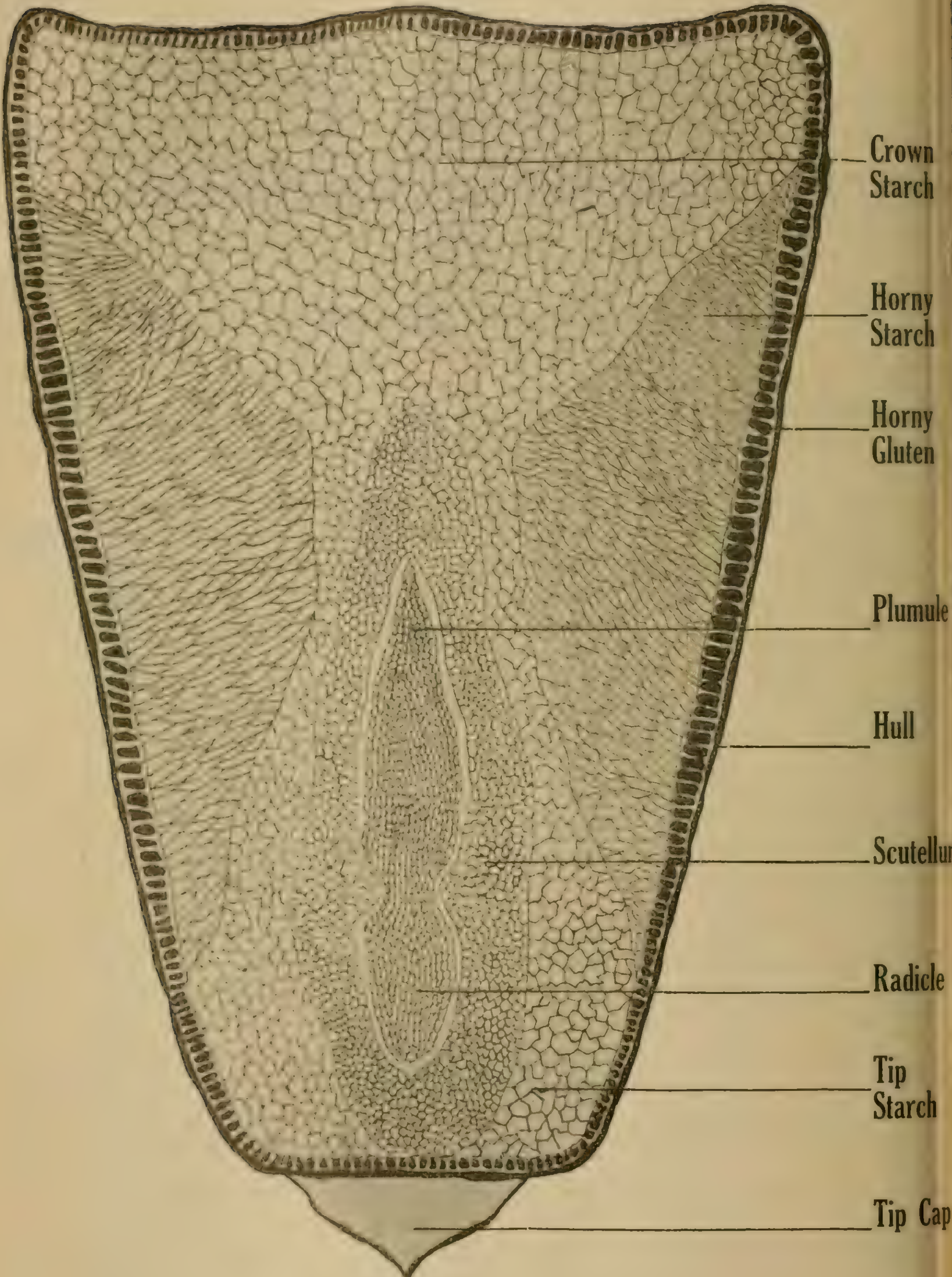


Fig. 130.

THE PHYSICAL PARTS OF THE CORN KERNEL. ....

of the kernel, and thus separates more or less completely the white starch.

6. **Germ.** The germ occupies the center of the front of the kernel toward the tip and usually extends about one-half or two-thirds of the length of the kernel.

MECHANICAL SEPARATION OF THE DIFFERENT PARTS. It is not a very difficult matter to obtain very pure samples of each of the above named parts of the corn kernel, although in making the separations there is of necessity some waste material consisting of a mixture of the different parts.

By use of a small, sharp knife anyone can make the following separations:

1. Tip Cap.
2. Hull.
3. Horny Gluten.
4. Germ.
5. White Starch.
    a. Crown starch.
    b. Tip starch.
6. Horny Starch.
7. Waste (Mixed Materials).

In making these separations, the kernels are first soaked in hot water for 15 or 20 minutes. **Making the separation**

Removal of Parts.—1. Tip Cap. With a knife cut one side, preferably that on which the germ is located, then cut the back side. Bend the whole tip toward the side of the first cut and the cap will come off with trim edges. If only one side is first cut, there is liability of removing part of the hull with the tip cap.

2. **Hull.** Catching the edge of the swollen hull under the blade of a knife, peel it back, beginning on the back side of the kernel first. Be careful to dislodge all of the hull from the wrinkled crown in pinched dent corn.

3. **Horny Gluten.** Covering the entire kernel like a coat of "sealing wax," will now be seen a thin layer, which in yellow corn is readily identified because of its yellow color, especially where contrasted with the white starch of the crown. In shaving off this thin layer, the greatest care should be exercised not to get too deep, either in the white or the horny starch. The fact that the horny starch loses its lustre just so soon as the horny gluten is removed, is

an indication that the scraping has continued long enough. No horny gluten will be found covering the surface of the germ.

4. **Germ.** Next split the kernel lengthwise, through center of the germ. With the knife slowly "scallop" out the half of the germ from each section of the kernel. The depth can easily be gauged by the line between the germ and the starchy part beneath.

5. **White Starch.—**

(a) **Crown Starch.** The large cap of starch at the crown can now easily be cut off just above its junction with the horny starch. Some white starch will have to be whittled out of the small strip appearing between the cheeks of horny starch.

(b) **Tip Starch.** Near the tip of the kernel will be seen a white starch which is removed with difficulty from between the cheeks of horny starch.

6. **Horny Starch.** This usually remains intact in two large pieces.

7. **Mixed Waste.** Because of the difficulty in securing pure samples of these parts, there will remain some particles of mixed material which results largely from scraping the horny starch to remove the white starch and horny gluten. This should be weighed separately.

PHYSICAL ANALYSES.

From physical analyses at Illinois, Hopkins found the percentages of the respective parts to vary as follows:

PERCENTAGES OF DIFFERENT PARTS.

Names of Parts	Low Protein Ear	Medium Protein Ear	High Protein Ear
Tip Caps	1.20	1.46	1.62
Hulls	5.47	5.93	6.09
Horny Gluten	7.75	5.12	9.86
Horny Starch	29.58	32.80	33.79
Crown Starch	16.94	11.85	10.45
Tip Starch	10.93	5.91	6.23
Germs	9.59	11.53	11.93
Mixed Waste	18.53	25.40	20.03

A very large percent of mixed waste will be noted from these tables. By computations it was shown that this waste consisted almost entirely of horny gluten, horny starch, crown starch, and tip starch. Consequently, after distributing the error secured from this mixed waste the percentages appear as follows:

Names of Parts	Low Protein Ear	Medium Protein Ear	High Protein Ear
Tip Caps	1.20	1.46	1.62
Hulls	5.47	5.93	6.09
Horny Gluten	11.61	8.51	13.32
Horny Starch	37.15	47.08	44.89
Crown Starch	21.26	17.01	13.88
Tip Starch	13.71	8.48	6.28
Germs	9.59	11.53	11.93
Total	99.99	100.00	100.01

Taking an ear of medium protein the following table shows the percentage composition of the different parts of the kernels.

COMPOSITION OF PARTS.

Names of Parts	Protein Percent	Oil Percent	Ash Percent	Carbo-hydrates Percent
Whole Kernel	10.95	4.33	1.55	83.17
Tip Caps	8.83	2.30	1.11	87.76
Hulls	3.96	.89	.79	94.36
Horn Gluten	22.50	6.99	1.72	69.09
Horny Starch	10 20	.24	.24	89.32
Crown Starch	7.92	.17	.24	91.67
Tip Starch	7.68	.39	.31	91.62
Germs	19.80	34.84	9.90	35.46
Mixed Waste	11.10	1.23	.57	87.10

A close study should be made of this table. The facts that the horny gluten is 22.50 per cent protein and that the germ is 34.84 per cent oil, are very striking.

The most significant table is here presented, which shows the percentage distribution of the chemical constituents among the physical parts for an ear of medium protein content.

Names of Parts	Percent of Total Protein	Percent of Total Oil	Percent of Total Ash	Percent of Total Carbohydrates
In Tip Caps	1.14	.69	1.06	1.56
In Hull	2.07	1.08	3.06	6.80
In Horny Gluten	16.67	12.21	9.56	7.15
In Horny Starch	12.36	2.32	7.38	51.12
In Corn Starch	11.88	.59	2.67	18.96
In Tip Starch	5.75	.68	1.72	9.45
In Germs	20.14	82.43	74.55	4.97
Total	100.01	100.00	100.00	100.01

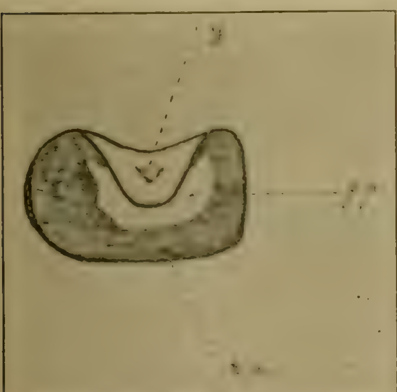


Fig. 131-1
CROSS SECTION OF CORN KERNEL.
g. Germ. f. p. Floury part or white starch. h. p. Horny part, or horny starch.

82.43 per cent of all the oil in a kernel of corn in the above case is in the germ. The fact that corn has a large or small germ is therefore indicative of its oil content. The large per cent (42.63) of protein in the horny starch accounts for the higher feeding value of well matured corn, which always shows a greater development of horny starch.

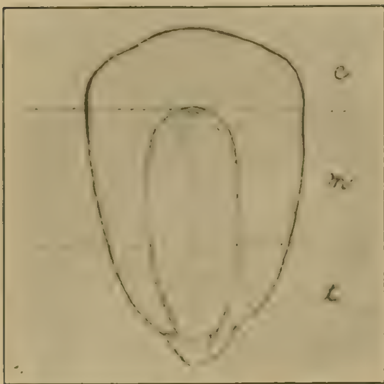


Fig. 131-2

Dividing the kernel into three parts, the crown, middle, and tip, the following percentages of the valuable food constituents are shown:*

A full, plump tip, as shown by this table, indicates that the corn is of high feeding value.

Fig. 131-2

1.—Corn kernel divided into (c) Crown, which is mostly white starch: (m) middle, which takes in some of the germ and the greater part of the horny starch and is therefore richest in protein: (t) tip, which is richest in oil.

Parts	Percent Protein	Percent Oi	Total
Crown	13.51	1.00	14.51
Middle	9.98	3.33	13.31
Tip	12.26	12.02	24.28

CHEMICAL COMPOSITION OF CORN

The animal body is made up of bones, flesh, tendons, skin, hair, horny substances, and a large, though varying amount of water. Just as the animal body is made up of varying proportions of flesh, fats, water and bone, so a plant is made up of various similar substances from which this flesh, fat, and bone is made. These component parts of the plant represent a large number of chemical compounds. For our discussion, however, they are grouped together under a few general heads and in two great classes.

I. Organic compounds.
  A. Nitrogenous.
    1. Protein.
  B. Non-nitrogenous.
    1. Fat.
    2. Carbohydrates.
      (a) Soluble carbohydrates or nitrogen free extract.
      (b) Insoluble carbohydrates or crude fiber.

II. Inorganic compounds.
  A. Ash.
  B. Water.

As each of these groups has its specific part to play in the building up of the animal body, they will here be discussed separately.

ORGANIC COMPOUNDS.—Protein. The beneficial results following the use of oil meal, bran, clover and alfalfa hay, we know, come largely from the protein which these feeds contain in greater abundance than most of the feeds grown on the farm.

The word "protein"* is used to designate a large number of substances that differ from each other more or less in chemical composition. These substances are alike in one particular—they all contain nitrogen. So the term protein has come to be applied to any nitrogenous substance, whether animal or vegetable.**

As far as we are at present able to determine, the proteids of the body are built up only by the animal assimilating the nitrogenous proteids already existing in the plant tissues which are consumed in its daily ration. Unlike plants, the animal cannot manufacture its own protein for flesh or milk forming. All it can do is to modify the plant protein and utilize it to form its body tissues, milk solids, and egg albumen. This is why, from the view point of the feeder, protein is such an essential part of corn or any other plant. Besides the part it plays in building up the tissues, protein has a stimulative effect upon the animal functions. It has been found by the Geneva, New York, Experiment Station that protein may be manufactured by the animal into body fat. It may also be used to supply heat and energy to the animal.

Carbohydrates and Fat.*** All plants contain fat chiefly in the form of vegetable oils. The oils of the corn germ, of linseed, of cotton seed, and the olive, occur in such quantities that they are pressed out or extracted and have a cremical value greater than they would have as feeds for our domestic animals. All plants contain starch (the corn kernel may sometimes contain as high as 70 per cent) ****sugars and vegetable gums. The starches, sugars, and gums are called carbohydrates. The carbohydrates, through a process of oxidation very similar to burning of wood in an engine or stove, supply the energy that the animal requires to masticate, digest, and as-

*About 16 per cent of most protein substances has been found to consist of nitrogen. In determining the amount of protein present in corn or other grain the amount of nitrogen it contains is firse obtained, then by multiplying the amount of nitrogen present in the feed by 100-16, or 6 1-4, we obtain an estimate of the protein present.

**Thus lean meat freed of fat and connective tissue is protein. The white albumen of egg is protein; so is the gluten of wheat flour. The protein of corn found principally in the germ and horny gluten, as well as in smaller amounts in the stalk and other portions of the plant. It supplies the flesh forming materials and repairs the wastes of the animal body. It is also one of the indispensable factors in milk production. It is from this substance that the cow makes the casein and albumens for her milk and that the hen manufactures the white albumen for her eggs.

***In determining the percentage of fat, anhydrous ether is used to extract this substance from the water-free plant tissues. Ether dissolves small amounts of vegetable gums and similar substances other than fats; so in the tables of analyses, fats, gums, etc. are classed as "ether extract." In calculations, however, the figures in the columns under "ether extract" may be used as indicating the percentages of fat. In the tables that follow the soluble carbohydrates are found under the heading of "nitrogen free extract." In the analysis of a grain or fodder the nitrogen free extract is determined by difference. That is, in a weighed sample of a grain or fodder the percentage of all of the other constituents, water, ash, protein, fat, and crude fiber, are first determined and the sum of these subtracted from 100. The difference is called nitrogen free extract or in some tables, carbohydrates.

****This starch which is also found largely in the fodder is not affected greatly by cold water, therefore little of it is carried off by leaching.

similate its food; to transform the crude food products into milk products or eggs; or, as in the horse to do its daily work. They also furnish heat to the body. After these maintenance requirements are fulfilled whatever food elements are left are stored away in various parts of the body in the form of animal fat for further use.

Chief food substances

Then when food supplies are insufficient, the animal draws upon its body fat for material out of which to manufacture milk, or for fuel to keep its body warm. The fats or oils of grains and fodders act in the body in very much the same way as do the carbohydrates, but they produce a greater amount of heat and energy. Fat has about 2.4 times as much heat and energy producing power as have the carbohydrates. For this reason, fats rank next in importance after protein as an essential part of an animal's ration. Protein, the fats, and the carbohydrates, are the three important food materials, but since the fats meet the same fate in the body as do the carbo hydrates, there are really only two chief substances, (1) the flesh formers (protein); and (2) the heat and energy formers (carbohydrates and fats). The part that each of these three constituents plays in the animal economy, is indicated in the following diagram:

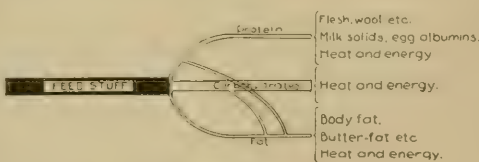


Fig. 320

*Diagram showing the uses to which feed stuffs are put in the animal body.

Crude Fiber. The cells and frame work of growing plants as well as the covering of seeds and grains are made up of more or less woody fiber called "cellulose." Cellulose is chemically similar to the starches and therefore might properly be termed a carbohydrate, but as the greater portion of it is practically indigestible, this indigestible or insoluble portion is classed by itself as "crude fiber." While yielding very little matter nutritious to the feeding animal, crude fiber has an important mechanical effect on the digestion of food.

Crude fiber gives bulk

It is the crude fiber in the feed that gives bulk to the contents of the paunch, and unless a cow or steer receives sufficient "roughage" with its ration it cannot ruminate. There is no foundation for the

*An original diagram, designed by Prof. L. G. Michael of the Iowa Experiment Station.

cud, and the food escapes that thorough chewing that is so essential to the complete digestion of the carbohydrates. This is the reason why it is advisable to feed chaffed hay or shredded corn stalks with grain to ruminants.

After mastication the crude fiber gives mass to the digesting substances in the stomach and bowels, rendering them porous and making it easy for the digestive fluids to find their way to the valuable food ingredients. After the digestive fluids have extracted all or most of the nutritious portions of the feed the crude fiber continues to keep the waste material in the lower bowels loose and bulky. The bowels are thus better able to grip and pass on the mass to final excretion. In this way crude fiber has a tendency to prevent impaction or constipation.

INORGANIC COMPOUNDS.—Ash. All feeds when burned leave an ash. The ash is valuable as a food inasmuch as it furnishes the materials that form the bones of the animal, especially a young growing animal, and that form the minerals for the blood, tissues and milk solids. Corn meal may contain as low as 1 per cent of ash while corn fodder may run as high as 3 or 4 per cent in these materials. These ash compounds have never been given sufficient consideration from the standpoint of their value in animal growth. As we have seen, the corn grain is noticeably lacking in mineral matter which makes up almost three-fourths of the bones of animals. In practice the hogs of Iowa and Illinois which have been fed an excess of corn through their growing period show a small frame and under size, although showing evidence of refinement and quality. The shoats of western Nebraska are rugged and growthy, showing when young, scale and roughness of frame due to running on alfalfa pasture which furnishes a large amount of mineral matter.

Corn is lacking in ash

As students of corn it should be observed that the ash is chiefly found in the part of the plant which is usually lost on the farms in the corn belt. In other words, the corn fodder, which is quite rich in mineral matter, remains in the field and the grain which is so deficient in inorganic elements is fed heavily. Corn is the one food which, while so heavily grown and fed in the greatest live stock area of the United States, is lacking in ash.

Corn stalks contain most of the ash

Water. The corn stalk may be apparently very dry, but if some loosely broken leaves are placed in a tumbler or drinking glass and the glass inverted on a dinner plate and set in the sunlight, drops of water will soon be seen to collect on the inner surface of the glass. All grains and feeds contain water no matter how dry they may seem.

Although apparently dry corn contains some moisture

The amount of water present depends upon the kind of feed and the conditions to which it has been exposed; for hay, fodders and grains are constanly taking up and giving off water according to atmospheric changes."*

Pasture grasses contain from 62 to 80 per cent of water; while roots, like mangles, beets, and carrots may contain 87 to 90 per cent; and hay and grains from 8 to 15 per cent. As the percentages of all the other ingredients decrease proportionately as the water content increases, this is an important factor to consider in the tabulated analyses of feeds.

Water, when organic, that is, a normal constituent of the feed itself, as in beets or silage, has a direct effect on the animal functions; especially is this true of the dairy cow. Within certain limits the more water a cow can be induced to take into her body, the more milk she will produce without affecting the quality. In this respect organic water, as in silage or roots, is most efficacious.

Water has several uses in the animal economy. It aids the digestive organs in dissolving the more concentrated portions of the feed and has the beneficial physiological effect of keeping the bowel contents free and loose. This is the reason why green fodder, used as a soiling crop, in fall after the pastures are dry, and ensilage, fed during the winter, are such valuable adjuncts to a corn and hay ration.

THE FEEDING VALUE OF CORN

The value of any feed depends upon, first, its percentage composition of digestible and desirable nutrients, together with the proportions of these components; second, its palatability and ease of mastication, and third, its cost of production and preparation for feeding.

PERCENTAGE COMPOSITION.

(Table showing in percent the chemical composition of corn in different forms.)

	Water	Ash	Protein	Crude Fibre	Nitrogen free extract	Fat
Dent Varieties	10.56	1.53	10.25	2.24	70.40	5.02
Corn Meal	14.98	1.42	9.17	1.90	68.76	3.77
Corn Cob	10.70	1.40	2.40	30.10	54.90	.50
Corn and Cob Meal	15.08	1.46	8.45	6.62	64.86	3.53
Corn Fodder	42.20	2.70	4.50	14.30	34.70	1.60

A study of this table shows corn to be very high in percentage of nitrogen-free extract. When it is considered that 70 per cent of the corn kernel is starch, the fact that corn is so heat-forming in working animals is not strange. The 5.02 per cent of oil is very

*For example, grains raised in California are sold by weight, and when loaded on ships are in a very dry condition. In their voyage across the Pacific they absorb water from the atmosphere and in this way often increase sufficiently in weight to pay the freight.

high, compared with other grains. This, together with the starch, is a rich source of fat in the animal body. The 10.25 per cent of protein is not so low in comparison with the other cereals, if it were not for the fact that the percentage of starch and fat is so high. The corn kernel is not coarse in cellular structure, as shown by the small amount of crude fiber. Corn is comparatively dry, considering the openness of its starchy cells, which tend to hold hydroscopic moisture.

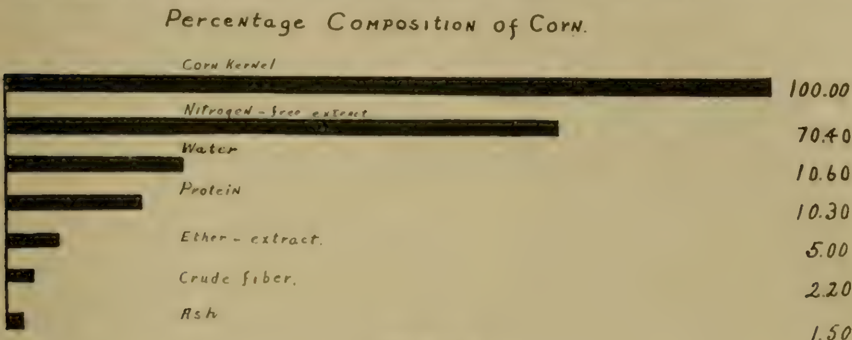


Fig. 132.

The mineral matter in corn is seriously lacking, due largely, no doubt, to its quick growth and starchy structure. The plant draws chiefly from the organic rather than the inorganic material in the soil.

DIGESTIBILITY.

The student who is just beginning to find out the chemical composition of corn is liable to overlook a second step in the study of the percentages. From experiments, the amounts of digestible nutrients have been found to be present in corn in its different forms.

Form of Corn	Dry Matter in 100 Lbs	Digestible Nutrients in 100 Pounds		
		Protein	Carbohydrates	Ether Extract
Corn Dent	89.40	7.80	66.70	4.30
Corn Meal	85.00	6.26	65.26	3.50
Corn Cob	89.30	.40	52.50	.30
Corn and Cob Meal	84.90	4.40	60.00	2.90
Corn Fodder	57.80	2.50	34.60	1.20

Comparing this table with the figures giving the total percentage composition, it will be seen that the protein is 76 per cent digestible, the carbohydrates (headed "nitrogen-free extract" in previous table) 94.7 and the ether extract 84.8. These percentages are significant. The fact that corn is so largely utilized by the animal makes it an economical food. Its constituents are in such physical and chemical combination as to be easily disintegrated, dissolved, acted upon by the digestive juices, and assimilated.

PALATABILITY AND MASTICATION. Except when dry and flinty from long storage, shelled corn is easily masticated. The starchy cellular structure breaks up irregularly and abruptly, there being no **Easily masticated**

formation of a glutenous and pasty mass. The starch of corn readily changes to sugar in the process of mastication, which renders it very palatable. Western stock which has never been fed corn, in a short time acquires a taste for it when put on feed in the corn belt.

COST OF PRODUCTION AND PREPARATION FOR FEEDING. As will be shown later, the number of pounds of corn required to produce 100 pounds of pork or beef is not much lower than in the case of other cereals. 1100 pounds of corn, the amount required to produce 100 pounds of beef, at 45 cents per bushel of 56 pounds, would be worth $8.03. The same amount of wheat meal would also be required to produce 100 pounds of beef, and would be worth $11 if figured on the basis of 60 cents per bushel of 60 pounds. This is not considering the cost of grinding the wheat.

Within the last year the price of corn has been so high as to nullistuffs of like chemical content. However, the cost of preparation is less.

Averages of results from several stations

CORN VS. OTHER CEREALS. The following table shows the number of pounds of corn in different forms required to produce 100 pounds gain in farm animals. The averages were made from reports of the stations of several states.

AMOUNT OF CORN REQUIRED TO PRODUCE 100 POUNDS GAIN.

Feed	Pork	Beef	Mutton
Ear Corn		1,410**	
Shelled Corn	534.4	1,100**	508*
Corn Meal	469.0	1,051.5**	
Corn and Cob Meal............	581.3	996**	

*Fed with hay to lambs.
**Roughage used also.

AMOUNTS OF OTHER FEEDS.

Wheat Meal	463	1,100	553*
Middlings	522		
Barley Meal	471		
Oats			518**
Oil Meal		732	

*Fed with hay.
**Fed with hay and roots.

No marked difference is noticed between the amounts of corn and those of other feeds required to produce gain. The economic importance lies in the comparative cost and palatability of the concentrates.

CORN AS A FEED FOR HORSES. Corn is very desirable feed for horses because it requires little time for mastication. A horse spends little time in chewing and when hard at work should not be required to expend a large amount of energy in preparing its food. As a horse chews its food but once, the starches in it must be readily changed into sugar. This characteristic is especially true of corn. There is no formation of a pasty mass so obnoxious to a horse. The stomach of a horse is of limited capacity, hence the food should be quite concentrated. This requirement is fulfilled by corn.

However, a work horse requires a narrow nutritive ration. The nutritive ratio of shelled corn is 1:9.7, which means that for every pound of digestible protein which is fed, there accompanies it 9.7 pounds of digestible carbohydrates. This is spoken of as a medium ratio. According to the Wolff-Lehmann feeding standards, the horse at medium work requires a nutritive ration of 1:6.2, which is much narrower than that supplied by corn. In other words, there is too much carbohydrates and fat for the amount of protein present. A larger percentage of protein is necessary to balance the heat-forming constituents. Draft horses sweat profusely and appear "logy" when fed corn too heavily during the working season. In winter, corn is bound to form a large part of the farm horse ration because of its abundance in the corn belt.

Nutritive ratio of shelled corn 19.7

Next to oats, bran is the best mixture with corn. It separates the particles of corn so that the juices can get at them. At times in winter, the whole grain feed may be made up of corn, and it may even supply three-fourths of the ration in summer.

CORN AS A FEED FOR HOGS. In arranging a ration for hogs it should be kept in mind that this animal has a very limited digestive capacity and therefore cannot consume a large quantity of bulky food. The purpose for which the ration is fed, whether for fattening, growing, or to the mother when carrying her suckling young, is also an important consideration.

For the Sow. Corn being so high in carbohydrates and fat, tends to produce an excess of internal fat in a brood sow before farrowing. After farrowing and during the suckling of the pigs, corn can be used in supplying the carbonaceous part of the ration. But it must be remembered that corn has a constipatory effect upon the sow, which is contrary to practical feeding. An addition of oil meal or grass will be necessary to produce laxativeness.

Corn produces too much fat for the sow

For the Growing Pig. The type of fat hog in the Mississippi Valley has been molded during the first months of the life of the pigs

LIGHT, ,MEDIUM, AND HEAVY GRAIN RATION FOR PIGS.

	Lot 1 No Grain Pounds	Lot 2 Light Grain Ration Pounds	Lot 3 Medium Grain Ration Pounds	Lot 4 Heavy Grain Ration Pounds
Average weight, each pig, August 27........	74.00	73.50	73.50	72.50
Average weight, each pig, October 27.......	75.40	95.20	113.30	126.20
Average gain from August 27 to October 27..	1.40	21.70	39.80	53.70
Daily gain per pig........................	.02	.34	.63	.85
Average amount of corn consumed by each pig per day		1.33	2.48	3.46
Corn consumed per pound of gain...........		3.86	3.98	4.23
Cost of corn per 100 pounds of gain..........		2.08	2.15	2.28
Cost of pasture per 100 lbs. of gain, $14.30...		.66	.30	15
Total cost per 100 pounds of gain, $14.30...		2.74	2.45	2.43

grown by the use of corn. For the young pig, corn lacks two essential constituents, protein or muscle-forming, and ash or bone-forming. The stunted, stubby, early maturing hog is the result of early forcing with corn. Formerly, only corn was used. The pasture grass made a splendid supplement. Then concentrates high in protein were fed with corn. With the introduction of alfalfa, greater gains and more general and profitable use of corn will come about.

Add a high protein food to corn

Fattening Hogs. A fattening hog requires for maximum gains 1 pound of protein to 6.5 pounds of carbonaceous constituents. As corn alone has an excess of the latter, so much digestible matter is lost for want of a balance of some other feed high in protein. In Missouri, oil meal has given the best results when fed with corn.

As a rule, a saving of one-third is made by adding 20 to 30 per cent of some high protein food to a corn ration.

The following figures taken from Bulletin No. 91 of the Iowa Station, show the relative value of corn alone as compared with corn and supplemental foods:

FEED	Total Feed Per 100 Pounds Gain	Cost Per 100 Pounds Gain	Daily Gain Pounds	Profit Per Bushel Grain Feed
Corn alone	463.5	3.56	1.88	.57
Corn 9, Meat Meal 1......	370.3	3.21	2.865	.70
Corn 9, Tankage 1.........	398.7	3.41	2.341	.65

The corn alone to these hogs in dry lot, give smaller daily gains and less profit per bushel of corn fed. The supplemental feeds, although having to be bought, brought in larger returns for the amount of corn fed.

Corn ration is too wide for sheep

CORN FOR SHEEP. The finishing of mutton has in the past been confined to certain districts of the West and North, as a specialized industry. However, the recent high prices of lambs upon the markets have opened the way for feeders in the corn belt to try their hand. As a result, the farm yards of Iowa and eastern Nebraska have seen more sheep than ever before. The one feed is corn. As fattening sheep require a very narrow ration, about 1 to 5, a hay high in protein must be fed in order to produce heavy gains. The corn is usually shelled before feeding, although the lambs are usually started on broken ears.

Lambs in corn field

As a cheap way of finishing, many lambs have been run in corn fields, beginning as early as September 15th. The weeds and lower leaves are first cleared up, but finally a taste for corn is acquired and soon they are on full feed. Rape sown in the corn at the rate of 5 to

10 pounds per acre, at the last cultivation, produces, if the stand of corn is thin, a large amount of succulent feed for early fall grazing. Very little grain is wasted by this method and the manure is left in the field.

Corn, as a part of the ration of breeding ewes, should be omitted. If any one feed has kept the English mutton breed out of Iowa and Missouri, up to this time, it is corn. Until it is either supplemented or else replaced entirely, a healthy lamb drop cannot be expected. The corn ration of 1:9.7 is too wide compared with 1:5.6, which has proved the best.

Not advisable for the breeding flock

FOR MILCH COWS. As a grain, corn lacks both the protein and ash which are so essential to milk production. The nutritive ration for heavy producing cows is 1:4.5, which is about one-half as wide as corn itself. No doubt the extensive feeding of corn on the farms in the corn belt accounts in a measure for the low milk production per cow in that district. The cow requires her carbonaceous constituents in the form of bulk or roughage and the protein in concentrates.

Lacks protein and ash for cows in milk

The usual farm rations of corn and corn fodder (1:15), or of timothy and corn (1:12) are entirely too wide. With the use of alfalfa, however, a ratio somewhere near the proper amount of protein is secured.

FOR YOUNG CATTLE. As corn will necessarily have to be largely used in the corn belt for winter beef calves and yearlings, which are intended for finishing when older, two rations taken from *Smith are given, figured on a basis of 500-pound calf.

	Dry Matter	Protein	Carbo-hydrates	Fat	Nutritive Ratio
Red clover, 12 pounds...	10.1	.82	4.29	.20	
Corn, 3 pounds..........	2.6	.24	2.00	.13	
Total	12.7	1.06	6.29	.33	1:6.6
Alfalfa, 7 pounds	6.4	.77	2.77	.09	
Corn stover, 6 pounds....	3.6	.10	1.94	.04	
Corn, 3 pounds	2.6	.24	2.00	.13	
Total	12.6	1.11	6.71	.26	1:6.6

Too often calves are stunted on a ration of corn and highly carbonaceous roughage. However, corn being economical, the thing to do is to balance it as well as possible with some home-grown roughage.

Corn alone stunts calves

As a rule, when feeding on pastures of short rotation, there is sufficient clover present to warrant the feeding of corn alone as a grain

*Profitable Stock Feeding by H. R. Smith, Page 160.

ration. Smith* had this to say in regard to supplemental feeds with corn for cattle on grass: "During a summer period of 30 weeks five two-year-old Angus steers were fed an average of 17.8 pounds of shelled corn each per day, making an average daily gain of 1.63 pounds. Another lot of five steers of the same kind were each fed 17.8 pounds of grain per day, consisting of 90 per cent shelled corn and 10 per cent of oil meal. These steers made an average gain of 2.02 pounds per day during the same time. The pasture was alike in both lots. Those fed corn and oil meal required but 8.8 pounds of grain for one pound of increase in weight, while those fed corn alone required 10.9 pounds. With pasture worth $3 per acre, corn worth at that time 33 cents per bushel, and oil meal $25 per ton, each 100 pounds of gain on corn alone cost 13 per cent more than on corn and oil meal. In this experiment, if the oil meal had cost $44 per ton, instead of $25, nothing would have been saved by feeding it."

(Courtesy A. E. Cook, Brookmont Farms.)
Fig. 133.

CATTLE IN AN IOWA FEED LOT

steer requires something like 6 pounds of digestible carbonaceous food to 1 of protein. Here again, corn alone or corn and corn fod-food to one of protein. Here again, corn alone or corn and corn fodder or timothy hay, are entirely too low in protein. One-third of the value of the digestible constituents is lost from lack of balancing with some concentrate high in protein or some roughage similarly constituted. At Nebraska alfalfa and corn gave 14 per cent larger gains than prairie hay and corn, and 10 per cent more than prairie hay, corn, and oil meal.** In tests at the Iowa Station corn and wheat straw produced gains for $10.71 per 100 pounds; corn and grass for

*Profitable Stock Feeding by H. R. Smith. Page 167.
**Iowa Bulletin No. 66.

$10.20; corn, gluten meal, and wheat straw for $9.34; corn, oil meal, and wheat straw for $11.02.

PREPARING CORN FOR STOCK.—Corn Meal. The grinding of corn would theoretically increase its digestibility and therefore enhance its feeding value. This is due to the greater accessibility of the digestive juices to the finer particles of the ground corn, and to the more complete mixing of the meal with the other feeds eaten, especially roughage.

Grinding increases digestibility

A summary of tests at the Kentucky, Missouri, and Ohio Stations, places the saving of corn due to grinding at 7 per cent. Wisconsin proved a saving of 8 per cent. It is something of a question whether even such a saving warrants grinding for hogs.

Although a saving of 8 per cent in the amount of corn fed was made at the Kansas Station in producing beef, Smith* concludes that this is insufficient to pay for the cost of grinding and the labor attached thereto.

INFLUENCE UPON DIGESTIBILITY OF FEEDING MATERIALS, WHOLE OR GROUND.

Feed	Number of Animals	Dry Matter	Digestion Coefficients		
			Protein	Nitrogen-free Extract	Fat
Corn Meal	2 horses	88.4	75.6	95.7	73.1
Whole Corn	2 horses	74.4	57.8	88.2	47.7
Difference		14.4	17.8	7.5	25.4

These figures show a slight increase in percentage of digestibility due to grinding.

Corn and Cob Meal vs. Ear Corn for Hogs. From results at the New Hampshire Station**, it was concluded that ground corn and cob meal had a slightly better feeding value in increasing the daily gain of hogs, but for practical purposes it is more economical to feed corn on the ear rather than hauling to the mill and grinding for feed. In any event, corn and cob meal is rather bulky.

THE FEEDING VALUE OF THE BY-PRODUCTS OF CORN

Supplemental foods high in protein are often used quite largely in the production of milk and pork. The by-products of corn are increasing in amount each year because of the demand for manufactured foods made from corn. These by-products are not as palatable as might be supposed considering the palatability of corn itself.

By-products not very palatable

*Profitable Cattle Feeding, H. R. Smith, Page 188.
**New Hampshire Bulletin 66.

In any case the choice of protein foods depends upon their real efficiency at the current market price. This efficiency depends upon their total protein content together with its digestibility. Palatability is a minor factor because such small amounts are fed.

COMPOSITION OF THE BY-PRODUCTS OF CORN AS FOOD FOR STOCK.*

Feeding Stuff	Water	Ash	Protein	Crude Fiber	Nitrogen-Free Extract	Ether Extract
Corn Bran	9.1	1.3	9.0	12.7	62.2	5.8
Corn Germ	10.7	4.0	9.8	4.1	64.0	7.4
Hominy Chops	11.1	2.5	9.8	3.8	64.5	8.3
Germ Meal	8.1	1.3	11.1	9.9	62.5	7.1
Dried Starch and Sugar Feed	10.9	.9	19.7	4.7	54.8	9.0
Starch Feed (wet)	65.4	.3	6.1	3.1	22.0	3.1
Grano-Gluten	5.8	2.8	31.1	12.0	33.4	14.9
Cream Gluten	8.1	.7	36.1	1.3	39.0	14.8
Gluten Feed	7.8	1.1	24.0	5.3	51.2	10.6
Gluten Meal	8.2	0.9	29.3	3.3	46.5	11.8
New Corn Product	9.22	4.0	6.38	28.70	48.70	2.84

Gluten Meal. Gluten meal as a pure product is now little known on the market. Consisting largely of gluten it is very rich in protein, reaching almost 30 per cent. Having very little foundation of indigestible material, care must be exercised in its feeding.

Rich in protein

The following table taken from Bulletin No. 156 of Virginia, shows the comparative value of gluten meal and cottonseed meal for milk production:

	Feed	
	Gluton Meal	Cotton Seed Meal
Cost per ton	$28.40	$27.00
Percent of Protein	36.25	37.81
Coefficient of Digestion	89.00	88.00
Percent Digestible Protein	32.26	33.27
Protein on Unit Basis (Equivalent)	103.00	100.00
Cost per 100 lbs. of Digestible Protein	$4.40	$4.05

The authors conclude that the two feeds have nearly the same value in milk production.

Based upon the comparative percentage of digestible protein and assuming clover to be worth $5 per ton, Smith** quotes alfalfa at $8; cow pea hay at $8; wheat shorts at $9; wheat bran at $9; Canadian peas at $12.50; cow peas at $13.60; skim milk at $2.10; soy beans at $21.70; oil meal (old process) at $21.50; gluten meal at $19. When the fats and carbohydrates are taken into consideration, assuming clover to be worth $5 per ton, gluten meal is worth $23 a ton.

*All taken from Appendix of Henry's Feeds and Feeding except the last, which is from No. 43 Maryland Bulletin.

**Profitable Stock Feeding by H. R. Smith, Page 299.

Corn Bran. Corn bran differs from wheat bran in containing more crude fiber and less protein. As a pure product when first put out it found but little sale. The hulls, even when ground finely, have very little flavor and are not palatable.

(Courtesy Lowden Mfg. Co.) Fig. 134.

FEED CARRIER IN THE ALLEY OF A COW BARN.

Gluten Feed. In order to dispose of the corn bran and to lighten the gluten meal, the two are now mixed and a product known as gluten feed put on the market. By a close study of the foregoing table, it will be noted that the content of protein is lowered about 5 per cent, while the percentage of crude fiber and ash is increased. This change widens the nutritive ration.

According to tests made at the New Jersey Station*, 100 pounds of milk were produced for 86.40 cents with gluten feed, when fed in conjunction with wheat bran, cottonseed meal, corn silage, and corn stalks.

Corn Oil Meal.—Corn Oil Cake. The residue remaining after all but about 10 per cent of the oil has been extracted, is known in the slab form as it comes from the press as "corn oil cake,"

*Bulletin No. 204, New Jersey.

as differentiated from "oil cake," the slabs from linseed oil factories. The English and Scotch live stock breeders use this cake in large amounts, because they are reasonably sure it has not been adulterated. The ground form, "germ oil meal," recognized as different from "oil meal" or "linseed meal," is used mostly east of the Mississippi river. This product is very uniform in composition and contains a large amount of ash.

Starch Feeds. Often with smaller glucose factories located in districts where considerable feeding is carried on, the by-products are sold collectively under the head of "Starch Feeds." Sometimes they are taken from the factory in the wet condition. They are in such case known as "wet starch feeds" or "wet glucose feed" and are variable in percentage of digestible nutrients. When dried they may be mixed with other feeds.

Hominy Chops. The hull, germ, and the starchy refuse from the hominy factory, are sold collectively under the term "hominy chops." Because of a uniformity in the composition of this feed it is very popular on the market. This fact is evident from tests at Geneva, New York.* The average of 7 samples showed 10.6 per cent protein and 46 per cent starch and sugar. However, when the screenings and pieces of cob are returned to this feed, the percentage of crude fiber may run as high as 7 per cent.

Hominy chops 10.6 per cent protein

Distillers Grains. In tests at the New Jersey Station** the average of 2 samples of corn distiller's grains showed 5.79 per cent water, 33.34 per cent protein, 12.05 per cent fat, and 11.17 per cent crude fiber. These were in the dried commercial form. As fed at the distillery the solid material is not separated from the slop. In this form the percentage of water runs as high as 94 per cent, with only 1.90 per cent protein and .9 per cent fat.

The New Corn Product. Investigations by the*** Maryland Experiment Station shows that this corn stalk product is much more valuable than the original stalk containing the pith. Not only does it contain more absolute nutriment, but the nutriment contained is more digestible.

The following tabulated data from the Maryland Station shows the relative feeding values of the new corn product, shredded corn fodder, timothy hay, wheat bran, corn blades, and shucks. These different feeds were fed to well bred steers and all excrement and urine carefully collected for a period of seven days.

*Bulletin No. 166, New York (Geneva).
**Bulletin 193, New Jersey.
***Bulletin 43, Maryland.

POUNDS OF DIGESTIBLE MATTER IN 100 POUNDS.

	Dry Substance	Ash	Protein	Crude Fiber	Nitrogen Free Extract	Fat	Nutritive Ration
New Corn Product	57.6	1.9	3.8	17.3	32.2	2.4	1:14.4
Corn Blades and Shucks	58.8	1.5	3.1	21.8	30.3	1.3	1:17.7
Shredded Corn Fodder.	46.8	1.3	1.6	19.0	23.2	1.7	1:28.7
Timothy	54.6	1.9	3.2	16.6	30.0	2.9	1:16.6
Wheat Bran	58.6	2.4	14.6	2.4	35.9	3.3	1:3.1

ACKNOWLEDGMENTS. We wish to express our appreciation of the valuable information secured from the works of Henry and Jordan. Professor H. R. Smith's "Profitable Stock Feeding" has been a source of many very practical points, applying especially to western conditions.

COLLATERAL READING:

Report on Chemical Composition of Certain Varieties of Indian Corn,
Ottawa Bulletin No. 12.

Composition of Maize,
U. S. Department Bulletin No. 50.

Feeding Cotton Seed, Cottonseed Meal and Corn to Dairy Cows,
Mississippi Bulletin No. 60.

Corn Plant, Feeding Value of,
Farmers' Bulletin No. 97.

Grinding Corn for Cows,
Farmers' Bulletin No. 107.

Soft Corn,
Farmers Bulletin No. 210.

Important Facts About Corn,
Maine Bulletin No. 17.

Corn, Barley and Speltz, Relative Feeding Value of,
South Dakota Bulletin No. 81.

Corn and Corn Meal, Relative Value of (for feeding hogs),
Wisconsin Bulletin No. 45.

Structure of Corn Kernel and Composition of its Parts,
Illinois Bulletin No. 87.

CHAPTER XVI.

CORN FODDER

When the entire corn plant is cut, allowed to cure by standing in shocks, and fed without removing the ears, the name "corn fodder" is applied. If the ears are husked from the fodder, "corn stover" remains. "Fodder corn" refers to corn which has been planted in any manner with the intention of securing rather small ears and stalks for fodder purposes only.

Great loss by leaving stalks unused

Iowa planted 9,450,000 acres to corn in 1906. The average yield was 39.5 bushels. If each acre produced three tons of corn fodder, 3,235 pounds of stover per acre were lost by husking the 39.5 bushels and leaving the stalks, leaves and husks in the field.

May be planted thicker

MANNER OF PLANTING. Thick planting tends to reduce the size of the ears and stalk. The entire plant is less woody. Nevertheless, in too close planting the plant often becomes stunted in growth, the leaves become yellow and lifeless, and the fodder obtained therefrom is tasteless and less nutritious. Numerous nubbins are desirable. Checking 4 to 5 kernels to the hill on land inclined to be foul, or drilling 6 to 10 inches apart on clean land, will give satisfactory returns in most parts of the central states.

DRILLING VS. HILL PLANTING.

Average Yields for Four Years at Ohio Station.

Distribution of Seed	1894 Bu.	1895 Bu.	1896 Bu.	1897 Bu.	4 yrs. gain	Av Lbs. Stover	Ears & Nubs % Ears	% Nubs
1 kl. every 12 in...	14.21	52.97	43.45	33.28	33.28	2,528	68	32
1 kl. " 18 in...	39.12	40.45	30.30		36.62	2,229	77	23
2 kls. " 24 in...	41.19	54.94	42.72	32.72	43.14	2,433	64	37
3 kls. " 36 in...	39.60	45.01	42.39	31.76	39.69	2,169	62	36
4 kls. " 42 in...	38.83	48.35	41.68	29.84	39.56	2,250	56	44
4 kls. " 48 in...	39.90	50.46	38.19		42.85	2,180	63	37

Another experiment of planting various numbers of kernels per hill gave the following results:

Kernels Per Hill.	Yield, Bushels.
1	47.6
1½	60.6

2	67.0
2½	77.5
3	79.0
3½	77.7
4	80.0
4½	87.0
5	88.0

Experiments repeated three times with Legal Tender, Reid's Yellow Dent, and home-grown seed, conducted by Mr. Fred McCulloch, of Hartwick, Iowa, gave the following results:

Kernels Per Hill.	Yield Per Acre, Bushels.
2	40.0
3	47.5
3½	56.0
4	56.0

One experiment by Mr. McCulloch showing yield of grain and stover:

Kernels Per Hill.	Yield. Grain, Bushels.	Stover, Pounds.
1	28.17	1,620
2	44.69	2,480
3	54.53	3,168
4	57.6	3,616

VARIETIES. Heavy leafing varieties and those which have a tendency to excessive tillering produce more fodder than those varieties which have long been selected for grain production only. Varieties adapted to a given locality furnish the surest returns, although the southern rank growing kinds produce a great deal of coarse forage.

Some varieties will produce more fodder

TIME OF HARVESTING. An Iowa Test. Bulletin No. 23 of the Iowa Experiment Station gives the results of an investigation to determine the best time to cut corn fodder. The following conclusions were reached:

1. The stover of a crop of corn seems to reach the highest yield and the best condition for feeding at the stage of growth indicated by a well-dented kernel and the first drying of the blades.

2. The grain of a crop of corn seems to reach the highest yield and the best condition for utility at the stage of growth indicated by a well-ripened ear and a half-dried blade, and the best time for securing the crop with reference to the highest utility of both corn and stover would be found at a stage of ripening between the above.

Great loss by leaving stover out in field

3. The loss resulting from stover remaining in the field under ordinary stalk-field conditions two months after ripening, amounts to about one-half of the dry matter and more than one-half of the total feeding value.

4. After the stover has reached the best condition for cutting, there is a rapid decline in both yield and feeding value.

5. There is but little change in the composition of the grain of a corn crop in the several stages of ripening; and there is little, if any decline in either yield or feeding value after the best condition is reached, nor does there seem to be much gain, except a small increase in yield after the denting stage of the ears is reached.

6. No material change occurs in the composition of the corn cobs during the several stages of ripening.

Yield in stover

The experiments from which these conclusions were arrived at were with five plats of one-fifth of an acre each, of good, well-grown field corn, put in shock at intervals of one week, commencing on September 17th and ending October 15th. In addition a plat of equal area was left in the field until December 17th, when the stalks were cut as in shocking and weighed and sampled for analysis. Of stover, plat No. 1, in earliest cut, yielded 2 tons per acre; the second plat, 2.12 tons per acre; the third and fourth plats each, 2.2 tons per acre; the fifth plat, 1.77 tons per acre, and the last plat, which was left standing until December 17th, 1.2 tons per acre.

Yield in corn

As to the grain, plat No. 1 yielded 53.6 bushels of ear corn per acre; plat No. 2, cut a week later, 57.9 bushels; plat No. 3, 63.6 bushels; plat No. 4, 64.3 bushels; plat No. 5, 60.3 bushels. (The yield from the plat that was left until December 17th is, for some reason, not given.)

Increase in Nutrients During the Stages of Maturity.

The following table gives the relative amount of water and dry matter in the corn crop at different stages of maturity and shows the loss accompanying the cutting of fodder when too green. The experiment was conducted by Todd, of New York (Geneva) Station.

TOTAL YIELD AND AMOUNT OF WATER AND NUTRIENTS IN AN ACRE OF CORN.

	July 30th In Tassel	August 9th In Silk	August 21st Milk Stage	Sept. 7th Kernels Glazed	Sept. 23d Fully Ripe
Total Green Crop.	18,045	25,745	32,600	32,295	28,460
Water	61,426	22,666	27,957	25,093	20,542
Dry Matter	1,619	3,078	4,643	7,202	7,918
Albuminoids	239.8	436.8	478.7	643.9	677.8
Crude Fiber	514.2	872.9	1,262.0	1,755.9	1,734.0
Nitrogen-Free Extract	653.9	1,399.3	2,441.3	4,239.8	4,827.6
Ether Extract	72.2	167.8	228.9	260.0	314.3
Ash	138.9	201.3	232.2	302.5	364.2

The following table further shows an increase in dry matter as maturity advances:

Milk	Glazed	Ripe	Increase in
August 21st,	September 7th,	September 23d,	Dry Matter.
4,643 pounds,	7,202 pounds,	7,918 pounds,	3,275 pounds.

Not only is there an increase in total dry matter as period of maturity advances, but the digestible materials, especially protein and carbohydrates, are deposited in larger percentages, as shown by the following tables:

ALBUMINOID AND AMIDE NITROGEN OF THE MATURING CORN CROP.
New York (Geneva) Station.

Date	Stage of Maturity	Albuminous Nitrogen	Amide Nitrogen	Total Nitrogen
July 30th,	Tasseled,	27.4	11.0	38.4
August 6th,	Silked,	44.6	25.2	69.9
August 21st,	Kernels in Milk,	66.4	17.3	77.6
September 7th,	Corn glazed,	78.5	24.5	103.0
September 23d,	Corn ripe,	91.1	17.4	108.5

This table shows that there is a steady increase in the albuminoid nitrogen, in digestible form, while the amide nitrogen fluctuated at the different periods, but was less at time of ripening than at earlier dates.

INCREASE OF CARBOHYDRATES IN RIPENING CORN.
New York (Geneva) Station.

Date	Stage of Maturity	Glucose	Sucrose	Starch
July 30th,	Tasseled,	58.3	9.1	122.2
August 6th,	Silked,	300.4	110.8	491.3
August 21st,	In milk,	665.0	129.0	706.7
September 7th,	Glazed,	720.2	95.1	1,735.0
September 23d,	Ripe,	538.4	148.9	2,852.9

Of these changes, Todd writes:

"The total starch per acre increased more than twenty-three times between tasseling and harvesting, a period of 55 days. From the stage of glazing corn until full ripening, the increase in dry matter was 716 pounds, the increase in nitrogen-free extract, 587 pounds, while the increase of sugar and starch was 989 pounds, or greater by 273 pounds than the entire gain in crop. That is, much of the nitrogen-free extract, which, at period of glazing of corn, was in the transitory state, had been translocated and transformed into sugars and starch."

Jordan studying this same subject states:

"Owing to the relatively large production of sugars and starches in the late stages of growth, a pound of the dry substance of the mature, well-eared corn plant possesses a higher nutritive value than at any earlier stage of growth."

From the above scientific findings as a basis, it is advisable not to cut fodder until well eared and in the glazing stage.

*CHEMICAL COMPOSITION OF GRAINS OF CORN AT DIFFERENT STAGES OF MATURITY.

Analysis of One Complete Row of Kernels from Ears Harvested on Different Dates.

Dates of Harvest	September 5, 1906	September 12, 1906	September 19, 1906	September 26, 1906	October 3, 1906	October 10, 1906
Water	48.47	39.52	33.61	31.33	24.54	19.35
Proteids	7.59	7.35	7.14	7.05	6.98	7.10
Carbo-hydrates ..	40.72	49.90	56.05	58.42	64.58	69.30
Fats	1.80	2.03	2.09	2.16	2.83	3.15
Ash	1.42	1.20	1.11	1.04	1.07	1.10

*CHEMICAL COMPOSITION OF COB AT DIFFERENT STAGES OF MATURITY.

Dates of Harvest	September 5, 1906	September 12, 1906	September 19, 1906	September 26, 1905	October 3, 1906	October 10, 1906
Water	63.94	40.40	36.28	35.43	37.18	38.38
Proteids	.90	1.01	.42	.52	.32	.43
Carbo-hydrates ..	34.31	57.75	62.79	63.87	62.30	60.96
Fats	.37	.27	.19	.12	.15	.19
Ash	.48	.57	.32	.06	.05	.04

METHOD OF HARVESTING. For many years corn fodder was cut by hand. A man with long arms, a steady stroke, and an intelligent understanding of shocking, could thus cut and shock daily from 50 to 75 shocks each ten hills square. Some men have cut as high as 100 such shocks. The rate paid was usually five cents per shock ten hills square. Larger shocks cost correspondingly more.

By hand

Later, a number of patent devices appeared for cutting corn. Sleds or low platforms on wheels with blades on the sides were used. One horse drew this down between two rows and two men sat on the machine to catch the stalks as they were cut. When an armful was gathered the horse was stopped and the men then carried the cut corn to shocks arranged at convenient intervals through the field. Another machine cut the corn and shocked it over a form on a platform to the rear. When a shock was completed a crane lifted it and swung it off to the ground.

By machinery

Corn fodder harvested in Iowa and the corn states today is cared for by means of improved machinery—the corn binder and the corn

The corn binder

*Taken from the thesis of D. Bustemante.

shocker. The advantage and preference lie with the corn binder chiefly for the following reasons. The shocker, so called, does not make shocks that are large enough, and it is a heavy, cumbersome machine. The fodder is in a less suitable form to be handled and there is much more loss due to exposure. The advantage of having the fodder in bundles is greatly in favor of the work of the corn binder. Only about one-half as much can be cut in one season as with a corn binder.

(Courtesy International Harvester Company.)

Fig. 135.

CORN BINDER AT WORK.

This machine is used to cut standing corn that is to be saved for the fodder or ensilage.

Probably among corn harvesting machines the corn binder has proved itself the most economical and useful to the farmer. When we compare it with the primitive methods we find that it is invaluable to the corn raiser who harvests for fodder or ensilage. The period when corn fodder is just right for ensilage or fodder is only a few days in duration. Here the corn binder has a decided advantage, for with it three men and two teams can put seven acres into the shock in one day, while by the hand method one acre per man is considered a fair day's work; thus a man is able to cut and shock twice as much by the use of the corn binder as against hand methods. **A saving in time and labor**

The life of a corn binder will be good for 1,000 acres. The first cost is about $125. Allowing $50 for repairs, it will amount to $175; or on the basis of 1,000 acres the machine cost will be about 20 cents per acre. Allowing $2.00 per day for men, $1.50 per day for each team, and about 50 cents per acre for twine, the approximate cost of **A durable implement** cutting and shocking by hand and with a corn binder for one day will be as follows:

	Binder.	Hand.
Three men	$6.00	$6.00
Two teams	3.00	
Twine	4.50	
Machine wear	1.80	
Board for men	1.00	1.00
Totals	$16.30	$7.00
Acres cut	9	3
Average cost per acre	1.81	2.33

This shows a saving of about 52 cents per acre in favor of the corn binder.

(Courtesy International Harvester Company.)

Fig. 136.

Corn Harvester and Shocker.

Used to cut and shock corn fodder with a minimum of labor.

While the saving is not so noticeable it will be seen that the more convenient condition the fodder is in for handling will reduce the comparative cost in preparing for feeding later on in the season.

SHOCKING OF FODDER CORN. Much loss is usually entailed by shocking corn fodder in a careless, slipshod manner. It is a common sight to see from 25 to 75 per cent of the shocks in a field nodding their heads and sprawling about upon the ground. Such work is due to carelessness and may be easily overcome. Shocks should be made of good size so that little loss from leaching and weathering is entailed. It is best to have two men working together, so that they may assist each other in getting the shock started, as this is the important point in good shock making. If very green the bundles should be allowed to lie upon the ground after cutting so as to permit of some curing before shocking. This should not be allowed to go far enough to cause the leaves to become brittle.

Shocks should be of good size

If the corn is fairly ripe it may be shocked as soon as it is cut. The shocks should be set in an upright position, and the tops well compressed together with a quarter-inch rope which has a ring or hook in one end. A shock to stand well must be braced from all sides and when the bundles are set up the butts should be placed down with some force and not thrown at the shock in a careless manner. A jack may be used to advantage in getting the shock started. A shock should contain from 30 to 40 bundles, depending somewhat upon the size and dryness.

Method of shocking

In commenting upon his method of shocking corn, Mr. John Gould, in writing to the Ohio Farmer in the fall of 1904, says, "The bundles as delivered by the harvester are left on the ground a short time to cure out and then the job commences. First, a bundle is laid on the ridge of a row, as that is usually a trifle raised above the level. Another bundle is then laid exactly crosswise of this, and this adding of crossed bundles goes on until the "X" is four or more feet high, as this "X"-making goes on the tops and butts of the bundles are reversed so that the top is always covering a butt below it which makes a perfect roofing in the angles of this."

Starting the shock

When a shock is well put up it should stand a whole year without any lodging. If well closed at the top little loss will result from penetration of moisture and the fodder when taken out of the shock will be fresh and green in color.

YIELD. Four tons of cured corn fodder is a good yield for an acre. Almost one-half of the weight will be in the ears. That proportion varies with the season, stage of maturity, variety, and thickness of planting.

With thick planting the yield of stover is greater, also the proportion of stover to grain. In a test at the Illinois Station, corn planted

The thickness of planting must be governed by conditions

in hills 3 inches apart yielded 3.6 tons of stover to 1 of grain, while tha planted 12 inches apart yielded 1.3 tons of stover to 1 ton of grain. The former yielded 50 bushels per acre, 13 of which were good and 46 poor. The corn planted 3 inches apart in the row yielded about 600 pounds more digestible matter per acre than that 12 inches apart. Too much importance should not be placed on this increased yield, for in a dry year, the reverse might have resulted. The fact that 46 bushels out of 50 produced in the corn 3 inches apart were poor in quality, is an important consideration.

(Courtesy Iowa State College.) Fig. 137.

CORN IN THE SHOCK.

A well drained place

METHODS OF FEEDING CORN FODDER. **Feeding Whole.** Bound corn fodder is much more conveniently handled than that which is loose. When fed on the hillside in the pasture the bands need not be cut. This practice has the advantage of keeping the waste stalks away from the barnyard, besides aiding very much in the spring of the year in holding the moisture which would otherwise run off. Some waste follows the feeding of corn fodder on the ground, but in dry winter weather it furnishes a means of drawing breeding stock out for exercise.

Many large and successful cattle feeders start steers on feed by this means. By nosing over the fodder a taste of the corn is acquired and soon grain in bunks can be supplied. By this time only sufficient fodder should be fed to act as a roughage; otherwise the waste is excessive. When fed in the barnyard, a manger with planks or poles arranged horizontally gives the best satisfaction.

For starting feeders

Shredding.

Fodder cutters which clip the stalk and leaves into inch lengths have been used to a limited extent. The shredder, which tears the stalk into linear strips, crushes the leaves and husks the ears, is very much used at present. Some machines husk the corn and elevate it separately, leaving but the shredded stover. Fodder which has been shredded is usually blown or elevated into the barn or else stacked in a feeding rack so that it can be fed without a second handling.

Shredded fodder more easily handled

(Courtesy Iowa State College.) Fig. 138

HUSKER AND CUTTER.

Used for removing the ears and cutting fodder which has been shocked in the field.

Corn fodder is very unsatisfactory to handle in the stable, and for this reason farmers have resorted to shredding, which consists in cutting up the fodder into very short fragments about one and one-half to two inches, or somewhat longer. When the fodder is in this condition it may be blown by the machine into the barn or onto a high stack outside. It is more easily handled when thus cut up finely. The parts not eaten by the cows or young stock are shoved out of the manger and utilized as bedding. For the purpose of soaking up the liquid portions of animal excreta nothing can excel shredded fodder. Professor Henry, of Wisconsin, found very satis factory results in feeding shredded fodder. He states that there was a saving of 24 per cent by feeding in the shredded form.

Waste used for bedding

Not only does shedding put the fodder in better condition, but it is a labor-saving device in that it husks out the ears of corn that the corn fodder contains.

Corn fodder when shredded should be in a well cured, dry condition. It should not contain over 25 per cent of moisture. If it is put in too wet there will be an immense amount of heating and much loss.

Cost of Shredding.

"Buff Jersey," in Hoard's Dairyman, gives cost of shredding 10 acres of fodder.

Three men and teams at $2.50 for 1½ days	$11.25
Two men in field at $1.50 for 1½ days	4.50
One man at crib at $1.50 for 1½ days	2.25
Engine and two men	10.00
Board of men	3.00
Coal	4.50
Total	$35.50
By 425 bushels corn husked at 3 cents	12.75
By 25 tons fodder at $2.00	50.00
	$62.75
Saved by shredding	27.25

The "Breeder's Gazette" of December 6, 1905, gives the opinions of Illinois, Indiana and Ohio men, who furnish some data on the shredding of corn fodder.

In shredding, the expense runs about as follows, according to the Illinois correspondent:

	Per Acre.
The Shredder	$1.20
Loading and hauling	1.00
Cribbing corn	.15
Total	$2.25

As to the feeding value this man states that it may take the place of timothy hay very successfully in any ration, for the part eaten is nearly as valuable. Some complaint is made by farmers on account of the heating of the shredded fodder, but if the heating does not go too far it is not very detrimental.

Shredded vs. timothy hay

Some of the advantages of shredding are a decided increase in the amount of roughage, a better preservation of food stuff, economy of storage, the corn husking is done more easily and cheaply, and the farmer is insured a good supply of bedding. Furthermore, a farmer following out such a system is able to keep more and better stock upon the same area of land.

Shredding has advantages

The Indiana farmer says in part: "In Clark County shredding of fodder is esteemed very highly, not so much because of its increased value, but because it fulfills the foregoing advantages so well. The operation of husking and shredding is performed at one operation and is much cheaper and more economical than the old system of cutting and husking from the shock by hand."

The Ohio party says that he considers shredded fodder a valuable form of roughage when preserved in a good condition. Shredding is not done until the sap is well dried out of the stalk, as this insures good keeping qualities. When filling the mow with shredded fodder it is well scattered and sprinkled with salt. The application of salt aids in the curing and makes the fodder more palatable for the stock to eat. Shredded fodder is much better kept in the barn, although many times it is made into a high stack out of doors, and fed by simply pushing or pitching the feed into an open rack where the cattle can reach it.

Should be stored in barn

Our own experience tells us that in order to make shredding profitable we must have the best quality of fodder and a good yield of grain, so that the husking and preparation of the fodder is done at the least possible expense. We can hardly agree that fodder containing a small per cent of corn will yield much profit by shredding.

Shredding not always profitable

Threshing Corn Fodder.

Threshing of corn which has been followed heretofore has given away to the use of regular corn machinery, such as the shredder and corn husker. This system consisted in running the corn fodder through an ordinary threshing machine, which left the grain in a shelled form ready for feeding purposes. The threshed stalks were either run into the barn or into a stack much the same as straw from threshed grain.

Threshing corn

LOSSES IN CORN FODDER. Considerable loss occurs in fodder exposed to weather conditions in washing and bleaching and by the wind blowing the leaves away. This brings up the question of shredding as a means of saving and preservation.

Shredded fodder in barn vs. left in field

Henry Wallace, of Wallace's Farmer, writes that 2 tons of shredded fodder in the early fall are worth 3 in the field, February 1st, exposed to the weather, provided, of course, that the early shredded fodder was put in the barn free from dew or rain. It is the rain and dew on stored hay and fodder and not the sap they contain that makes conditions favorable for the action of bacteria, resulting in fermentation.

Henry's "Feeds and Feeding" has the following paragraph on the subject of "Loss in Fodder:"

Usual method a wasteful practice

"We are told of a loss of nearly one-fourth of dry matter and protein which the crop contained at harvest time, by preserving corn forage in the usual manner. This seems incredible, but the subject has been studied by too many Stations with unanimity of results to admit of further question. Cooke has shown that heavy losses occur in shock corn in the dry climate of Colorado. The substances lost through wasting are protein and nitrogen-free extract (sugar, starch, etc.), the more valuable portions of the forage. Now, it is not possible to entirely prevent the losses by placing the cured fodder under shelter or in the stack, for it has been found that the forage continues to waste even under these favorable conditions."

Green corn fodder relished by colts

FEEDING VALUE OF CORN FODDER. Fodder corn grown so thickly as to allow only the formation of nubbins, furnishes for the farmer one of the cheapest and best forms of roughage obtainable for horses, mules and colts. Green corn fodder when fed in liberal quantities to work horses during the late summer months is greedily eaten. During the winter months the farmer will find that the colts relish good green corn fodder much better than do the cattle. It is less dusty and there is much less danger in feeding it to horses than there is in feeding musty hay. The leaves contain considerable nutriment and will be entirely cleaned up when fed in the manger, rack, or in the open upon the frozen ground. When the farmer compares the value of corn fodder in contrast to timothy hay, considering the amount that may be grown, he must come to the conclusion that it is one of the most economical as well as most nutritious forms of roughage that can be produced upon the farm.

More economical than timothy hay

Corn fodder also furnishes one of the best substitutes for ensilage that has yet been found. When corn fodder is harvested at the right time it furnishes a feed for cows that will not only be relished by them, but that will result in a good flow of milk. The corn fodder must be, however, preserved in large shocks and stored in a shed of some sort to protect it from the bad effects of stormy weather. If corn fodder be left in the fields the mice may destroy considerable, especially if the snow covers the ground and the winter is bad. If much drifting of the snow takes place the difficulty of getting the fodder is quite an item of labor. The ordinary cow giving an average flow of milk will daily consume from 10 to 15 pounds of good corn fodder.

Corn Fodder vs. Silage.

The following table arranged by Woll gives the average digestion coefficients for corn silage and green and cured fodder corn:

Forage	Dry Matter	Ash	Protein	Crude Fiber	Nitrogen-Free Extract	Ether Extract
Corn silage	66	31	53	67	70	74
Cured fodder corn....	66	34	55	66	69	72
Green fodder corn.....	68	35	61	61	74	81

It will be noted in the above table that there is very little difference in the digestibility of cured fodder corn and corn silage. Both of these forms, however, are less digestible than green fodder.

Corn Fodder vs. Hay.

Professor Henry, of Wisconsin, in experimenting with the relative value of fodder with mixed hay and clover hay for dairy cows, found that 1 ton of mixed hay was equivalent in results to 3 tons of stover. Also 1 ton of clover hay was equal to a little more than 3 tons of stover. The hay was of excellent quality. The stover yielded 2¼ tons per acre, besides a 70-bushel corn crop. According to this, it would take but 2 or 3 acres of corn to take the place of 1 acre of hay for roughage, and still produce a heavy grain crop.

Stover should be utilized

Digestible Nutrients in Corn Stover.

Digestible nutrients in one acre of corn and stover. Average of results from four experiment stations.

Digestible Nutrients.	Ears. Pounds.	Stover. Pounds.	Total Crop. Pounds.
Protein	244	83	327
Carbohydrates	2,301	1,473	3,774
Ether extract	125	22	147
Total	2,670	1,578	4,248
Per cent	63	37	100

The data is in regard to crops grown for grain, but will compare favorably with the average crop in Iowa, cut for fodder.

Stover contains much of the total nutriment

Patterson, of Maryland, found that under Maryland conditions 48 per cent of the nutrients is in the ear and 52 per cent in the various other parts of stover.

Redding, of Georgia, found about two-thirds of nutrients in the ear and the remainder in the stover, thus corroborating Armsby's results.

Proportion and Composition of Parts of Corn Stover.

*Weights and Proportions of Parts of Corn Stover.

	Weight. Pounds.	Proportion. Per cent.
Leaves and husks	55.0	65.2
Stalks minus pith	20.7	24.5
Pith	8.7	10.3
Total	84.4	100.0

Out of a total of 84.4 pounds the leaves and husks constituted 65.2 per cent, or 55 pounds.

**COMPOSITION OF DIFFERENT PARTS OF CORN STOVER.

	Air-Dry Material					
	Percent Water	Percent Ash	Percent Protein	Percent Fiber	Percent Nitrogen-Free Extract	Percent Fat
Whole Stover	19.81	4.55	4.19	26.02	42.87	2.56
Stover without Pith	12.21	4.58	4.60	28.55	47.35	2.71
Pith	13.27	3.92	3.02	29.15	45.77	4.87

***DIGESTIBILITY OF CORN STOVER.

Coefficients.

	Percent Dry Matter	Percent Organic Matter	Percent Protein	Percent Fiber	Percent Nitrogen-Free Extract	Percent Fat
Stover with Pith	53.5	56.7	16.6	64.3	56.8	76.2
Stover without Pith	55.1	57.2	20.5	62.7	56.6	72.0

*Bulletin No. 141 New York (Geneva).
**Composition of Different Parts of Corn Stover.
***New York (Geneva) No. 141.

THE VALUE OF STALK FIELDS. Depending upon the severity of the winter and the amount of snow on the ground, the value of stalk fields varies. 15 to 25 cents per acre formerly bought the best of fields, but in recent years 50 cents to $1.50 an acre have been paid. Dense foliage and heavy husks produce considerable roughage upon which to winter stock cattle. Close stocking during the winter facilitates spring work because less stalks remain upright to bother in preparing the ground. If cattle, or horses are left in the fields too late in the spring the soil is liable to be puddled by trampling so as to ruin the tilth for a whole season.

Generally sell from 50 cents to $1 per acre

TURNING STOCK IN THE UNHUSKED FIELDS. In the western part of the corn belt some farmers do not husk their corn at all. The crops are fed at home and the finished product turned off in the form of beef, mutton, or pork. Since the fields are fenced, there is no reason why the animals themselves should not gather their own feed, and such is the practice in vogue. In early autumn sheep (preferably western lambs) are turned in to eat the weeds, grass, and down corn. They are then taken out and put on regular feed in the yard. About the middle of October the two or three-year-old fattening steers are let into the field. These cattle have been previously brought up to full feed of corn, either old or new, usually newly cut corn. For the first two weeks they are only allowed in the field a few hours daily, but later are given free access to the crop. The hogs, which are spring shoats, are not turned in until three or four weeks later, as they make the fodder somewhat distasteful to the cattle.

Sheep very generally used

Advantages of This Practice:

First, labor saving in both husking the corn and preparing it for feed.

Second, the husks take the place of hay or shocked fodder which may be used as roughage and which costs labor and time.

Third, all the manure from both cattle and hogs is left right on the land in an available form and not deposited in the feed yard to be leached out by the rains before it can be spread. Of course, during the finishing period of feeding, closer attention and confinement is required. There is positively very little or no waste. During the fall of 1905, on a farm in western Iowa, forty acres were handled in this manner. The following spring there was hardly a grain of corn to be seen, the cobs laid on the ground, and the stalks were easily turned under by the plow.

INVESTIGATION OF THE PRODUCTION OF CORN FODDER IN IOWA

The following questions were sent to farmers in different parts of the state:

Town—————— County——————

1. Is corn which is to be cut for fodder planted at the same time as other field corn or a little later?
2. Is the corn which is to be cut for fodder checked or drilled in your locality as a rule?
3. What varieties of corn are used for fodder?
4. At what stage of maturity is most of the fodder cut?
5. What are the average yields in tons per acre?
6. Is most of the corn cut with the machine or by hand?
7. How much shredding is done in your locality?

The following answers were received from the above inquiries:

Mt. Etna. Adams.

1. Same time usually.
2. Checked.
3. Same as for feeding.
4. When the leaves commence to dry up just before frost.
5. About eight tons.
6. Machine.
7. About half shredded and half threshed. Some is fed without either process; simply hauled from the field to the stock.

Burt. Kossuth.

1. The last planting is generally used for fodder, but is not planted late for that purpose.
2. Generally checked. Most of our ground is quite weedy.
3. Common varieties raised for corn.
4. When most of the ears are well ripened, unless struck by frost.
5. Estimate eight to ten tons.
6. Machine.
7. Only five or six farmers in Burt Township shred every year.

Alden. Hardin.

1. Very little planted, especially for fodder. If the season is late the late planting is used.
2. Checked, unless where the first planting failed to grow or was drowned.
3. Ordinary varieties, except the Evergreen fodder have been tried by drilling thick, and same was so wormy that many would not use it. This year I do not know of any being planted.
4. Just as it begins to dent, if the season is favorable.
5. Never weighed.
6. All with machine (binders).
7. Just a very small per cent of the acreage—not five per cent. No silos here and no ensilage cutters. Fodder is mostly fed corn and all, and hauled from the field to the feed lot.

Maquoketa. **Jackson.**

1. At the same time here.
2. Checked here.
3. The same as for other uses throughout this locality.
4. As soon as they are sure it is all glazed.
5. Have never given it any thought.
6. As near as I can tell there is about as much one way as the other.
7. For a few years there was about 25 per cent of the crop, but hay was quite plentiful last year, so there was not much shredding done.

Marathon. **Buena Vista.**

1. At the same time, with few exceptions in case of being wet ground or feed lot.
2. Two-thirds checked, one-third drilled.
3. Large varieties.
4. It is cut just as late as can be without frost.
5. Ten tons.
6. With machine; probably five per cent by hand.
7. Ten per cent. The last three years there hasn't been very much cut for fodder. I think four per cent of the entire crop would be large in 15 miles square.

Danville. **Des Moines.**

1. Generally later.
2. I prefer drilled if free from weeds, but both kinds are used.
3. Ordinary field corn.
4. About frost time is the best.
5. Can't say.
6. Mostly with a binder.
7. Most of the fodder is shredded and makes great feed and fine bedding for hogs or any stock.

ACKNOWLEDGMENTS. The material for this chapter has been drawn freely from Henry's "Feeds and Feeding," and from the reports of the State Board of Agriculture of Kansas.

We appreciate especially the way in which the farmers of Iowa have co-operated with us in furnishing original information.

We are indebted to Prof. L. G. Michael for his assistance in preparing the discussion of the chemical composition of corn.

COLLATERAL READING:

Cornstalk Disease of Cattle,
Kansas Bulletin No. 58.

Proportion of Grain to Stover,
Farmers' Bulletin No. 56.

Indian Corn as a Fodder Plant,
Ottawa Bulletin No. 12.

Cornstalk Disease,
Nebraska Bulletin No. 52.

Feeding Corn Stover,
South Carolina Bulletin No. 66.

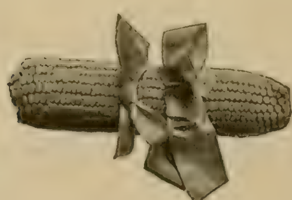
Why Pull Your Fodder,
North Carolina Bulletin No. 104.

Fodder,
Arkansas Bulletin No. 24.

Cornstalk Disease,
Indiana Circular No. 3.

Composition and Digestibility of Corn Fodder and Corn Stover
Illinois Bulletin No. 58.

Corn for Forage, Varieties for,
South Dakota Bulletin No. 81.



CHAPTER XVII.

CORN SILAGE AND CORN SILAGE PRODUCTION

HISTORICAL

IN EUROPE. The preservation of green food in silos commenced more than one hundred years ago. In 1786 Symonds wrote of Italians preserving fresh leaves for cattle in casks and pits in the ground. In 1843 Johnston, an Englishman, published an article on preserving green clover, grasses, and vetches in pits, basing his statements on observations made in Germany. Pits were dug 10 to 12 feet square and about as deep, the sides lined with wood, and a clay floor made. The green stuff was placed in the pit and plenty of salt scattered over it from time to time. When the pit was full, the top was well salted and a close-fitting cover of boards was placed over it. Dirt to the depth of a foot or so was thrown on the cover to exclude air. In a few days, after the contents had fermented and settled, the cover was removed, and more green fodder was thrown in, and the cover again put on. In commenting on the contents of such a pit, Johnston notes that the grass when thus fermented had the appearance of being boiled, had a sharp acid taste, and was greedily eaten by cattle.

Silos used over one hundred years ago

Pits were first used

In England, between 1860 and 1870, Samuel Jones stored rye, cut green and chopped, and fed the fermented material on an extensive scale.

Adolph Reihlen, a sugar manufacturer of Stuttgart, Germany, probably stored the first green maize in pits. He also preserved green beet leaves and beet pulp in silos with marked success. He had lived a number of years in the United States and on his return to Germany experimented with large dent corn, the seed of which he carried with him from this country. As the crop did not always mature in that climate, the green crop was pitted after the manner of the beet refuse. This work was conducted between 1860 and 1870, and the results were published in the German and French papers of the time. The use of the silo was strongly urged upon the

Maize, beet leaves and beet pulp were early used

people of France, and considerable attention was given to the subject. Many farmers built silos on the basis of Reihlen's experience. In 1877, A. Goffart, of France, wrote, a book on "Ensilage," which was translated into English and published in New York a year or two later.

Introduced first in Michigan in 1875

IN UNITED STATES. The first to prepare silage in the United States were Manly Miles, of Michigan, who built two silos in 1875, and Francis Morris, of Maryland, who commenced experiments in this line in 1876. One of the earliest experimenters with silage in the United States was John M. McBryde, whose investigations began at the University of Tennessee in 1879. Several other silos were also built by people in the eastern states within the next few years. In 1882, in a report on silage by the United States Department of Agriculture, statements were published from 91 persons who had silos, 81 of which were in Atlantic seaboard states. No doubt numerous others were in use at that time.

Silos now widely scattered

At the present time the silo is found on many thousands of farms in the United States, especially in dairy regions, and it may be considered a well-established feature in American farm economy where stock feeding is practiced. In fact, the use of silage for beef cattle is meeting with more and more favor.

There are many reasons why silage should be utilized more largely for the maintenance of farm animals. In almost every soil type and every part of the country where grass cannot be profitably produced, some of the crops suitable for silage can be grown quite successfully. If it happens that there is a shortage in the hay crop, the farmer need not sell off his dairy cows if provided with a silo.

The most economical means of providing feed

Because grass land has been so cheap and the farm land so productive, the farmers of Iowa and other of the corn states have preferred to feed their corn in the form of grain and market it as pork and beef. They have feared what they have always termed an experiment. But now the days of experimentation with silage have passed and it is known to be one of the most economical and readily available foods for beef and dairy animals that can be obtained in the corn states.

Even in the blue grass sections of the country there are times during the year when something must be provided that will be succulent and palatable. The fact that silage is so succulent makes it very valuable as a supplementary food during the dry hot spells which are common in the latter part of July and August.

Because green crops may be preserved in this way, the Iowa farmer can by thus handling his forage carry much more stock on his land than by any other method practiced today. It means greater returns from high priced land, because milk, butter, and beef can be produced more cheaply on silage than on any other food stuff the Iowa farmer grows.

Farmers of corn belt well provided with crops for filling

Another thing that makes silage of so much value is the fact that many different crops may be utilized and made much more valuable than in any other way. Among the crops most commonly grown for silage are corn, clover, alfalfa, cowpeas, sorghum, rye and oats. These crops when stored and preserved in an immature state, form "ensilage" or "silage." In Iowa, corn, because of its immense production of foliage and ears, makes one of the most valuable crops to be utilized for silage purposes. Cow-peas, clover, sorghum, and the others named, may be utilized to fairly good advantage. During rainy spells it is often a good plan to put clover and alfalfa into the silo. This provides a means of saving a crop which might otherwise be destroyed by rain.

Various crops may be used

PRINCIPLES OF PRESERVATION. The receptacle or vat in which the silage is preserved must be tight enough at the base and around the sides to exclude all air. Within a short time after the maize or other green material has been packed in the silo there is a great accumulation of heat.* This tends to start an upward current, thus excluding the surface air which might enter from above. The mass generally reaches its maximum temperature in the course of only a few days. This rise of temperature is due to chemical changes during which oxidation takes place, producing compounds which did not exist in the fresh material.

Sides of silo must exclude the air

The nature of the chemical changes which actually take place is very complex and is supposed to be due to the action of ferments which are believed to be the same as the ferments which bring about the formation of alcohol, lactic, acetic, and other closely allied acids. Whether the entire degree of fermentation is brought about by the ferments or partly by some other agent is not definitely known. Babcock and Russell have conducted experiments at the University of Wisconsin to determine the causes of silage formation. These investigators after careful research have come to the conclusion that silage formation is not due wholly to bacterial action.

Chemical changes take place due to ferments

The information secured by the investigations of these men led them to believe that the respiratory processes and intra-molecular activity within the plant, are the chief causes of the chemical transformations which produce carbon dioxide and the evolution of heat within the ensiled mass. Direct respiration appropriates the oxygen confined in the air spaces between the pieces of green corn and the

Other causes have influence

*A temperature of 145 degrees Fahrenheit has been reported.

intra-molecular respiration uses the oxygen combined in the tissues. Both forms of respiration go on only so long as the plant cells remain alive. In regard to bacteria, Babcock and Russell say: "The bacteria, instead of functioning as the essential cause of the changes produced in good silage, are on the contrary only deleterious. It is only where putrefaction changes occur that their influence becomes marked."

A loss in dry matter

Whatever the changes may be, the chemist will find that corn in the real silage form will not contain quite as much dry matter as was contained by the original green corn fodder. Just how this depreciation comes about is not clear, but is supposed to be due to loss through volatile gases. It has been found by chemical analyses that the sugar which may be found in the corn fodder when put into the silo almost totally disappears. Later on, after the silage has gone through the curing processes, acids are present, such as acetic and lactic. These changes are similar to the changes which take place in the formation of acetic acid in cider and of lactic acid in milk. During the development of these processes there is given off carbon dioxide, and water is accumulated, due to the breaking down of the carbon compounds. This process of combustion actually burns up some of the dry matter. This combustion also generates heat, causing a rise of temperature in the fermenting mass.

Acids are formed

Heat is generated

Silage contains a higher amine content than green fodder

It is also found by chemical analysis that silage contains a much higher amine content than the green corn fodder. Amines are nitrogen compounds formed from the proteid compounds during the processes of fermentation and are somewhat more indigestible than the normal nitrogen compounds. Investigations conducted at the Pennsylvania State College showed that in some cases over one-half the nitrogen of silage existed in the amine form. This was between two and three times as much as was found in the original green fodder. It may be that the same change goes on with field fodder, but it must be in a much less degree since little or no fermentation takes place where the fodder is well shocked and cared for.

All air must be excluded

In order that the above changes may go on and excessive fermentation be prevented, all air must be excluded. Fermentation will consume all the air found in the open spaces and in the cells of the undivided particles. Soon the resulting gases will begin to ascend and will aid in excluding any entrance of air from above. If access of air is allowed, "fire fanging" takes place immediately, leaving a charred condition of the ensilage as a result. Damage to this extent will make it very unpalatable.

TIME TO PLANT. Indian corn, or Zea mays, being a semi-tropical plant, needs the entire season of Iowa for its development. Some varieties are earlier than others. The calico varieties, sweet corn and the flinty types ripen in a much shorter season than our common dent varieties. They are, however, smaller yielders and therefore not used much for silage purposes. The dent varieties demand from 100 to 120 days of fairly good weather for maturity. In order to secure this amount of time the Iowa farmer must plant early in May. Corn frozen off in the spring is better than frozen corn in the fall. This is a fact worth remembering.

MANNER OF PLANTING. In growing corn for silage on land foul with weeds, checking in hills will be found to be the safest method. In other words, in order to force the growth along during the summer to insure early maturity, the ground must be kept clean.

Ground kept cleaner with checked corn

On sod ground, or in fields which are comparatively clean, drilling may be practiced. With drilling there is more uniformity of size in the stalks, and at harvest time the machine runs much more smoothly because the stalks are cut one at a time.

When grown in hills there is a tendency for the harvester to cut by jerks as it strikes the stalks, then ease up between each hill.

In the corn belt the rows are usually planted 3 feet 6 inches apart. This is the most suitable distance for ease of cultivation with modern farm tools.

THICKNESS OF PLANTING. There are Objections to Corn Being Planted Too Thick for silage purposes.

First, the stalks grow up slender, with elongated cells which lack substance. When put in the silo the whole mass shrinks badly.

Second, the leaves will be scarce, narrow, and lack the dark green color.

Third, the green fodder when cut will be tasteless because being grown without sufficient sunlight the vital activities in the leaves have not had a chance to perform their functions.

Fourth, the plants will not withstand heavy winds, the stems being slender and weak.

When Corn is Planted Too Far Apart.

First, the stalks grow up rank, the cell walls are heavy, and there is too much deposition of indigestible crude fiber.

Second, there is a tendency toward late maturity because of the overabundance of plant food furnished each stalk.

Third, there is an overproduction of large ears which, when cut up in the silage and afterwards fed, are not wholly digested because of insufficient roughage and succulent material which can be assimilated with them.

The Thickness of Planting Will Depend Upon,

First, the fertility of the land.

Second, the amount of rainfall in the region.

Third, the length of the growing season. Where the growing season is short, thickly planted corn will mature earlier.

Fourth, the variety. A rank growing variety which attains considerable height should be planted just a little thinner than a variety with short stalks, because the tall growth shades the lower leaves when drilled thickly.

As a rule, one stalk every 9 to 10 inches will produce the best corn for silage purposes. When checking, 3 stalks on land of medium fertility and 4 on richer land will be found thick enough when the hills are 3 feet 6 inches.

VARIETIES TO PLANT. When Selecting a Variety of Corn to Plant for Silage, Consider That,

First, there must be a large yield of foliage which will be succulent and palatable.

Second, there should be enough matured ears to raise the percentage of digestible nutrients in the silage.

Third, the variety must mature early in order to be ready for cutting before frost and also to have a large content of dry matter.

Corn should be sufficiently matured

Corn harvested on the Experiment grounds of the Iowa State College on September 27th, immature, slightly dented, mature, and well dented, showed a difference in yield (dry weights) per acre of 56 and 82 bushels of grain respectively, with about equal amounts of stover. This shows the importance of planting varieties that will mature.

Northern vs. southern grown varieties

As an average of several cultural trials, Professor Jordan of the Maine Station found a greater amount of green fodder and total amount of dry matter in large southern varieties than in the adapted northern varieties. The difference, however, was but 175 pounds per acre. Considering that an additional 6 1-4 tons more green fodder was handled in case of southern varieties, and that the former was of a more watery nature and more susceptible to fermentation in silo, the northern variety was the more profitable. Other northern Stations have come to the same conclusion.

Varieties Recommended.

"Modern Silage Methods", published by the Silver Manufacturing Company, of Salem, Ohio, gives the following varieties for different sections of the country. "The best varieties for the New England States are the Sanford and Flint corn; for the Middle States, Leaming, White and Yellow Dent; in the Central and Western States, the Leaming, Sanford, Flint and White Dent are best adapted. In the south, the Southern Horse Tooth, Mosby Prolific, and other large dent corns are preferred."

Varieties commonly grown in U. S.

For Canada, Rennie suggests for Northern Ontario, King Phillip's North Dakota and Compton's Early Flint varieties; for Central Ontario, the larger and heavier varieties, as Mammoth, Cuban, and Wisconsin Earliest White Dents. A strain of Leaming corn is also being grown considerably for silage purposes in southern and central Canada.

In Canada

King, of Wisconsin, recommends for northern United States the earliest maturing dent varieties and the largest flint varieties. The flint varieties will stand thicker planting than the dent varieties. He further states that those varieties that will mature 3 to 5 stalks per hill 3 1/2 feet square will produce more fodder and of better quality than when planted thinner.

Flint varieties will stand thicker planting

Soule, of Tennessee, recommends Cooke's Prolific and Virginia Ensilage for the south. Cooke's Prolific is a large southern variety, bearing from two to six ears per stalk.

Iowa Varieties.

Throughout Iowa the larger and medium dents may be grown for the most profitable silage. In the northern part of the state the larger flints may be grown for this purpose. Some of the most prominent varieties for Iowa are:

Large and medium dent for Iowa

Reid's Yellow Dent,
Silver Mine,
Boone County White,
Legal Tender,
Leaming,
Gold Mine,
Silver King,
Calico.

THE TIME OF HARVESTING. As maturity advances the content of water is lessened, which, of course, corresponds to an increase of dry matter. The nitrogenous substances and the oil decrease in comparative percentage to the rapid increase in the content of starches and sugars.

Percentage of starch and sugar increase with maturity

The following table from Professor Ladd of the Geneva Station, New York, substantiates the above statement:

Yields Per Acre	Tasseled July 30	Silked Aug. 9	Milk Aug. 21	Glazed Sept. 7	Ripe Sept. 23
	Pounds	Pounds	Pounds	Pounds	Pounds
Gross weight	18,045	25,745	32,600	32,295	28,460
Water in crop............	16,426	22,666	27,957	25,993	20,542
Dry matter	1,619	3,708	4,642	7,202	7,818
Ash	138.9	201.3	232.2	302.5	364.2
Crude Protein	239.8	436.8	478.7	643.9	677.8
Nitrogen-Free Extract (Sugar, Starch)	239.8	436.8	378.7	643.9	677.8
Crude Fat	72.2	167.8	228.9	260	314.3
Crude Fiber	514.2	872.9	1,262.0	2,755.9	1,734.0

The actual amount of all the constituents increases as the ripening process goes on. The deposition of the protein and oil seems to be accomplished early in the season. The stuffing of the cells with starch is always later. Hence what is termed immature starchy corn is not due to the over supply of starch, but to the lack of it. In other words, the cells are large and open, giving the shelled grain very little weight. Cattle feeders complain that steers do not fatten well on this immature corn. Their observations are practical. Fat forming components are not present in sufficient quantities. The digestion and assimilation of more material is required to obtain an equivalent amount of nutriment.

Protein deposited early

Increase in Food Ingredients.

Below are presented two tables, one introductory to the other, which show the relative increase of the constituents in the maturing corn plant:

INCREASE IN FOOD INGREDIENTS FROM TASSELING TO MATURITY.

Experiment Station	Variety	Stage of Maturity First Cutting	Last Cutting
1. Cornell, N. Y.,	Pride of the North,	Bloom,	Mature
2. Geneva, N. Y.,	King Phillip,	Tasseled,	Mature
3. Cornell, N. Y.,	Pride of the North,	Bloom,	Nearly Mature
4. New Hampshire,	Average of 4 varieties,	Tasseled,	Glazed
5. Pennsylvania,	Average of 10 varieties,	Tasseled,	Mature
6. Vermont,	Average of 2 varieties,	Tasseled,	Glazed
7. Vermont,	Average of 2 varieties,	Bloom,	Glazed

GAIN IN PER CENT BETWEEN FIRST AND LAST CUTTING.

	Dry Matter	Crude Protein	Crude Fat	Carbohydrates
1	150	80	129	169
2	217	134	374	300
3	289	183	335	662
4	112	50	84	130
5	155			
6	120	50		
7	204	81		
Averages	193	98	230	265

There is a decided increase in the amount of dry matter as maturity advances. Upon this principle the time of cutting should depend. The further reason for postponing cutting is that, in early stages, the sugar is most abundant. Later the sugars are made over into starches as the grain develops and mtaures. When the corn is cut green the accompanying bacterial fermentation falls most heavily on the sugars and the loss is quite decided. It is, therefore, advisable to put off cutting until grain is well formed and sugars changed to starch.

The percentage of dry matter increases with maturity

Fermentation causes loss in sugars

Professor King, of Wisconsin, states that corn should be well matured and well eared and contain not less than 30 to 35 per cent of dry matter. If corn contains but 20 per cent of dry matter, there will be much greater loss either as silage or as fodder, due to the greater fermentation. Large amounts of water in silage are more favorable to growth of bacteria than the concentrated juices found in the later stages of the corn plant.

Water favors growth of bacteria

While corn should not be cut too early, neither should the cutting be delayed too long. It should be cut somewhat earlier for silage than for fodder to be left in the field. The corn for silage should be cut when the grain is past the dough stage, well dented, and beginning to glaze. The foliage at this time will be green and succulent—not coarse and pithy—and will still retain a superabundance of watery materials to be handled.

Corn should be cut at proper time

INVESTIGATIONS OF THE GROWTH OF CORN FOR SILAGE*

Town——————— County———————

1. Do you drill or check the corn which you intend to cut for silage?
2. Do you plant the silage plot at the same time as your regular field, or a little later?
3. What varieties of corn do you use for silage?
4. At what stage of maturity do you cut the corn for silage?
5. What was the date of filling your silo in the fall of 1907?
6. What was the yield of green fodder per acre at that time?
7. What percentage of loss do you figure in silage?
8. To what class of stock are you feeding this silage?

*These inquiries were sent to farmers of Iowa who have silos.

The following answers were received from the above inquiries:

Forest City. Winnebago.

1. Drill.
2. As soon as we can after planting other corn.
3. Reid's Yellow Dent.
4. When most of it is dented; that is, commence cutting then, but it takes six to ten days to fill.
5. I think we commenced the 23d of September.
6. I do not know, only it takes from 11 to 13 acres to fill the silo, which is about 19x28 feet.
7. Very little. Most of the loss is at the top before we commence to feed.
8. Cows and young cattle that we are feeding for market.

Cedar Falls. Black Hawk.

1. Check.
2. Generally the last planting.
3. Never have used any but regular field corn.
4. When the lower leaves and husk is partly dry. Kernels should be well hardened. Generally leave as long as can without frost.
5. Do not remember exact date. One-half day filling before frost.
6. Two 12x24 silos filled from fourteen acres.
7. Estimate 1906, 10 per cent; 1907, 20 per cent. Believe increase caused from frozen silage.
8. Cattle, hogs and horses, with good results in each and every instance.

Bedford. Taylor.

1. List preferable; drill 8 inches.
2. Just as it happens.
3. None special. Have yellow now.
4. Full ripe for fodder. Kernel glazed, but stalk and blades yet juicy. Think more often is cut too green.
5. October 10th.
6. Could not tell—about 12 acres—equals 100 tons.
7. 2 per cent.
8. Young Angus bulls and heifers, calves and cows generally. Sheep and brood sows. Some to horses, but limited amounts, as too much tends to purging.

Buckingham. Tama.

1. Usually drill.
2. Sometimes.
3. Same as for main crop.
4. Aim to cut when just going out of dough.
5. Twentieth of September, late.
6. For 1907 about 9 tons; 1906, 14 tons.
7. Varies with different years so much that we cannot make any correct estimate.
8. Holstein-Friesian cows and young stock.

Lake View. Sac.

1. Have tried both ways, but like checking better as it can be kept cleaner.
2. At the same time. Sometimes first or last, as it comes handy.
3. The same as for regular crop; about like Reid's Yellow Dent.
4. It makes the best ensilage cut just at denting and glazing, when the husks are turning brown. I would rather have it a little ripe than too green.
5. September 9th to 18th. Had some trouble with machinery. Corn about right September 15th.
6. From 13 to 15 tons, 6 or 7 acres, and for a 90-ton silo, and it was well filled and partly settled.
7. Last year not over 2 per cent spoiled. Nothing in feeding.
8. Dairy cows, calves and young stock.

Ankeny. Polk.

1. Check.
2. Plant same as for cribbing.
3. Reid's Yellow Dent.
4. Kernels well glazed and lower leaves on stalks beginning to brown.
5. About first of October.
6. About 12 tons.
7. About five per cent.
8. To dairy cows mostly, but feed some to my mules and colts.

Waterloo. Black Hawk.

1. I checked the past two years. 1908 I drilled.
2. The same time as regular field corn.
3. Common field corn.
4. When it is about ready for shock corn.
5. Cannot give date, but just after the first frost.
6. About nine tons per acre, 1907; 1906, 12 tons.
7. About 5 inches on top of silo is all my loss for two years.
8. Milk cows, young cattle, calves, brood mares, colts and sheep and brood sows.

West Union. Fayette.

1. Drill one stalk in a place as a thick as I can and rows three feet apart.

2. First that I plant I use for silage.

3. The same that I use for regular corn crop.

4. When dented and husks begin to turn white.

5. Don't just remember, but think about September 18th and 19th.

6. Filled 14x28 silo with 4½ acres corn.

7. Don't think there is over seven per cent.

8. Milk cows, young stock, sheep, hogs, and a little to the horses and chickens.

Davenport. Scott.

1. Check or drill as condition of ground.

2. At the same time as other corn.

3. I always have used Reid's Yellow Dent in mine.

4. When the husks begin to dry.

5. September 25th.

6. I did not figure up the yield per acre.

7. Last year I didn't lose more than five per cent, but the year before about 25 per cent.

8. Cattle, young and old, and what is a little mouldy or tainted to hogs.

Manchester. Delaware.

1. Check.

2. Same time.

3. Common field corn.

4. When ears are dented and glazed and lower leaves on stalk dead.

5.

6. About 12 to 15 tons per acre.

7. None excepting about foot on top.

8. Everything on the farm except work horses.

Corn binders largely used

METHOD OF HARVESTING. Cutting by hand is still practiced. The armfuls are laid on the ground ready to be loaded. Bound corn is more conveniently handled, especially at the machine. A low truck wagon with flat rack facilitates the work of loading. A rack hung from the axles of a wagon is advocated as the best means of hauling corn to the silo.

SIZE OF SILOS.

Corn silage weighs on an average about 40 pounds per cubic foot. Thus a silo with a depth of 30 feet, having a diameter of 16 feet, will hold around 119 tons.

The following table gives the capacity of different sized silos:

Capacity of Round Silos.

APPROXIMATE CAPACITY OF CYLINDRICAL SILOS, FOR WELL-MATURED CORN SILAGE, IN TONS.*

Depth of Silo, Feet	INSIDE DIAMETER OF SILO, FEET.												
	10	12	14	15	16	18	20	21	22	23	24	25	26
20	26	38	51	59	67	85	105	115	127	138	151	163	177
21	28	40	55	63	72	91	112	123	135	148	161	175	189
22	30	43	59	67	77	97	120	132	145	158	172	187	202
23	32	46	62	72	82	103	128	141	154	169	184	199	216
24	34	49	66	76	87	110	135	149	164	179	195	212	229
25	36	52	70	81	90	116	143	158	174	190	206	224	242
26	38	55	74	85	97	123	152	168	184	201	219	237	257
27	40	58	78	90	103	130	160	177	194	212	231	251	271
28	42	61	83	95	108	137	169	186	204	223	243	264	285
29	45	64	88	100	114	144	178	196	215	235	265	278	300
30	47	68	93	105	119	151	187	206	226	247	269	292	315
31	49	70	96	110	125	158	195	215	236	258	282	305	330
32	51	73	101	115	131	166	205	226	258	271	295	320	346

*Modern Silo Methods.

Amount of Silage Needed.

With good corn from 12 to 15 tons of silage may be secured per acre. 35 to 40 pounds of silage per day is sufficient when feeding cows.

30 to 40 pounds daily feed for cow

The following table will be of interest, showing the dimensions of silo, capacity in tons, acres to fill, and the number of cows it will keep 6 months:

Dimensions	Capacity in Tons	Acres to Fill, 15 Tons to Acre	Cows it Will Keep 6 Months, 40 lbs. feed per day.
10x20	28	3	8
12x20	30	3	11
12x24	49	3 2-5	13
12x28	60	4	15
14x22	61	4 1-2	17
14x24	67	4 2-3	19
14x28	83	5 2-3	22
14x30	93	6	23
16x24	87	6 2-5	24
16x26	97	7	26
16x30	119	8	30
18x30	151	10 1-5	37
18x36	189	12 1-3	45

*Modern Silo Methods.

Should be firmly packed

FILLING THE SILO. Some money must be expended in purchasing a substantial silage cutter of large capacity. The price varies from $125 to $200. An attached elevator or blower may be used, according to the amount of power at hand. A blower has a tendency to separate the coarse and fine material. Several men are required to tread continuously in the silo during the filling operation. This is essential to secure the exclusion of air and in order to compact the entire mass. Eight horses will supply power enough for ordinary work. Teams are cheaper than hiring an engine, engineer, and water boy, besides having to furnish the coal. However, steam is more steady power. Gasoline engines are fast becoming serviceable for silo filling.

(Courtesy of Iowa State College) Fig. 140.

FILLING SILO AT THE IOWA EXPERIMENT STATION.

COST OF SILAGE. F. D. Coburn estimates the total cost of a ton of silage as follows:

For cutting and putting in silo, per ton................	58.59 cents
For interest and taxes on silo investment, per ton........	10.97 "
For insurance and maintenance, per ton................	3.66 "
Total..................................	73.22 "

The following table taken from Farmers' Buletin No. 292 shows the cost of a ton of silage as estimated on 31 farms:

COST PER TON OF PUTTING UP SILAGE.

Labor	Team	Twine	Fuel	Engine	Total
$0.21	$0.12	$0.03	$0.02	$0.08	$0.46
.23	.07	.03	.03	.12	.48
.22	.12	.05	.03	.07	.49
.21	.13	.05	.04	.08	.51
.22	.13	.03	.03	.10	.51
.25	.12	.03	.02	.09	.51
.20	.17	.03	.05	.08	.53
.23	.16	.05	.02	.09	.55
.25	.14	.03	.02	.12	.56
.29	.13	.02	.02	.10	.56
.26	.15	.03	.03	.09	.56
.24	.14	.04	.04	.13	.59
.27	.18	.05	.03	.07	.60
.28	.16	.05	.03	.08	.60
.28	.14	.04	.06	.10	.62
.34	.16	.00	.05	.08	.63
.28	.17	.07	.03	.09	.64
.36	.13	.04	.03	.11	.67
.33	.14	.04	.07	.09	.67
.25	.20	.05	.03	.15	.68
.33	.16	.04	.03	.14	.70
.35	.18	.03	.03	.11	.70
.33	.16	.05	.03	.14	.71
.28	.20	.04	.03	.17	.72
.44	.16	.00	.02	.13	.75
.36	.20	.07	.03	.11	.77
.34	.22	.05	.04	.13	.78
.42	.18	.04	.06	.10	.80
.38	.18	.06	.05	.15	.82
.40	.21	.05	.03	.15	.84
.45	.20	.04	.05	.12	.86

COST OF FILLING SILOS IN IOWA.

1. Town, Manchester. County, Delaware.

ITEMS.	AMOUNTS.
Size of Silo, 150 tons. Date filled in 1907, Last of Sept.	
1man, team and binder for 2 days	$ 15.00
4 men and teams for 2 1-4 days	30.00
4 men for 2 1-4 days	15.00
Use of gasoline engine, for 2 1-4 days	10.00
40 gallons gasoline	7.00
Twine, 30 pounds at 10 cents	3.00
Use of cutter for 2 1-4 days	10.00
	$90.00

Cost per ton, 60 cents.

Signed: W. J. Davis.

2. Britt. Hancock.

Size of Silo, 16x26, 108 tons. Date filled in 1907, Sept. 15.

Cutting	$11.00
Hauling	16.00
Feeding Cutter	6.00
Tramping Silage	6.00
Gasoline	3.20
Other oils	.40
	$42.60

Cost per ton, 39 cents.

Signed: J. F. Bullis.

3. Bancroft. Kossuth.

Size of Silo, 16x30, 119 tons. Date filled in 1907, Sept. 28-9.

Cutting and twine	$13.00
6 men and teams	18.00
Use cutter	5.00
Use engine and coal	7.50
4 men to feed machine, etc	8.00
	$51.50

Cost per ton, 43 cents.

Signed: A. Mayer.

Cost per ton ranges from fifty to seventy cents

An average of these results is 57 cents per ton for filling the silo. A farmer in southern Iowa has put up his silage for less than 50 cents per ton. Another Iowa farmer paid in 1906 70 cents per ton.

Fermentation

LOSSES OF SILAGE IN THE SILO. The losses in the silo are due to fermentation—the action of bacteria on the proteids and carbohydrates. The effect is to reduce the more valuable carbohydrates, as starches and sugars, and to change a part of the albuminoid nitrogen into the amide form, which is indigestible.

Accompanying this reduction and changing, is the formation of acids, causing a sourness. The greener and more watery the silage is, the greater the percentage of loss, both in dry matter and in feeding value.

The following table, taken from Henry's "Feeds and Feeding" shows the changing of the several constituents in the green fodder and silage:

WATER FREE SUBSTANCE OF GREEN CORN AND THE SILAGE MADE THEREFROM.

Constituents	Percent 1881		Percent 1882		Percent 1883		Average Percent	
	Green Corn	Silage	Green Corn	Silage	Green Corn	Silage	Green Corn	Silage
Ash, pure	5.0	5.5	3.7	4.0	3.3	3.7	4.0	4.4
Nitrogenx6.25	6.5	7.2	8.0	8.9	7.3	7.3	7.26	7.8
Crude Fiber	24.2	27.4	35.2	35.8	29.3	33.8	29.56	32.33
Other Carbohydrates	62.3	57.0	51.0	49.2	57.7	52.6	57.0	52.93
Ether Extract	1.9	2.9	2.0	2.3	2.4	2.8	2.1	2.66

The following table, also taken from Henry's "Feeds and Feeding", shows relative losses of dry matter in silage and corn fodder:

Station	Corn Silage		Corn Fodder	
	Dry Matter Percent	Protein Percent	Dry Matter Percent	Protein Percent
Vermont Report 1889............	14.7		13.6*	
Vermont Report 1891...........	20.0	13.0	19.0	17.0
Vermont Report 1892...........	18.0	11.0	18.0	9.0
Vermont Report 1894...........	20.0	12.0	20.0	12.0
New Jersey Bulletin 19.........	18.0		17.3	
Pennsylvania Report 1889......	10.0	26.5	21.0	13.8
Wisconsin Report 1891 (Average Four Years)	15.6	16.8	23.8	24.3
Average	16.61	15.86	18.96	15.22

*Large shocks. 15.1 per cent for small shocks.

It will be noted from the above table that the losses are about equal in the silage and corn fodder.

The silage loss includes that waste found in the top layer. This loss may be largely prevented by spreading green grass, wet chaff, or other covering over the top of the silage. Professor King says on this point, that after four years' experience, he is convinced that the total losses minus those found on the top and bottom may not exceed 10 per cent.

Loss largely in upper layer

In the above case the fodder was analyzed in early winter. The loss in the fodder would increase, the longer it stood and the wetter and more unfavorable weather to which it was exposed. On the other hand, the maximum loss of silage is reached within a short time after siloing.

Time of maximum loss

VALUE OF SILAGE. **In Milk Production.** Silage is not a concentrated food stuff. Its value lies in being a roughage in supplying succulence. The dairy districts have found silage indispensable for winter feed. The Ohio Station conducted an experiment to determine the relative value of beets and silage in milk production. This test was carried on for four years and showed a gain in milk production of 6 per cent per 100 pounds of dry matter fed, in favor of the silage rations. Pennsylvania found a similar gain of 5 per cent. The pro-

Silage for milk production

ficiency of the Jersey over the other herds at the St. Louis test speaks well for silage. Such constancy of milk flow was never before known.

In Beef Production.

Silage for beef production

In beef production the Ottawa Experiment Station found that in fattening steers a gain of 1.33 pounds per day was obtained from the rations of silage and straw, against a daily gain of 1.05 pounds on roots and hay. The former was also cheaper. The Illinois Station came to the conclusion in feeding calves intended for beef production. that for equal areas fed, silage produced more rapid and economic gains and left the animals in better thrift in the spring, than did shocked corn. Silage when fed to fattening steers is thoroughly digested. Shoats following animals thus fed gain but very little. In the case of an epidemic of cholera silage is a valuable cattle feed.

Corn largely digested

COMPOSITION AND FEEDING VALUE OF CORN SILAGE. Corn as used for silage purposes, necessarily contains a high percentage of water. A compilation of the analyses of the American feeding stuffs, made by the various experiment station chemists, as given in Bulletin No. 11 of the U. S. Department of Agriculture, gives the analyses of silage corn as follows:

Silage Corn.

Kind of Corn	Water	Ash	Protein	Fiber	Nitrogen-Free Extract	Fat
Dent	78.99	1.2	1.73	5.59	11.98	.51
Flint	79.76	1.05	1.96	4.32	21.26	.65
Sweet	79.08	1.26	1.86	4.42	12.92	.46

Flint corn highest in protein

From this table we see that the flint corn is highest in protein and fat and that sweet corn is slightly better than the dent corn. These relations remain the same among the flint, sweet and dent corns, when the analysis is made of water-free substances, as shown in the following table:

Water-Free Silage Corn.

Kind of Corn	Ash	Protein	Fiber	Nitrogen-Free Extract	Fat
Dent	5.7	8.3	26.3	57.1	2.6
Flint	5.2	9.7	21.3	60.6	3.2
Sweet	6.0	8.9	21.2	61.7	2.2

Silage Compared with Hay. Jordan, in charge of the Maine Station, compared silage made from the various kinds of corn with good hay made mainly from timothy, for milk production. Four cows were used in carrying out the experiment. They were first fed hay, then hay and silage and then hay again. An equal amount of concentrates was given each cow during the experiment. The following interesting results were secured:

	Periods.	Milk.
On hay and grain	2-17 to 3-9	21.7 lbs.
On hay, silage and grain	3-10 to 5-11	22.5 lbs.
On hay and grain	5-12 to 5-25	19.6 lbs.

It will be noted from the above that there was a decided increase when the cows were changed from hay to hay and silage, and a noticeable decrease when they were shifted back to the old ration of hay

The ultimate effect of the two feeds is shown in the following table. Here Mr. Jordan groups the milk yields of the four cows in 14-day periods just preceding or following a change in the roughage fed.

Total Yield of Milk, Four Cows, for 14 days.

On hay	1,212 pounds
Changed to silage and hay	1,297 "
An increase of 85 pounds or about 7 per cent.	
On silage and hay	1,200 pounds
Changed to hay	1,098 "
A decrease of 102 pounds is shown, or about 8 per cent.	

It will be noted from the above that when the cows were changed from hay to silage and hay there was a decided change or increase, amounting to 7 per cent. and when the cows were again shifted to hay from silage and hay there was a decided loss in flow of 8 per cent. In summing up the above results, Jordan reaches this conclusion: "In the experiment the addition of silage to the ration resulted in a somewhat increased production of milk solids, which was not caused by an increase in the digestibility of food material eaten but which must have been due either to the superior value of the nutrients of the silage over those of the hay, or to the general physiological effect of feeding a greater variety of foods. In other words 8.8 pounds of silage proved to be somewhat superior to 1.98 pounds of hay (mostly timothy), the quantity of digestible material being the same in the two cases.

Silage increases flow of milk

"Assuming the digestible matter of hay and silage to be of equal value, pound for pound, when hay is worth $10 per ton silage of the kind used in the experiment would be worth $2.25 per ton. But this silage contained more water than the average. Had it been of average quality, then the ton value reckoned on the above basis would be $2.62. But in this case we should give the silage the credit of the increased milk production, which seems to have been at the rate of 85 pounds of milk to each ton of silage."

Comparative value per ton with hay

Value of Silage versus Fodder Corn. Vorhees and Lane of the New Jersey Station,* conducted an experiment to find the comparative values of silage versus fodder corn.

For the use of the experiment a 15-acre field planted to corn, with rows 3 feet 6 inches and stalks 8 inches apart in the row, was taken. The crop was cared for during the first week of September, when the ears were nicely glazed over. Twelve acres of the field were put in the silo and three acres were harvested as fodder corn and shocked in the usual manner. Two lots of cows consisting of 4 in each were used in the experiment, one being fed corn fodder and the other silage, the feeds being changed at the end of the first period so as to have a check upon the experiment. The rations fed were so mixed that the silage or fodder corn furnished at least one-half the total dry matter and two-thirds the digestible carbohydrates. The cattle seemed to relish the silage better than the corn fodder, as a portion of the corn fodder was left uneaten. There seemed to be a gain with both lots of cows.

Silage vs. corn fodder for milch cows

The following data gives the production of milk and fat:

	Number of Days	Total Yield of Milk	Average Yield Per Day Per Cow	Average Percent of Fat	Total Yield of Fat	Average Fat Per Day Per Cow
		Pounds	Pounds		Pounds	Pounds
Silage	24	2,276.2	23.7	3.78	86.15	.897
Dry fodder ration	24	2,017.9	21.0	3.86	78.02	.813
Gain for silage...		258.3	2.7	0.08	8.13	.084
Per cent of increase		12.8			10.4	

By noting the above table we see that the silage ration produced 12.6 per cent more milk and about 10.3 per cent more of the fat than the fodder corn.

Large yields and economy in production

Large yields and economy in production and storage are among the highest values of silage. Beets also supply succulence. Careful tests at the stations of Ohio, Maine, Pennsylvania and Ontario have been made with rutabagas, mangels, turnips, and sugar beets. They were found to furnish but 35 to 60 per cent as much dry matter per acre as silage. The Pennsylvania Station found that $56.07 had to be expended to grow an acre of roots, while $21.12 would pay for the same area in corn and put it in the silo. The United States Department of Agriculture estimates the cost of the care of an acre of corn at $11.07, counting all details.

*Bulletin 122, New Jersey.

ACKNOWLEDGMENTS. In all our chapters in which we have discussed the feeding value of corn, we have drawn freely from Henry, Armsby, Jordan, and Smith. We have tried not to take up stock feeding except as it pertains directly to corn and its by-products.

The farmers of Iowa have promptly responded whenever called upon for original information.

The reports of the State Board of Agriculture of Kansas has been a very fertile source of practical data.

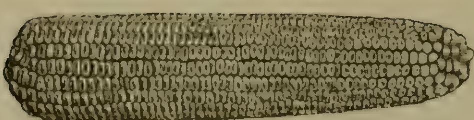
COLLATERAL READING:

Corn as a Silage Crop,
Maine Bulletin No. 11.

Composition and Digestibility of Corn Silage,
Illinois Bulletin No. 43.

When to Cut Corn for Ensilage,
New Hampshire Bulletin No. 3.

Corn Ensilage for Steers,
Kansas Bulletin No. 136.



CHAPTER XVIII

JUDGING CORN

WHY JUDGE CORN? The highest and only purpose of the judge is to give first ranking to that sample which in his estimation will, if planted the next spring, produce more corn of better quality than any other sample on exhibition. Furthermore, it should show breeding, that its good qualities may be more surely perpetuated. A true and thorough understanding of the ear of corn can only be ascertained by practice in judging. The judge cannot do his duty until he knows what to look for.

The purpose of the judge

The criticism at times has been very legitimately made, that in corn shows the winning samples had been sometimes chosen too much because of attractive appearance and fancy points, the essential points being too often lost sight of. That is, over-valuation was laid on filling of tips and butts, while size of ear, depth of kernel and germinating power were ignored. The Agricultural Colleges have taken up the task of training men to be proficient in placing awards. Often these men have become somewhat stilted and impractical, but their influence has aroused an enthusiasm in corn growing all through the corn belt.

Judge should be practical

For years, intelligent and progressive farmers selected their seed corn according to ideas of their own. Corn breeders who established the standard varieties of the present time, laid stress on certain points. They knew a good ear of corn, but because of few occasions (corn shows, etc.) for the expression of this knowledge it was not widely disseminated.

INTRODUCTION OF THE CORN SCORE CARD. As corn growing and breeding became of more recognized importance and the essential characteristics more thoroughly understood by interested persons, the formulation of a definite scale of points became necessary. *"In 1886, at the great corn exhibit at the Exposition at Chicago, the five expert judges worked some days in preparing a scale of points to guide them in their decisions." A score card which has been used for years was arranged for the Illinois Fair at Peoria in 1891 by Orange Judd (now deceased), the founder of the Orange Judd Farmer and other agricultural papers. Later the Illinois Corn Growers' Association modified the original form by aid of the agronomists at the University of Illinois. This institution has been in the

Score card first used in 1886

Orange Judd wrote a score card in 1891

*Indian Corn Culture, Plumb, Page 56.

(Courtesy Iowa State College)

Fig. 141.

SHORT COURSE STUDENTS JUDGING CORN AT THE IOWA STATE COLLEGE.

vanguard in adopting changes for the better in the old score card. The corn growers of Missouri have a slightly different scale of points, as do those of Nebraska also. Some very radical changes have been made in the last two years by the Iowa State College, because of the failure of the old score card to meet the need of simplicity and definiteness in short course and institute work.

Definition of the Score Card. After having been charged in many details, and when only essential things have come to be considered, it may be said that the corn score card is an outlined statement and explanation of the points to be observed in the elimination of undesirable ears or samples and of recognizing and selecting those of desirable characters.

The Purposes of the Score Card are:

(1) To present to the mind of the student, judge and grower the essential points to be considered in examining an ear or sample of corn.

(2) To impress the relative value of these points, placing first those of the greatest importance.

(3) To explain and illustrate as much as possible just what these points mean.

(4) To go even further and point out the reason why these points mean so much.

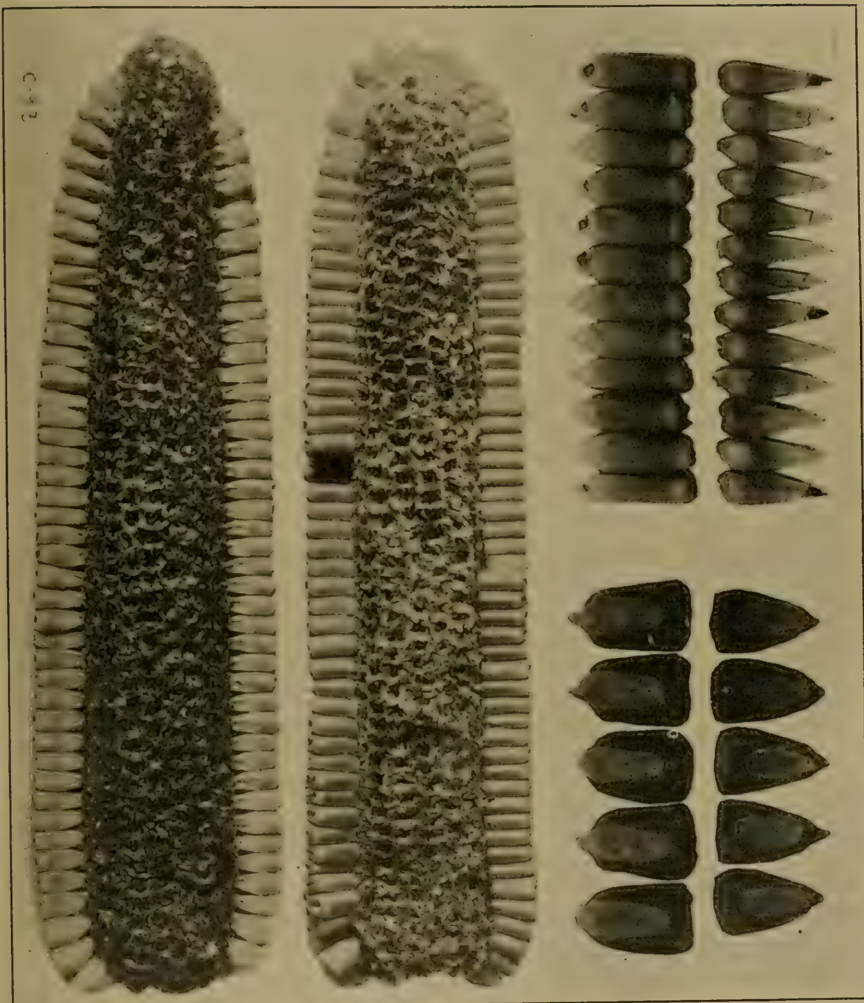
SCORE CARD USED BY THE FARM CROPS DEPARTMENT OF THE IOWA STATE COLLEGE.

Students' Score Card.

Name of Scorer....................No.........Date...............

Sample No. ....Table No.........Variety..................

I. **General Appearance, (Productiveness)**		20	
	1. Size and shape of ear,		12
	2. Constitution,		4
	3. Filling of butts,		3
	4. Filling of tips,		1



(By courtesy of the Iowa State College.)

Fig. 142.

Space at Cob and Shrunken Tips.

The ear on the left shows excessive spacing at the cob. The kernels from it are very pointed and weak at the tip. The ear on the right is full at the cob. Its kernels are plump at the tip.

II. Trueness to Type or Breed Characteristics,		20	
	1. Shape of ear,		5
	2. Shape of kernel,		5
	3. Purity of color of cob,		2
	4. Uniformity in size and shape of kernels,		2
	5. Purity of color of grain,		2
	6. Straightness of rows,		1
	7. Arrangement of rows,		1
	8. Form and filling of tips		1
	9. Form and filling of butts,		1
III. Maturity and Market Condition,		25	
	1. Sappiness.		8
	2. Chaffiness,		5
	3. Starchiness,		3
	4. Adherence of tip cap to cob,		3
	5. Adherence of chaff to tip cap,		2
	6. Plumpness of tips of kernels,		1
	7. Depth of kernels,		1
	8. Size of ear,		1
	9. Size of cob,		1
IV. Vitality.—Germinating Power,		25	
	1. Color of embryo,		4
	2. Condition of embryo,		4
	3. Adherence of tip cap to cob,		3
	4. Blistering of kernel,		3
	5. Size of germ,		2
	6. Plumpness of tips of kernels,		2
	7. Adherence of chaff to tip cap,		2
	8. Condition of cob,		2
	9. Starchiness,		2
	10. Chaffiness,		1
	11. Sappiness,		1
V. Shelling Percentage,		10	
	1. Depth of kernel,		4
	2. Size and density of cob,		3
	3. Filling of butts and tips,		1
	4. Space at cob,		1
	5. Furrows between rows,		1
		Total,	100

NOTES.

1. An ear need not be deficient in all points mentioned under the respective headings to score zero in that particular heading.
2. A score of zero in any one of the first four main headings disqualifies the ear.
3. An ear or sample scoring below seventy-five (75) does not deserve a place.

EXPLANATION OF POINTS IN CORN JUDGING

I. GENERAL APPEARANCE. (PRODUCTIVENESS.)

1. **Size and Shape of Ear.** With the proportion of corn to cob being the same, the larger the ear, the larger the yield, providing the same number of ears are grown on an acre. The ability to mature limits the size. Well shaped ears show strength, vigor, breediness.

   An ear with a full middle is stronger

2. **Constitution.** As shown by an ear of desirable size, well proportioned, strong, full in the middle. This does not mean vitality.

3. **Form and Filling of Butts.** Properly filled butts indicate perfect pollination, strong shanks and power to withstand the winds. A well filled but is more important than a well filled tip.

4. **Form and Filling of Tips.** Filling of tips, if the depth of grain is maintained, produces higher yields.

II. TRUENESS TO TYPE OR BREED CHARACTERISTICS.

1. **Shape of Ear.** This should conform to the variety type. It should be full in the central portion and hold its size well out to the tip. In general, circumference should be about three-fourths of the length.

2. **Shape of Kernel.** The shape of the kernel should conform to the variety type. The tip should be full, since such a condition indicates strength, high proportion of corn to cob, and high feeding value. The edges should touch well up to the crown, which necessitates a more or less wedge-shaped kernel. A rounding crown gives a smooth appearance and shows lack of breeding in dent corn.

   A wedge-shaped kernel most desirable

3. **Purity of Color of Cob.** Variation of color, a white cob in yellow corn or a red cob in white corn, indicates impurity and should disqualify the ear, unless such be a variety type.

4. **Uniformity in Size and Shape of Kernels.** The size and shape of all kernels of each ear and of all kernels on all the ears in a sample should conform to the **variety type** and be uniform throughout the sample. This will insure more even stand in planting.

   Much care should be exercised in selecting kernels of uniform size

5. **Purity of Color of Grain.** In color, the kernels should be free from mixture and also true to the variety which they represent.

6. **Straightness of Rows.** The rows of kernels should run straight from butt to tip; any twisting of the rows around the ear is objectionable.

7. **Arrangement of Rows.** This depends upon the variety. For example, Reid's Yellow Dent is distinctly paired, while Golden Eagle is arranged in single rows.

8. **Form and Filling of Tips.** A tip well filled with uniform kernels indicates proper development of the ear and a relatively high proportion of corn to cob. It should conform to the variety. The kernels should keep their shape and size well out toward the tip of the ear. This is strong evidence of good breeding.

9. **Form and Filling of Butts.** A butt well filled with uniform kernels indicates more complete development of the ear. Variety type should be considered.

Fig. 144.

TYPES OF KERNELS.

III. MATURITY AND MARKET CONDITION.

1. **Sappiness.** Containing a high percentage of moisture. The ear is heavy and can usually be twisted out of shape. The kernels generally presenting a glossy, waxy appearance.

Close observation should be made for signs of immaturity

2. **Chaffiness.** When the hand is passed roughly over the ear, a rattling sound indicates chaffiness. The kernels usually have an extremely pinched dent and show immaturity.

3. **Starchiness.** Generally a large amount of white starch indicates immaturity. This may be present on the back or on the front of the kernel, or on both.

4. **Adherence of Tip Cap to Cob.** The adherence of the tip cap to cob in shelling, leaving the black tip of the germ exposed, indicates immaturity.

5. **Adherence of Chaff to Tip Cap.** If the chaff adheres to the tip cap in shelling, it indicates more or less immaturity. The shrinking kernel has drawn the chaff with it in the process of drying.

6. **Plumpness of Tips of Kernels.** Shrunken tips indicate immaturity; that is, they were full of moisture when stored. They also indicate lack of vigor, low proportion of corn to cob and low feeding value.

7. **Depth of Kernel.** As a general rule, deep kernels require more time in which to mature than do shallow kernels. The depths will vary with the variety type, climatic and soil conditions. Deep kernels are liable to show starchiness.

8. **Size of Ear.** The size will vary with the soil and climatic conditions. The usual size of an ear in the northern sections of the State of Iowa is from 8 to 9½ inches; in the to 10 inches. The circumference should generally be central sections, 8¾ to 9¾; in the southern sections, 9 about three-fourths of the length. Ears a trifle long, having a circumference of such size that the ear matured, should not be cut seriously for this excessive length. Large ears showing signs of immaturity should be cut very heavily.

Do not sacrifice maturity for size of ear

9. **Size of Cob.** Ears with large, coarse, pithy cobs dry out slower, are later maturing, and shell less corn. The cob may be so small as to indicate weakness.

IV. VITALITY (GERMINATING POWER).

An injured embryo means weak germination or even a lack of vitality

1. **Color of Embryo.** A yellow or brownish colored embryo indicates that it has been frozen. Paleness in color usually means loss of vitality, due to long storage. Sometimes just one of the sprouts will be affected.

2. **Condition of Embryo.** A large, swollen embryo indicates that it is full of moisture and liable to freezing. When shrunken, it may be weak because of prolonged storage.

3. **Adherence of Tip Cap to Cob.** Tip caps adhering to the cob, leaving the black tips of the germs exposed, indicate weakness.

4. **Blistering of Kernel.** A kernel blistered on the back indicates that it was immature and from rapid drying the contraction of the cells left an air space under the hull. When the face of a germ is puffed up or wrinkled, it shows that the material composing the germ has shrunken and a close inspection of the embryo should be made.

5. **Size of Germ.** The germ should be large and open on the surface, deep, showing strength and plenty of nutriment for immediate use of the germinating plantlet.

Minor signs of weakness should be observed closely

6. **Plumpness of Tips of Kernels.** Plump tips indicate maturity and give room for large germs.

7. **Adherence of Chaff to Tip Cap.** Chaff adhering to tip caps of kernels indicates lack of vigor.

8. **Condition of Cob.** A cob is often dark colored or may show a bluish, mouldy appearance around the butt. In such a case, it has not been properly stored or else was immature when gathered.

9. **Starchiness.** Starchiness indicates a smaller food supply for the growing plant.

10. **Chaffiness.** Looseness on the cob and thin, light kernels are indicative of weak germinating power.

11. **Sappiness.** Corn containing a high percentage of moisture is liable to freezing.

V. SHELLING PERCENTAGE.

1. **Size and Density of Cob.** A large cob means low shelling percentage. A cob of woody texture is always heavy.
2. **Depth of Kernel.** The deeper the kernel, the greater the proportion of corn to cob.
3. **Filling of Butts and Tips.** Other things being equal, ears with well filled butts and carrying their size well out on the tip, will shell the highest percentage of corn to cob. The depth of the kernel should also be maintained over the tip.

   Depth of kernel is the largest factor in shelling percentage
4. **Space at Cob.** Space at the cob is a very definite indication of a low proportion of corn to cob. Ears apparently sound on the surface may have faults which should be carefully looked for.
5. **Furrows Between Rows.** A wide open furrow between the rows indicates a low shelling percentage and lack of breeding. Closeness at the crown or lack of furrow usually indicates space at the cob. There should be sufficient furrow to permit the corn to dry out readily.

All scoring should be proportionate

THE USE OF THE SCORE CARD. In judging single ears in class work, or at short courses, the sample usually consists of ten ears. After filling out the proper blank at the head of the score card and arranging the ten ears in order with two kernels placed germ side up at the tip of each ear, the student is ready to score the sample. It will be found most convenient and practical to score each ear under a respective point before going to the next point; that is, mark each ear under the point "shape and size" of ear, before the point of "constitution" is considered. By so doing, a comparison is kept constantly in mind. The scorer should look over the sample and choose the ear which he thinks is nearest to perfection and set down an estimate for it, then rate the remainder in comparison. If a similar method is followed for each individual point on the score card, the work of scoring will be much more correct as well as more rapid. In scoring, the cut should not be put down, but the amount allowed entered in the first column under the number of the ear. In place of using fractions, decimals should be placed in the second column. A cut of .25 per cent is the least. In summing up the results, the rating of the ears by the score card should correspond with the way one would place them without scoring. That is, your judgment should correspond with the score card. In scoring a sample of corn the amount that an ear is cut in a given point is not so important as it is that the cut be in proper proportion in its relation to that same point in the other ears in the sample.

SCORE CARD OF EXTENSION DEPARTMENT.

The score card used by the Extension Department of the Iowa State College takes up the points considered in judging under four headings. Being plainly stated and logical, they are easily grasped by the average short course student who studies corn but two weeks during the year.

Four questions which the farmer should ask himself

I. Will it Yield? 25 Points.

That is, will it yield well; has it constitution; can we depend on it even when conditions are unfavorable?

II. Will it Ripen? 25 Points.

That is, will it mature; will it ripen every year; is it safe for the locality?

III. Does it Show Improvement? 25 Points.

That is, has it breeding; has it a distinct type; will it reproduce itself; has it several years of careful selection and improvement back of it?

IV. Will it Grow? 25 Points.

That is, has it vitality; will it germinate; will it all grow and grow uniformly, giving strong, vigorous plants?

SCORE CARD OF I. C. G. A.

The Iowa Corn Growers' Association adopted in 1908, the following score card:

I. General Appearance,	25	
1. Size and shape of ear,		10
2. Filling of butts and tips,		5
3. Straightness of rows,		5
4. Uniformity of kernels,		5
II. Productiveness,	60	
1. Maturity,		25
2. Vitality,		25
3. Shelling Percentage,		10
III. Breed Type,	15	
1. Size and shape of ear,		5
2. Size, shape, and dent of kernel,		5
3. Color of grain,		2
4. Color of cob,		2
5. Arrangement of rows,		1

The explanation of points is practically the same as that previously described. Its purpose primarily is to condense as much as possible the essential points to be considered by a judge in placing awards in the State Contest at Ames. The judge is to score each sample and attach the score thereto for the benefit of the exhibitor.

PRACTICAL HINTS IN JUDGING CORN. Exhibitors are rapidly acquiring an intelligent understanding of how to show corn. A judge will arrive at a town in which an institute and corn contest are to take place. It may be that an old store, a hall, or open tent has been reserved for the purpose. A number of entries have been made. The corn is in baskets, boxes, sacks, or even hanging about the walls by the husks. The first thing for the judge to do is to get some wooden horses made or secure some dry goods boxes about three feet long. Lay these with end up. Have 14 or 16-foot planks brought up from the lumber yard; place three of these side by side on a row of boxes. Twelve-inch boards are too light and sag in the middle, causing trouble with the kernels. Arrange the samples of corn, ten ears in a place, at intervals along the outside planks. Separate the samples about six inches, by the use of ten-penny nails driven two at each end of a sample. If a farmer has brought 13 or 14 ears, let him pick out what he considers the best ten to enter. When every improvised table has been set in order and all the samples arranged with butts even with the outer edge of the outside plank, the corn is ready to be judged. Before going any further, have a definite understanding with the officer in charge, regarding the classification, rules of entry, number of prizes for each class, and other details, in order that there may be no errors made.

Arrange all samples before beginning to judge

Beginning at one end, take two kernels out of each ear, near its middle, place the kernels, germ side up with tips of kernels pointing toward the ear, at its tip. An experienced judge can now pass upon each sample with his eye as he slowly walks by and immediately eliminate some samples from the competition. That is, there may be samples which show lack of any definite breeding; each ear is a type in itself. Other samples may have a very shallow, flinty kernel with large cob and poor butts and tips. Another sample may be a mixture of varieties with a number of kernels showing immaturity on the surface.

Taking out the kernels

If the show happens to come early in the gathering season, very careful examination must be made for maturity. This is especially true of corn in the northern districts. By taking each ear in the hands and twisting slightly, the movement and sound of the kernels will indicate the degree of ripeness. Many samples which are large and showy-

Observe maturity closely

looking, indicate to the touch and eye of the experienced judge that they may not mature. In other words, he cannot place such an entry at the top because it is liable to injury by freezing and may not produce if planted the next year. Such samples should also either be eliminated at once or considered only on condition.

Frozen germs disqualify an ear

Corn exhibited during the winter is liable to injury by freezing, or may have been frozen previously. A sappy condition of the ears will arouse suspicion. Careful examination with a knife of several kernels from each ear will indicate those ears which have been frozen and hence are likely to germinate weakly. Simply lay open the surface of the germ with the point of a knife blade. Allow the embryo to lie in its place. If it is brownish or yellowish and swollen, it has very likely been frozen. The entire mass of the germ is often like salve, having also a yellowish color. A frozen ear could not possibly score more than zero for seed purposes. A sample with several frozen ears cannot be placed high in the awards if unfrozen corn is on competitive exhibition. If judging is to be done with old corn which has been stored a year or more, it will be difficult to detect an injured embryo. Usually, if the embryo be pale in color and much diminished in size, the chances of strong germination are slight. Starchiness and chaffiness are generally indexes of immaturity in old samples.

Balance points closely between the best samples

After all means of ready elimination have been carried out, a careful study of the samples at hand should be made. The size and shape of the ears, the size and shape of the kernels, evidence of definite selection for breed type—all should be considered. Choose a small number of the samples of the highest standard. Study still more, carefully balancing the points in favor of one over another. One sample may show more breed type, but be a little bit immature, while another of large ears may lack uniformity and show little evidence of definite selection. It is best to choose the former sample. If any one is an outstanding winner, then balance one against another as the ranking of the remainder is continued. Often in close competition, the ears of two samples may have to be pitted against each other; that is, place all the ears of each sample in order of their merit from 1 to 10. Then compare ear No. 1 of sample A with ear No. 1 of sample B, and so on until the majority of points lies with one sample or the other.

Be sure you are right before tying the ribbons

When all the samples are placed, a good plan is to walk around the tables once more to satisfy one's self that no samples of worth have been overlooked. Always maintain a respect for the opinions of those who may be on-lookers or owners. They are present to learn, if not to criticise. Answer questions civilly, taking care to offend no one, yet placing the awards by your own judgment. Be sure you have a good reason for placing every sample before you call the secretary or entry clerk to record the winnings. If you have no such reasons, then you have placed the samples not by good judgment, but by guess. When the ribbons are brought, tie them yourself, reading the entry number for the clerk as you do so. In a large show this is often impossible, but many times trouble arises from someone tying ribbons on the wrong samples.

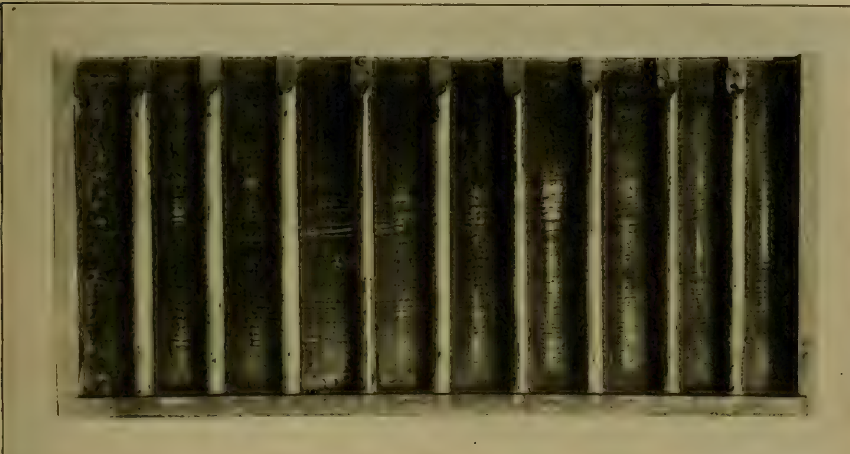


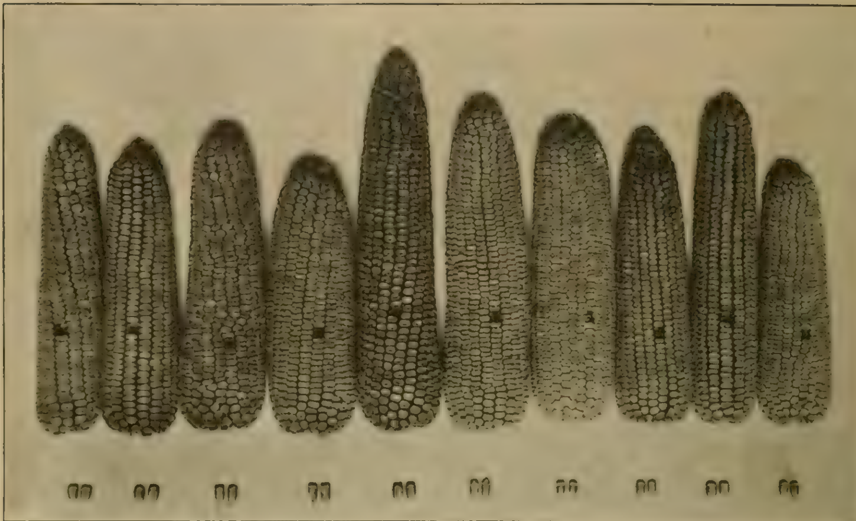
Fig. 321.

CORN TRAY.

Very convenient for handling samples of 10 ears either in the class room or for exhibition purposes. Dimensions—28 inches long by 12 inches wide by 1½ inches deep. Divisions 2 inches apart. Sides and bottom of ½ inch material, Groove in front ¾ of an inch wide.

SELECTING A SAMPLE OF CORN FOR SHOW. There are a great many different points to be taken into consideration in selecting a sample of corn for show purposes. An ear of general utility should always be uppermost in mind. We often find at corn shows a sample of corn in which each ear, while it may be very serviceable, differs so much from the other ears in the sample that it is impossible for the sample to rank high in the competition. When choosing a sample of corn, as in choosing animals for breeding purposes, it is necessary that there be a definite type in mind and that each ear of the sample conform as nearly as possible to that type. The type will vary according to the variety of corn which is being grown and this type should be firmly fixed in the mind of the one who intends to show. (See Fig 145.)

Often ears differ in length



Courtesy of the Iowa State College.) Fig. 145.

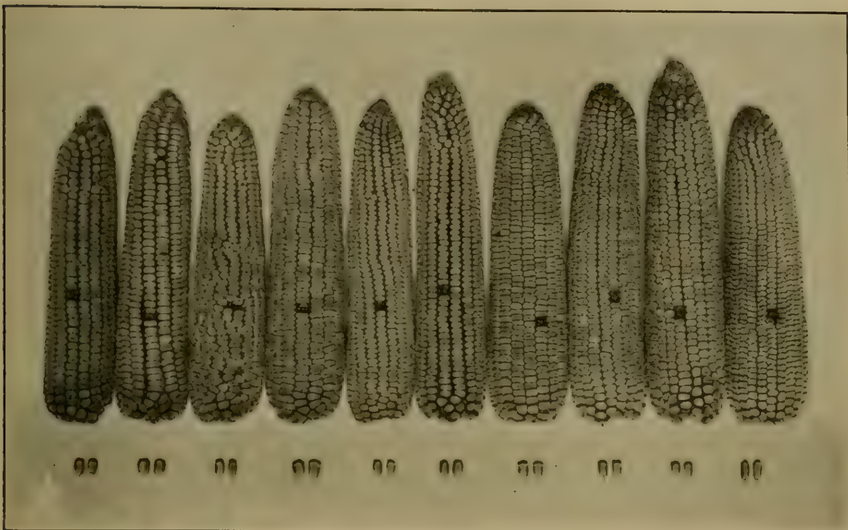
SAMPLE LACKING UNIFORMITY IN LENGTH OF EARS.

The kernels should have uniform shape and depth

The ears should be as far as possible of the same shape; of uniform length and circumference. The kernels of each ear should conform to one another throughout, being of uniform size and color. Too often the regularity of the kernel is lost sight of and an ear will be displayed in which the kernels have a tendency to run in various directions, as well as being of numerous sizes. No matter how well matured an ear may be, having a very desirable shape, of good size, and shelling a high percentage of corn to cob, if the kernels are very irregular and of different sizes, it is impossible for that ear to rank high as a seed ear. This applies to our dent varieties, all of which we expect to be regular and uniform in kernel. (See Fig. 145.)

The butts and tips should be well fitted with kernels of a regular, uniform size. The tendency is for the kernels to be large and of irregular size at the butt, while often small and shallow at the tip. An ear should not be thrown out because the tip is not completely covered. A good butt is more essential than a good tip; it is, however, very essential that there be a large amount of good corn between the butt and tip.

There is another class of samples that is very frequently found at corn shows in which the ears are of quite uniform size and shape, yet the kernels are greatly different. (See Fig. 146.)



(By courtesy of Iowa State College.)

Fig. 146.

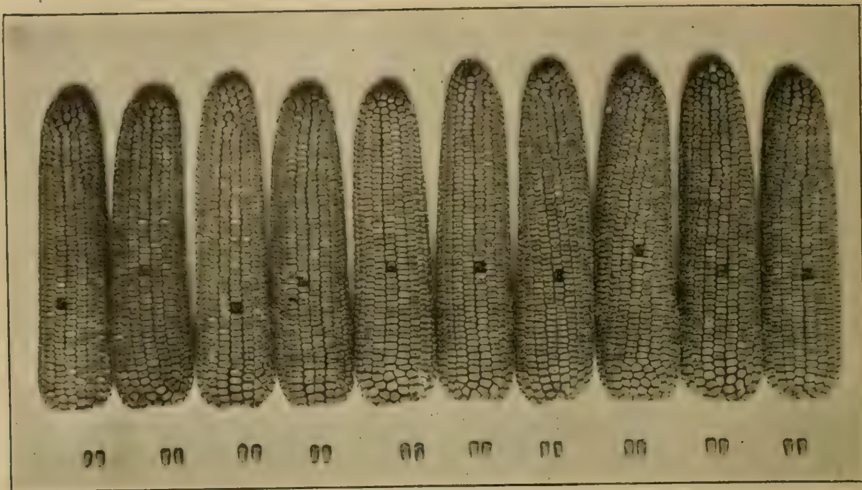
SAMPLE SHOWING FAIR UNIFORMITY IN LENGTH OF EARS BUT THE KERNELS ARE OF DIFFERENT TYPES.

Kernels should be taken out by an exhibitor in selecting the sample

Very frequently at corn shows the following question will be asked by exhibitors: "Has a person a right to take kernels out of an ear to examine them before showing?" He most certainly has! It is impossible for him to be sure regarding the depth of the kernel without making an examination. The best way is to take a couple of kernels out, examine them for shape and depth and place them back in the ear, turning one of them about. In this way, they will very generally retain their places. There is a very common opinion prevalent that if a couple of kernels are taken out of the ears, the judge is very liable to consider that these kernels had been "white caps," and therefore the ear will be discriminated against. An exhibitor can no more exhibit a ten-ear sample of corn intelligently without taking a couple of kernels out of each ear to examine them to see that the sample conforms in uniformity of kernels as well as uniformity of ear, than the judge can properly judge a sample of corn without also examining the kernels in each ear exhibited. The depth of kernel, plumpness of tip, and size are important factors.

Immature corn can not be placed

An immature ear is not entitled to a place. Maturity cannot be profitably sacrificed to size of ear, though a nubbin is never desirable from the show standpoint. The practical ear (and that is the ear for which we should strive), is the largest possible ear that will mature



(ByCourtesy of the Iowa State College.) Fig. 147.

EARS OF SAME LENGTH AND KERNELS SIMILAR IN TYPE.

in each respective locality, being of the desired type, and shelling a high percentage of corn to cob. A small, matured ear is much more

Fig. 148.

SECTION OF CORN EXHIBIT AT THE IOWA CORN GROWERS' ASSOCIATION, JANUARY, 1907.

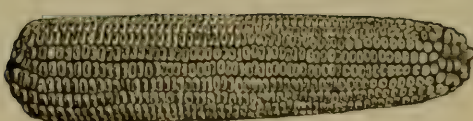
desirable than a larger immature one. Examine each ear thoroughly. Samples of corn with germs showing evidence of freezing are found frequently at corn shows. Such samples are unfit for show and should receive no place in competition with corn for seed.

COLLATERAL READING:

Score Card for Dent Corn,
Ohio Circular No. 61.

Hints on Preparing and Holding Corn Shows,
Indiana Circular No. 1.

Send for score cards of the Corn Growers' Association of each state.



CHAPTER XIX

THE VARIETIES OF DENT CORN

NOW PRINCIPALLY GROWN IN THE CORN BELT

LEAMING.

Originated by S. Leaming, Wilmington, Ohio

HISTORY. This is the oldest known variety of corn, having been originated by Mr. J. S. Leaming, near Wilmington, Ohio, in 1826. At this time he began selecting seed from the ordinary yellow corn grown in Hamilton County on the Little Miami bottoms. As soon as the ripening of the husks indicated that the corn was beginning to mature, he would go through the field, selecting an ear slightly tapering from butt to tip, well filled at butt and tip, with straight rows, and ripening in from 90 to 110 days. For 56 years he followed this careful system of selection. His son and other breeders have continued his work.

BREED CHARACTERISTICS.—Stalk. The Leaming is not a rank growing variety, being more of a producer of grain than stem. It has very little tendency to sucker and does not remain green late in the fall.

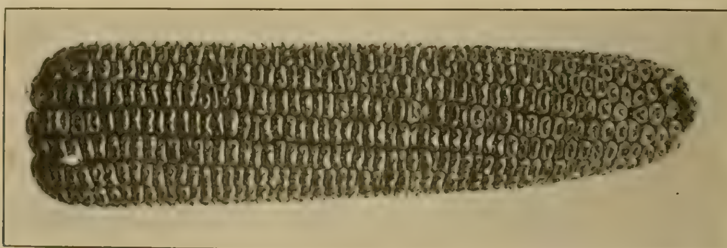


Fig. 149.

LEAMING.

Ear. The tapering ear of the Leaming is a most marked characteristic. When allowed to do so without care in selection, the ears will so become short with a flaring butt and a rapid, pointed taper from shank to tip. Often a row or several rows will be lost near the tip. The best breeders today are trying to hold the type full in the middle with a gentle taper at the tip. Being a heavy ear, the shank will always be large and when removed leave a somewhat open butt. The length of ear varies from 9 to 10½ inches, even the northern-grown Leaming keeping its length. The cob is red, although a pale color sometimes appears. Breeders today are trying to eliminate this.

Tapering ear

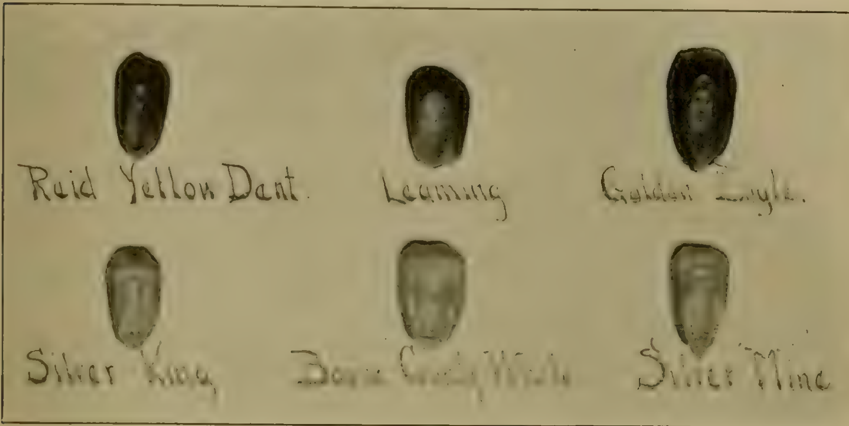


Fig. 150.
KERNELS OF DIFFERENT VARIETIES.

Kernel. A Leaming kernel is of medium depth, quite thick, and the edges touch each other at the tip, but part near the crown. The kernel is less of a parallelogram than the Boone County White, and consequently has less shoulder at the tip. The germ is very broad and sometimes covers the face of the kernel almost as much as the Reid. Being horny almost to the crown the kernels give the surface a rich, almost orange yellow appearance. The original type was a dimple dent, but breeders today have evolved a heavy crease. Being of shallow kernel and often having a large cob, the shelling percentage is rather low, not exceeding 88 per cent as a rule.

Blocky thick kernel

Adaptability. Being the first corn to be systematically improved in the United States, the Leaming has been carried to all parts of the corn belt. The shape of the ear and blockiness of the kernels mark many mongrel types to-day. In fact, the one fault of this corn is its irregularity of rows and lack of uniformity in the shape of the kernels. From the beginning, the breeders have had to watch this character, and among the best of them it appears to-day. Not being particular as to soil and having originally been selected for early maturity, it is found among the most northern of dent varieties.

Adapts itself readily

CONTEMPORARY BREEDERS. In 1885, E. E. Chester, of Champaign, Illinois, secured seed from J. S. Leaming. In continuing the type, Mr. Chester has selected ears which ripen in from 100 to 120 days. J. H. Coolidge, of Galesburg, although securing seed from Mr. Chester, has developed even a deeper kernel.

Leigh F. Maxey, of Curran, Illinois, says that he purchased his first bushel of Leaming seed on March 10, 1897, of Mr. E. E. Chester, Champaign, Illinois, who secured his seed direct from the originator, Mr. J. S. Leaming, of Wilmington, Ohio, in 1885, and from this stock of seed perhaps all strains of Leaming corn now grown by different breeders in Illinois have been originated. He has grown this variety continually since his first purchase.

In Iowa, the Leaming strain is shown in almost all the unimproved corn throughout the state. The large shank and tapering ears are commonly present. This corn, however, has been a fair yielder and always hardy. Fred Woolley, of Garden Grove, Decatur County, is the only breeder who has tried to improve the Leaming in Iowa. He began 18 years ago with the common strain as a foundation. However, in 1904, he secured the improved type from E. E. Chester, of Champaign, Illinois, and has kept this pure by the "ear to the row" method. The original type formerly grown he found earlier than Reid's Yellow Dent, but this larger, deeper grained, more improved kind is a little later.

REID'S YELLOW DENT

Originated by Reid in 1846 in Tazewell County Illinois

EARLY HISTORY. In 1846 Mr. Reid moved from Brown County, Ohio, to Tazewell County, Illinois, taking with him a reddish colored variety of corn known as the "Gordon Hopkins" corn, which was widely grown in the vicinity where Mr. Reid had lived. The corn was planted late in the spring of that year and though yielding well the corn was immature. The best of this was selected for seed the next year, but because of the immaturity of the seed a poor stand was obtained. The field was then replanted with seed of the Little Yellow corn and thus a mixed red and yellow corn was obtained. Since that time, or for nearly sixty years, this corn has been kept pure and carefully selected for a definite type, and because of this long and careful selection its characteristics are unusually well fixed.

BREED CHARACTERISTICS.—The Stalk. The Reid corn is a gross feeder. Being rather highly bred under the best of conditions, the stalk is rank with abundant foliage, although not so likely to sucker badly as some other varieties.

Ear cylindrical and slowly tapering

The Ear. The Reid's Yellow Dent is characterized by a slowly tapering ear, with deeply rounded and compressed butt. When first recognized and brought out for exhibition, the tip was very stubby and

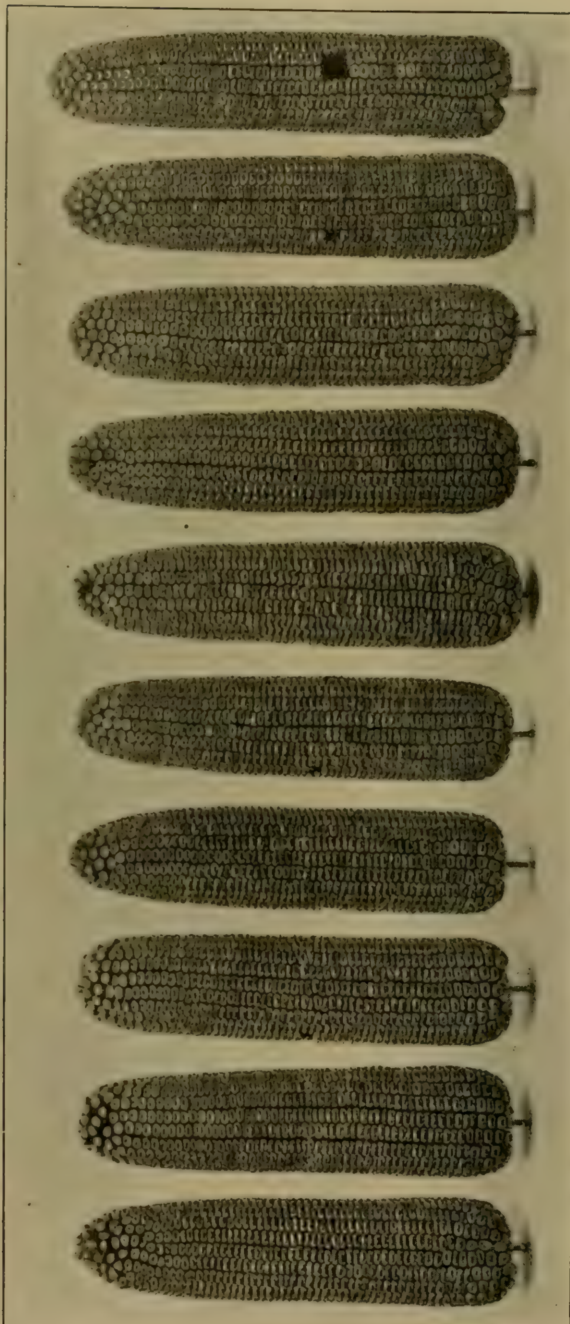


Fig. 151.

REID'S YELLOW DENT. CHAMPION TEN EARS OF IOWA SHOWN JANUARY, 1907. GROWN BY BENNETT BROS.

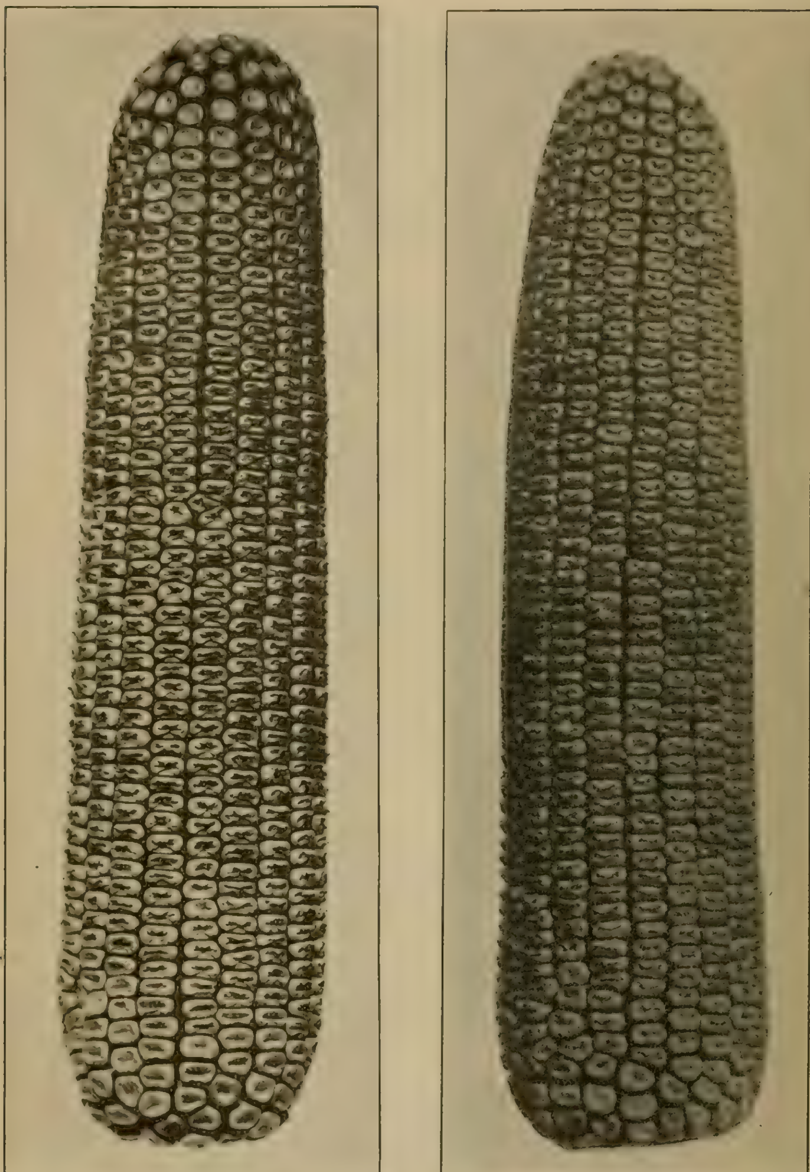


Fig. 152.

TWO TYPES OF TIPS IN EARS OF REID'S YELLOW DENT.

The ear to the left has the abruptly rounded, very full tip. This is the D. L. Pascal ear, champion of the world. The ear on the right has the gently tapering tip which goes with an earlier maturing type of corn. Champion of Iowa in 1908, shown by J. A. Mason.

was cut off squarely. This peculiar though very showy character was found to reproduce a late maturing ear. Hence, at present a gently rounding tip is preferred, with, however, depth of kernel over the entire cob. A Reid ear hangs on a very small shank and often because of too close selection on this point, is even too fine. The ear is medium in length, measuring 8 to 10½ inches.

Kernels. The distinct pairing of the rows of kernels, the extreme triangular outline of the edges of the kernels which dovetail together and the large open-faced germ extending almost to the crown and covering the face of the wedge-shaped outline, are all characteristics of the Reid corn. Usually the germ has a marked seam down its center. The kernels, which are firm and upright on the cob, are of varying shades of yellow, usually being light, though not of a weak, starchy appearance. Often a tinge of copper color shows on the surface, due to the early breeding of the "Gordon Hopkins" corn.

Rows paired kernels wedge-shaped

The dentation of the kernels is very noticeable when grown in the central part of Illinois or southern Iowa. On strong ground a pinched appearance may occur. As it is acclimated to more northern latitudes the kernels become shallow and flinty with a dimpled surface. This was the original Reid type, but the best breeders today select a bridge-crease dent.

Adaptability. Reid's Yellow Dent matures in 110 to 120 days, being a medium late maturing variety. Many farmers in Iowa and Nebraska have had very poor success with it the first year, because it keeps on growing on rich soils until caught by frost. It has, however, become a very versatile variety, and by changing its type adapts itself to new environments. Being highly bred, rigid seed selection must be continually practiced or the prolificacy and trueness to type of the variety is rapidly lost.

Has spread over a large territory

CONTEMPORARY BREEDERS. It has been said that there are as many types of Reid's Yellow Dent as there are men who grow this variety. There are, however, a few breeders who have developed such strength of blood lines that each has a group of amateurs following in his footsteps. The Funk Brothers, of Bloomington, Illinois, have evolved the Funk's Yellow Dent by selection and mating from the original Reid stock. W. E. Johnson, of Athens, has been a pioneer in a very substantial way, not only distributing seed in other states, but following it up and encouraging the purchasers by putting up premiums for them. W. H. Young, also of Athens, has been a consistent winner in the Reid classes. His corn shows a wonderful trueness to type. W. H. Dunseth, of Waverly, Illinois, though a grower of several other varieties, has developed a heavy yielding, rough-dent Reid, which has been an annual sweepstakes winner at the Illinois State Fair.

D. L. Pascal of Iowa

In Iowa, D. L. Pascal, of DeWitt, who purchased his own grown ear at $150 at the auction of the Iowa Corn Growers' Association in January, 1907, has through rigid selection established a Pascal type. Mr. Pascal is himself a lover of good corn, and studies the growth of the trial plots in the field. Eastern Iowa has profited much by his influence.

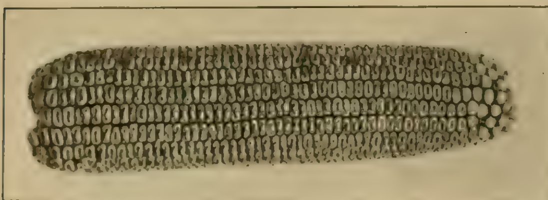


Fig. 156(d).
REID'S YELLOW DENT

J. F. Summers, of Malvern, being on the rich soil of the Nishnabotna River, has by careful selection and care in removing weak and barren stalks from his breeding blocks, brought out a heavy yielding type with a very deep kernel.

F. S. Bone, of Grand River, has carried the theory of experimental breeding into actual operation on the farm. The results of his efforts are showing in local and state contests.

W. A. Hook, of Packwod, though starting in a small way, may be said to be keeping the closest records of his breeding work of any breeder in the state.

Among other men who are producing a consistent type of Reid corn are John Sundberg, of Whiting; Bennett Brothers, of Ames; M. S. Nelson, of Goldfield; Fred McCulloch, of Hartwick; J. W. Coverdale, of Elwood; L. C. Hutcheson, of West Branch; Neal Brothers, of Mt. Vernon; George M. Allee, of Newell; Paul C. Taff, of Panora; W. P. Coon, of Ames; Charles O. Garrett, of Mitchellville, and C. R. Bishop, of Altoona.

IOWA SILVER MINE

Originated with J. H. Beagley of Sibley Illinois

HISTORY. The Iowa Silver Mine originated with J. H. Beagley, of Sibley, Illinois, from seed of a white corn which won a prize at the Ford County Farmers' Institute in 1890. After several years of careful breeding, enough seed was secured to plant 20 acres. The resulting entire crop was bought by the Iowa Seed Company, of Des Moines, in 1895, for $1,000. They named it the Iowa Silver Mine.

BREED CHARACTERISTICS.—**Stalk.** Silver Mine is not a rank growing variety; even on rich ground it does not produce such an abundance of foliage as other varieties. The stem itself is short and of a finer texture with little coarseness about the joints. Even under adverse conditions the hills seem comparatively free from barren stalks.

Not a rank grower

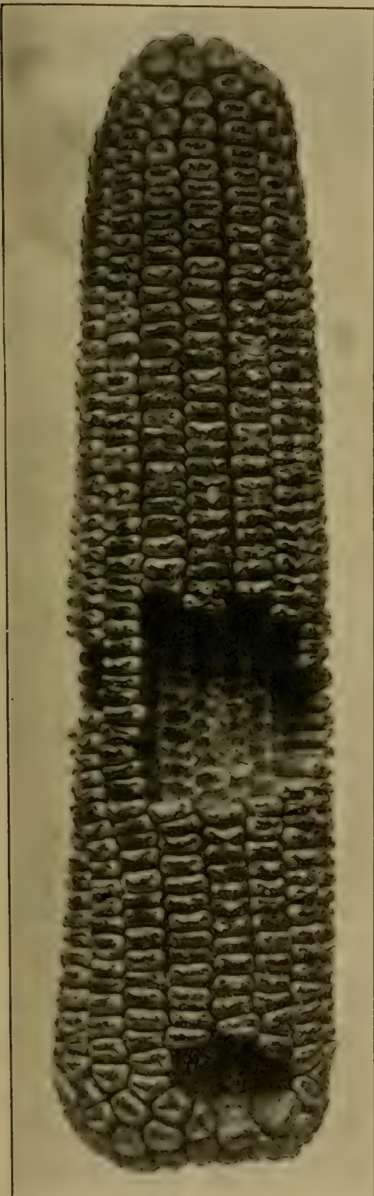


Fig. 153.
SILVER MINE.

Ear. The type of ear sought in the Silver Mine corn is only medium in size, with a full middle, being cylindrical part of the way from butt to tip, and then slowly tapering off at the tip. The length runs from 8 to 9½ inches and the circumference is large in proportion. The shank is medium small in size, but the butt does not have the smoothly rounded cup-shape that is found in the Reid. The cob is pure white, with a very fine texture and weighs light when dry.

Ear with full middle

Kernel. The rows, which average about 18, are paired, though less distinctly than in the Reid. There is considerable space between the crowns because of the depth of the kernels. However, the grains are firm on the cob and no chaffiness is present. The kernel itself is a slowly tapering wedge, with a plain open-faced germ which graduallly widens from crown to tip, until it almost covers the endosperm on either side. The tip of the kernel lacks prominent shoulders, but rounds off plumply. The kernel has very little thickness compared

Kernel deep, wedge-shaped, thin

with its width and often the germ extends almost to the back side. Silver Mine is properly of a creamy white color, with a medium pinched dent. However, some breeders select a shallow kernel with a heavy crease dent. The deep grain and small cob in Silver Mine, together give it a high shelling percentage, averaging 88 to 89 per cent. This deep kernel is, however, very seldom starchy, being horny almost to the crown. Starchy crowns are pale white and lose the strength of appearance found in the cream color.

Most adaptable of all varieties

Adaptability. It is claimed by its distributors that the Silver Mine is adapted to a wider range of climate and soil than any other corn offered on the market. This claim seems very true because it is capable of growing on especially poor soils. As it has a tendency toward grain rather than fodder production, the plant food in the soil goes directly to feeding the ear. The fact that this corn matures in from 100 to 105 days accounts for its forging northward on the richer soils where previously only very early shallow grained varieties were grown.

CONTEMPORARY BREEDERS. F. A. Warner, manager of the Sibley Estate, Sibley, Illinois, has bred the Silver Mine corn for a number of years. His type is somewhat larger than that of Iowa and is coarser in the cob and later in maturing.

In Iowa, M. S. Nelson, of Goldfield, has grown this variety in the northern section of the state. J. H. Petty, of Elliott, and W. A. Hook, of Packwood, have grown a large type quite extensively in the southern counties. The latter has tried a few ears in the test plots.

BOONE COUNTY WHITE

Originated with James Riley of Boone Co. Indiana

HISTORY. This variety was originated by Mr. James Riley, of Boone County, Indiana, in 1876. In that year he selected what he considered a desirable type from a large, coarse corn grown in his county, known as the White Mastodon. He planted the selected seed in an isolated field and developed it by selection without crossing with any other varieties. The barren stalks were removed before thep produced pollen. After several years of such careful work he developed a new type of corn which he named after his home county.

BREED CHARACTERISTICS.—Stalk. Boone County White is a vigorous grower and requires a strong soil. The stalk is rank, with heavy joints and short internodes. Although not suckering extremely, the leaf expanse is large.

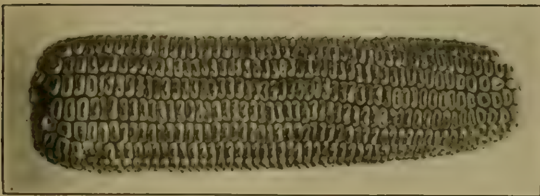


Fig. 156(c).
BOONE COUNTY WHITE.

Ear. The ear of this variety of white corn is longer in proportion to its circumference than is the Silver Mine. The shape is quite cylindrical, with a slow taper the entire length of the ear. Both butt and tip are cut off squarely. The shank is very large and when broken off leaves a flat, rather open butt, around which the kernels do not fill in. The cob is rather open and porous and usually quite heavy. The length of ear varies between 9 and 10¾ inches.

Very large cylindrical ear

Kernel. The Boone County corn is a pearly, clear white, due to the fact that the crown starch is such a very thin layer that the horny endosperm below shows on the surface of the ear. The kernels are medium to shallow in depth, but because there is no excess of dent the percentage of corn to cob is surprising though not high. The rows have some space at the crown due to the fact that the sides touch all the way down to the tips. That is, the kernel is almost a perfect oblong with little narrowing at the tip. The thickness of the kernel is greater than any other of the principal varieties. The germ extends almost to the crown, but is not so wide at the tip as in the Reid or Silver Mine. In other words, the horny endosperm lies prominently on each side of the germ, forming near the attachment at the cob a pronounced shoulder. The dent in earlier years was sometimes so smooth as to resemble the dimple. It later became the crease, and some breeders have deepened the kernel and shortened the ear, until a slight pinch is noticed. Although bred pure, unless the care is taken in selecting seed each year, there is a tendency for the ears to become shallow and flinty over the tip. Often the furrows become too deep also.

Very thick blocky kernel

Adaptability. Boone County White makes demands on the soil which can not be supplied except in alluvial districts. Being a medium to late maturing corn, requiring a season of 120 to 125 days, it will never move northward very far. At present, it is found principally in the southern half of Indiana and Illinois, and in a few counties near the south line of Iowa. Missouri is a Boone County corn state.

Limited to southern sections

CONTEMPORARY BREEDERS. In Illinois, O. C. Black, of Champaign, has developed a rougher type with a deeper kernel. A number of other breeders in the state have done the same thing.

In Iowa, Lenus Hagglund, of Essex, on the rich soil of the Nishnabotna, has kept very pure and raised to high standard of productiveness and quality, a type of Boone County which, although of a rough dent, shows the original form. Because of the quality of this seed a considerable locality near Essex has taken up the variety. F. S. Bone, of Grand River, breeds the Riley type strictly.

LEGAL TENDER

Iowa variety originated by Nims Bros. Emerson Mills Co.

HISTORY. In 1876, Nims Brothers, of Emerson, Iowa, crossed two distinct types of corn, one a short ear with deep grains and from 20 to 24 rows of kernels; the other a long ear with good shaped kernels and from 12 to 16 rows. The resulting cross was developed into a variety that has been carefully selected for 30 years. Their first winnings were made at the corn exhibit held in connection with the Chicago Fat Stock Show in 1886. The late D. B. Nims, deceased November 1906, was an inveterate worker and did much to disseminate this breed of corn by exhibiting at the Iowa State Fair and at the annual contests of the Iowa Corn Growers' Asociation. In all his breeding he strove for yield, even sometimes losing sight of uniformity of kernels and shapeliness of the ear. J. W. and Henry L. Nims are continuing the work of the brother and father.

BREED CHARACTERISTICS.—Stalk. A field of Legal Tender can almost be distinguished from that of any other variety even under similar conditions. From the time of germination to maturity the plant is a very vigorous grower and shows an abundance of foliage even on poor ground. In fact, it can be severely criticised for this tendency. The nodes are thick and prominent and the internodes stocky. Because it does draw heavily upon the soil and because this character has not been discriminated against in its early development, the Legal Tender throws out a large number of suckers.

Ear lacks proportion

Ear. The ear of Legal Tender when judged by the standards of other breeds seems to lack proportion. That it, its extreme length, 9 1-2 to 11 inches, is not proportioned by like circumference. The ear is almost cylindrical and the tip rounds off abruptly. There is a tendency about the butt to be poorly filled, but the shank is none too large for the weight of the ear. The cob does not have quite the cherry-red color found in the Reid corn.

(Courtesy F. S. Bone) Fig. 154.

SECTIONAL VIEW OF AN EAR OF LEGAL TENDER.
Note the deep kernels with large germs.

Kernel. The original type of Legal Tender was a kernel of medium depth. But a few breeders have developed a very deep grain which soon became shoe-pegged and lacking in fullness at the tip. This type was also very chaffy and became late in maturing and rather starchy. However, the kernel is the deepest of the varieties of Iowa and is rather narow with straight sides, and quite prominent shoulders at the tip. The germ, which extends in depth almost to the back of the thin grain, is very broad and covers the entire face of the kernel, reaching near the crown as well. Although very deep and shelling 90 per cent of corn, the kernels are firm on the cob.

Deep kernel rather narrow.

Adaptability. Having originated on the rich, warm soils of southwestern Iowa, the Legal Tender is really a special purpose variety. When tried farther north the only outcome has been a shortening of the kernel and a lessening of the size of ear. In northern Missouri and eastern Kansas it has proved to be a very heavy yielder. When pushed farther westward into Kansas, however, it did not secure sufficient rainfall.

CONTEMPORARY BREEDERS. The immediate locality of Emerson has developed a number of Legal Tender enthusiasts. Montgomery and Page Counties have several men who produce a winning type. As yet all are amateurs and could not be spoken of as breeders.

RILEY'S FAVORITE

Originated by James Riley

HISTORY. This variety of Yellow Dent corn was originated by Mr. James Riley, of Boone County, Indiana, in 1885. He will be remembered as the originator of the Boone County White corn. Mr. Riley desired a larger corn than the Pride of the North, which was quite generally raised in his section, and yet one that would mature. Accordingly he crossed the Golden Yellow, a large late corn, with the Pride of the North, a small early maturing corn, thus producing a hybrid. He planted this corn in isolated places each year, carefully cutting out diseased and barren stalks until he fixed a type of fully desirable yellow corn which would mature in a little more than 100 days. With this object in view he selected for a medium sized ear, small cob, well filled butts and tips, and stalks of medium height.

BREED CHARACTERISTICS. Riley's Favorite is not a rank grower and usually has a stalk of medium height. The ear is slowly tapering, seldom exceeding 9 inches in length. For a crossed variety the rows are surprisingly uniform and the butt is quite evenly rounded with very little coarseness. The cob is small and for an early corn is a high sheller, even up to 89 per cent. The kernels are only fairly firm on the cob, with considerable space at the crown. The outline is that of a thin wedge, and the dent is markedly pinched. The ear presents a very striking orange yellow color.

GOLDEN EAGLE

H. B Perry Stark County Illinois

This variety of corn was originated by Mr. H. B. Perry, of Toulon, in Stark County, Illinois, in 1871. He began his selection from a variety known as the "Mason County Yellow," which was a small eared corn with small, bright yellow kernels and red cob. This corn has never been crossed with other varieties and selection has been especially for a large proportion of corn to cob, which fact is evidenced in the deep kernels and well filled ends.

The ear should be slowly tapering and of medium length; kernels

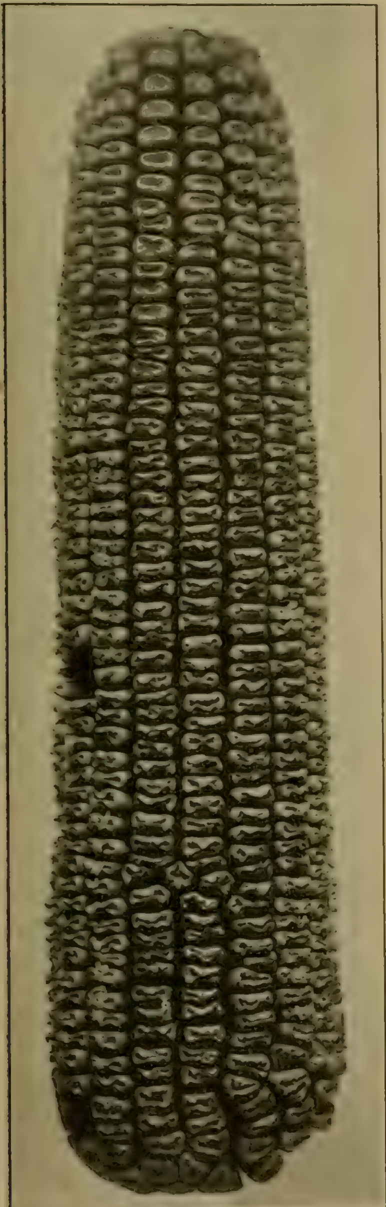


Fig. 155.

GOLDEN EAGLE.

deep, bright yellow in color, loose, and upright on cob, with straight edges and sharp, rough dent; number of rows 16 to 20, with medium to wide spacing between the rows; butt moderately rounded and compressed, cob small and red with small shank. This variety is of medium maturity, ripening in from 100 to 115 days, and is adapted to the latitude of central Illinois, where it is grown to a considerable extent.

Highest shelling percentage of all

WHITE SUPERIOR

The history of the White Superior variety, as nearly as can be learned from the account of Mr. P. R. Sperry, of Warren County, Illinois, a breeder of this corn, is as follows: Mr. Shaffer, a seed specialist, in 1880 brought from Pennsylvania to Warren County, Illinois, a variety of corn called White Elephant. In 1895, Mr. Sperry began selecting seen from this variety for a different type than the White Elephant. He selected one bushel of seed of the type desired and planted this seed by itself, so that it would not be mixed with any other variety. In changing the type of corn Mr. Sperry changed the name to the White Superior. It is a medium to late maturing variety, ripening in 105 to 120 days.

Originated by P. R. Sperry of Warren County Illinois

His selection was as follows: Kernels one-half inch in length and one-fourth inch in width; ears 11 inches long, 7 1-2 inches circumference, with little space between rows. The White Superior is adapted to central and north central sections of the state of Illinois.

Corn of medium size

This white corn as it is bred today is of medium size, the length not exceeding 9 and the circumference 7 inches. There are usually about 18 to 20 distinct rows of tapering, dented kernels, with slightly curved edges. The shank is medium to large, with a medium white cob.

SHENANDOAH YELLOW.

Said to be Originated by S. E. Field Page County Iowa

*History. The Shenandoah Yellow has been a distinct variety or rather type, in the vicinity of Shenandoah, Iowa, for twenty years. It is the result of improving and selecting good strains of yellow corn brought there from Illinois by the early settlers. It represents the southwestern Iowa idea of a big, rough, yellow corn of good form, high feeding quality, and extra heavy yielding ability. S. E. Field and others of Page County, Iowa, were the early growers of this corn. It was not offered for sale and distribution until 1901, when it was entered in the seed catalog of Henry Field. It has proved a great success in loose, warm, fertile soils; but as it is a heavy feeder, it has proved a failure on hard-pan land in light soils. It is especially popular in northwestern Missouri.

Large ear, orange yellow

Breed Characteristics. The stalk is very coarse, with abundant foliage. This corn is a very rank grower. The ear is a large one, measuring about 10 inches. The kernel is very deep and is broader than most of the high shelling varieties. It has a very sharp, pinched dent. The type is not as yet very uniform, but the predominating color is a dark orange yellow, and the shape of the ear is almost cylindrical.

FARMERS' RELIANCE. H. H. Connell, of Deep River, Iowa, is the breeder of this corn, which is the result of a cross, his object being an extra early corn, yet as large as it could be made. As Pride of the North has been improved, he has allowed Farmers' Reliance to become somewhat larger and also later. It is now medium early, a strong, rapid grower, and a sure cropping variety. The ears are medium in size, tapering, with firm, rather smooth grain.

Very popular where seasons are short.

PRIDE OF THE NORTH.—History. Pride of the North was originated and developed by H. J. Goddard of Fort Atkinson, Iowa. Mr. Goddard began breeding this corn in 1890. 40 bushels of this seed were sold to the Adams Seed Company, of Decorah, Iowa, in 1875. The next year Mr. Savage, special agent for the Hiram Sibley Seed Company of Chicago, came out to Mr. Goddard's farm and con-

*The real development of this variety has been brought about by the efforts of Frank Keenan of Shenandoah.

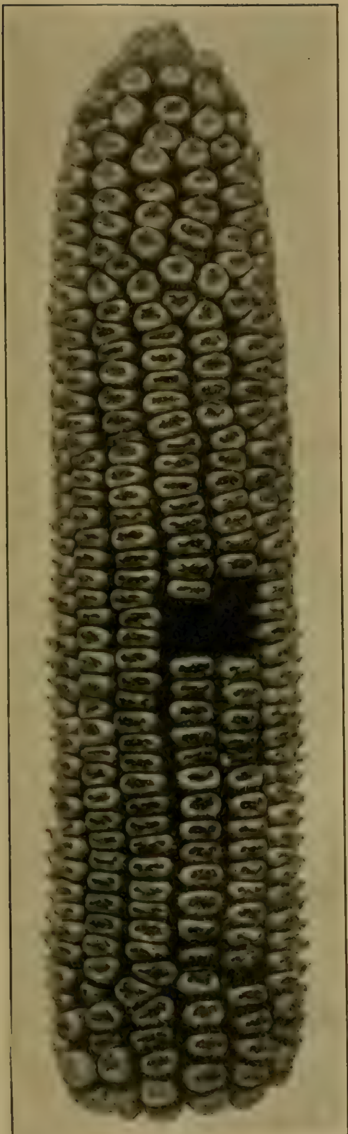


Fig. 156.
PRIDE OF THE NORTH.

tracted his entire crop. The publicity given the new variety by this large company, together with its record in the corn show soon made the Pride of the North the most widely grown corn in the northern part of Iowa and Illinois. In 1886 a sample of Mr. Goddard's own breeding was awarded first premium at the Chicago Exposition.

Breed Characteristics. Pride of the North is a yellow corn with rather shallow kernel, slightly tapering ear, and having 12 to 16 rows of kernels, is therefore small in circumference. Its strongest points are early maturity and strength of breeding.

SILVER KING.—History. Silver King Early Dent corn was originated and developed by H. J. Goddard, of Fort Atkinson, Iowa. Of the truly **originally came from Indiana** great breeders of corn which have carried on their work in Iowa, Mr. Goddard is the foremost. In 1869 he purchased half a bushel of seed corn from a man living in Eldorado, Fayette county, Iowa. The seed originally came from Indiana. Mr. Goddard has persistently kept the large yet early maturing type in mind. Selection in the field each year has tended to produce uniformity and fixity of breed characteristics. Silver King dent corn was successfully shown at the World's Fair in New Orleans in 1884 and again in Chicago in 1886. Its value as a heavy yielder for the northern localities has led Professor R. A. Moore, of the Wisconsin Agricultural College, to distribute it over that state. Results show its adaptability.

Breed Characteristics. It is a pure white corn, very large ears for

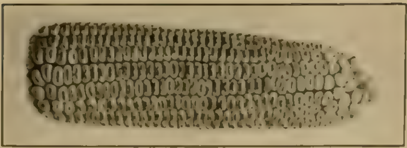


Fig. 156(b).
SILVER KING.

Maturity assured

northern sections. The butts and tips have been bred to complete filling. The grain is very deep for such an early corn. Its maturity is assured every year.

EARLY MASTODON. The Early Mastodon corn originated with C. S. Clark, of Huron County, Ohio, to meet the demand for a large eared yet early maturing variety. It is reckoned as a 100-day corn and has a very wide field of tested adaptability.

CHASE'S WHITE DENT.

History. *"The original stock of Chase's White Dent corn has been grown in southeastern Nebraska for 30 years or more, and was known as the Tucker corn. This old strain of corn is quite popular today in some localities. It has a long slender ear, a universally white cob, and is an easy picking, hardy corn. In 1894, the dryest season probably ever seen in this section, this Tucker corn gave an average yield of 25 bushels or thereabouts. Noticing the hardiness of this corn we obtained some for seed for the next season. In 1894, O. E. Hall, while visiting in Arkansas, chanced to find a white corn with a very deep grain and short cob well filled at both ends. He brought a few ears home with him and planted them. We obtained a few ears of this seed, and planted it with our corn in a fertile portion of the field—a rude, but effective cross. Since that the improvement has been by ear selection entirely, until the last two years, when the row selection system of breeding has been practiced. No pedigree seed for sale however. A son in the agricultural school, believing the corn a good corn for show, selected 30 ears for the corn show at Lincoln in the winter of '03-'04. This exhibit attracted such favorable comment as to cause a representative of the Nebraska Commission at St. Louis to come to our farm cribs and examine the corn and purchase 100 bushels of it for that show, to represent the state."

Well adapted to dryer sections

Breed Characteristics. Owing to the fact that this corn had no name, and as the Nebraska Corn Improvers' Association required a standard, the corn was named Chase's White Dent and given a standard. The standard was adopted by the Association and is as follows:

*F. W. Chase, Pawnee City, Nebraska.

Shape, slowly tapering.
Length, 9 inches.
Circumference, 7 inches.
Kernel, upright.
Translucent in color, and rough.
Kernel, shape, broad wedge.
Cob, white and carries from 14 to 18 rows of grains.
Per cent of corn to cob, 86.

This corn has won its own place in the corn world, and has shown itself to be one of the fittest. It matures about two weeks later than Reid's Yellow Dent.

Matures two weeks later than Rei ' yellow

WISCONSIN NO. 7.—(Originally Silver King.) *"The foundation stock of this corn I received from Mr. William Banks, Burt, Iowa. My attention was called to this corn at a corn contest held at Algona, where I assisted Professor Holden in judging corn. We awarded first prize to this type of corn and I was so satisfied with the corn that on my return to Wisconsin I corresponded with Mr. Banks, the exhibitor, and secured 30 bushels of this corn for our use. We carried on breeding work at our station farm in accordance with the ear-to-the-row method and improved the corn considerable in leaf and stalk development; also in yield of perfect ears. In 1907 something like 17 or 18 per cent of all ears gathered from the field classed as seed ears. We have bred to produce as far as possible one ear to the stalk, because where it produces only one ear the seed is likely to be better than where two or three are produced. Since the corn was perfected we began a rapid dissemination of it through our Experiment Association. We established some 1500 corn centers in Wisconsin, and had members of our Association growing corn for seed purposes at these centers. We feel that the equivalent of no less than 12,000,000 bushels of this corn was grown in Wisconsin last year (1907). One breeding acre at the station farm produced 98.6 bushels in 1907. This is the largest yield ever secured from this or any other variety."

Dent. Originally came from northern Iowa

McAULEY WHITE DENT. Briefly stated, the history of McAuley White Dent corn, how it was produced and how it is now grown, is as follows:

**"The original stock from which the corn is now grown was two

*Prof. R. A. Moore, University of Wisconsin.
**W. S. McAuley, Americus, Kansas.

white varieties mixed and planted together. The one variety was known as 'The Mortgage Lifter,' rather late, the seed being brought from Iowa. The other was known as 'Bulgarian Corn,' an early variety which I think came from Illinois.

Result of a radical cross

After planting the two varieties together for two years I began to notice quite a number of stalks and ears that were entirely different from the original of either of the two varieties planted. I then commenced selecting my seed from this stranger, and by careful selection of seed the type of ears and stalk has become a distinct and established variety. The improvement in ear has been to lengthen it and get uniformity in size and a better filled out ear at the tip. The ears as now grown are 10 1-2 to 12 inches long, with grains set on a white cob of good depth, and running in straight rows from butt to tip of ear. The original stalks were very short and stubby. As now grown, they will measure from 6 1-2 to 7 feet. It has proved itself a fine producer and a very hardy variety."

Stalk very short

GOLDEN ROW. Golden Row originally came from Scioto County, Ohio, 34 years ago, but has been grown by Lee Smith & Son, of DeSoto, Nebraska, as a distinct variety for the past 28 years.

Golden Row is of a bright yellow color, with deep grains. The ears grow from 9 to 11 inches in length, with a circumference of 7 1-2 to 8 1-2 inches. Although having a strong tendency to sucker it matures in from 110 to 120 days.

MAMMOTH GOLDEN YELLOW. Mammoth Golden Yellow is a cross of Golden Row and Hogue's Yellow Dent.* The crossing occurred 15 years ago. Although requiring from 120 to 125 days for maturing, it is a heavy yielding variety.

NEBRASKA WHITE PRIZE. Nebraska White Prize is a very strong heavy rooted variety, stands drought well, and is extra free from suckers. The crop matures in 110 to 120 days and produces an ear 9 to 11 inches in length by 7 1-2 to 8 inches in circumference. This variety has been bred pure for 38 years. It has been selected to a definite type by Lee Smith & Son, of DeSoto, Nebraska, for the last 32 years.

*One of the most widely grown varieties in Nebraska.

IOWA IDEAL. **In 1883 Mr. W. D. Kaylon, of Strahan, Iowa, purchased several bushels of white corn of a neighbor. The variety was known as St. Charles White. In 1894 H. Hilton, of Malvern, Iowa, secured some of this corn. At that time it was a good corn, but there were two different types; one a very thick ear with a large shank; the other a well proportioned ear with a medium shank and

Bred since 1894

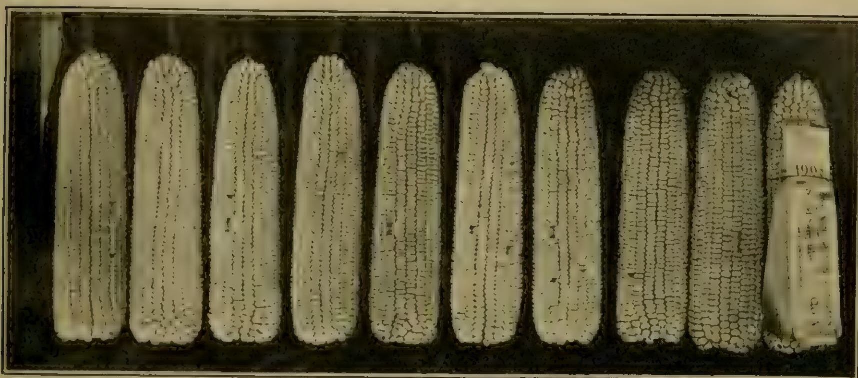


Fig. 156(a).

IOWA IDEAL.

thinner kernel. The best ears of the latter were selected and by close breeding the type has become unusually well fixed. In changing the type of this corn it was named the "Iowa Ideal." This corn was first shown in 1904 by the originator, and won at every place exhibited. It has been shown at all of the leading corn shows since and has always "been in the money." In shape of ear, trueness to type, uniformity in size, and shape of kernel, this corn is not excelled by any other variety. The shape of ear is partly cylindrical, tapering at tip; kernels creamy white, rather thicker than Silver Mine, having no thin-grained chaffy ears. The grain is well dented, a pinched crease dent, with plump, rounding tips; 20 rows distinctly paired; cob medium size, white, shank medium, well filled butts and tips; length of ear 9 to 10½ inches; circumference 7½ to 7¾ inches; matures in 110 to 115 days. This corn does not come from the Silver Mine, as is often thought.

Grain is thick though deep

**From letter of H. Hilton, of Malvern.

"WILLHOIT." *"We began to breed the Willhoit corn forty years ago by using corn that my father brought from Kentucky in the year 1848. I used the best ears that I could find in the field in the fall, by going through and selecting the earliest and best shaped ears, free from mixed grains, and at the same time being careful to get ears that grew out and down from the stalk so as to turn the water out of the ears. As you will know, all ears that grow straight up with the stalk are filled at the butt in the fall with water and spoiled, and also very hard to shuck and never grow even on the stalk.

The result of 40 years of close selection

"I will say it took me ten years to get the corn to send out ears at an even height and to grow on a small shank with just enough husk to cover the corn and no more. I was 15 years getting rid of the red ears and somewhat longer getting rid of white cobs. We make our selection of seed in the fall as we gather, so that we can get the best ears from the stoutest stalks, the proper height from the ground, and also those not having too much shuck."

CATTLE KING. Cattle King originated with W. W. Van Sant in Mercer County, Illinois, in 1868. In 1877 this corn was brought by the originator to Fremont County, Iowa, in the great Nishnabotna Valley, three miles northwest of Farragut. Here on a farm of two sections Mr. Van Sant and his sons have developed a very large yellow variety which is a heavy yielder. The ears are from 9 to 12 inches long and from 7½ to 9 inches in circumference, containing from 16 to 24 rows and weighing 10 to 18 ounces. The kernel is very deep, rather broad, closely packed on the cob, with little space between the rows. The stalk grows rank, producing in many cases two ears.

A large yellow corn

KANSAS SUNFLOWER. The Kansas Sunflower variety originated with John Moody, Eudora, Kansas. Although the ears are somewhat small in circumference, the length allows a very heavy yield. This variety is especially adapted to rather dry soil. The rich yellow color and deep kernel make it a good feeding corn, very much desired by the farmers.

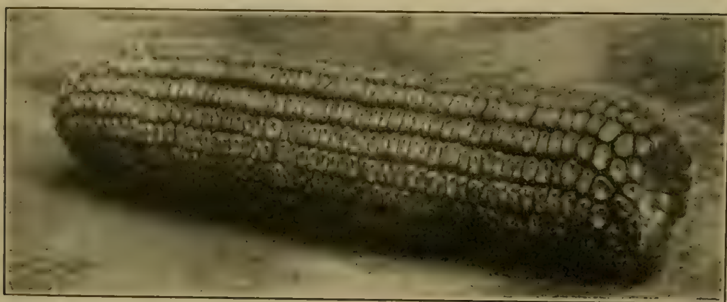
MINNESOTA NO. 13. Minnesota No. 13, a very early maturing, yet heavy yielding variety, has been developed and brought before the farmers of Minnesota by the Minnesota Experiment Station. The ears, though but of medium size, show a wonderful uniformity of rows, and evidence breeding and selection. The dent is that of the dimple and the endosperm is largely horny, showing little of the cloudy, white starch at the crown. Nevertheless, there is no sign of

The most successful in Minnesota

*Written by the originator, Willis J. Willhoit, after forty years of experience.

the flinty, round tendency of the kernels, although the tips of ears are not so well covered as in the varieties farther south.

The Gurney Seed Company, of Yankton, South Dakota, introduced Minnesota No. 13 into their state in 1906. The success of the variety has been amazing. By August 20th of that year the ears in the field were safe from frost, and husking began October 8th. Yields in general have run from 50 to 75 bushels per acre.



(Courtesy C. E. Hildreth) Fig. 157.
HILDRETH CORN GROWN IN KANSAS.

HILDRETH YELLOW DENT. Hildreth Yellow Dent may be called a native variety, so to speak, of Labette County, Kansas. The originator C. E. Hildreth, of Altamount, Kansas, began selecting and breeding this corn after 1901, because of the sturdy way in which it withstood the drought of that year. It is a large, rank growing, late variety, maturing in 125 to 130 days; ears large; length 9 to 11 inches; circumference 7 to 8 1-2 inches; slightly tapering; medium large shank and cob; red cob with 18 to 24 rows of well formed deep, yellow grains; well filled out at butt and tip. Grains wedge shape, medium in width and indentation; large germ; deep and firm on cob, giving large percentage of shelled corn.

One of the best varieties for Kansas conditions

ACKNOWLEDGMENTS. The corn breeders of the states of the Mississippi Valley have responded readily and faithfully when called upon for information regarding the breeds of corn originated and developed by them.

Bulletin No. 63 of Illinois, so ably edited by A. D. Shamel, has been the source of many facts regarding the older breeds. In short, the Illinois breeders have been pioneers in corn breeding.

COLLATERAL READING:

Co-operative Variety Tests of Corn in 1902 and 1903,
Nebraska Bulletin No. 83.

Seed Corn and Some Standard Varieties for Illinois,
Illinois Bulletin No. 63.

Test of Varieties,
Iowa Bulletin No. 55.

Varieties for Minnesota,
Minnesota Bulletin No. 40.

New Strains of Corn,
U. S. Report No. 83.

Variety Tests of Corn,
North Dakota Bulletin No. 76.

Variety Tests of Corn,
Virginia Bulletin No. 165.

Variety Tests of Corn,
Indiana Bulletin No. 124.

CHAPTER XX

CORN BREEDING

THE FARMER AS A CORN BREEDER

Every farmer should grow the greater part of his own seed corn. The idea that corn will run out if grown for a long period in a given locality is a fallacy There is no corn so well adapted to a given locality as that which has been grown there and given intelligent selection for a period of years. Therefore, every farmer should have his "Selection Bed" each year, from which he selects his seed corn for the planting of his larger fields the following year.

Corn adapted to your locality best as foundation

SECURING THE SEED FOR PLANTING THE SELECTION BED. In starting the "Selection Bed," seed may be secured from three sources:

1. From your own corn.
2. From someone in your locality.
3. From someone not in your locality.

These will be discussed separately under their respective headings.

From Your Own Corn. As suggested above, this should be the best source to secure the seed for starting the selection bed. Your own corn may naturally be expected, after having been home grown for a period of years, to be the best adapted to your own peculiar climate and soil conditions.

From Someone In Your Locality. If your own corn is badly mixed, with no type, seed having been saved each year without any special attention being paid to maturity and type, then, it is very probable that a neighbor in the immediate locality, who has been careful regarding these particulars, will be able to furnish seed which is much more desirable than your own. This should be given a germination test, that all weak and worthless ears may be discarded.

Give this seed a germination test

From Someone Not In Your Locality. It is to be hoped that this will not be necessary. It is the least desirable source of the 3. When going outside your locality for seed, it is best to keep within your own latitude and at very moderate distances, that there may be less chance for contrast in soil and climatic conditions.

Do not go far south for foundation stock

It is dangerous to go south, owing to the longer growing season. Such seed is likely to produce a crop, which, under normal conditions, will not mature satisfactorily, while an early fall would prove disastrous, resulting in a quantity of "soft corn." It is better to go north for seed than to go south. Seed secured from the north is accustomed to a shorter growing season, producing a smaller stalk and ear than that grown further south. Should seed corn be secured from a distance, especially southward, it should be only for the planting of a small patch and not for planting the general fields. By means of proper selection, it will be found to more closely adapt itself to its environment, so that in a few years it will have become thoroughly acclimated. The length of time depends upon the contrast in the soil and climatic conditions between the two localities.

Grade the kernels before planting

SELECTING SEED FOR SELECTION BED. As it takes but from 12 to 14 average sized ears of corn for the planting of an acre where a 3 foot 6 inch planter is used, with 3 kernels to the hill; 40 to 50 ears will be a desirable number to select. In the first place, it is to be expected that a quantity of seed corn has been previously selected and stored. In the process of giving this seed corn the germination test, it will be noticed that some of it comes with much more strength and vigor than the rest. In fact, by careful examination it will be found that 40 to 50 ears may be selected in the germination box, which have pushed forward during the process of germination more rapidly than have the rest. These ears may be laid aside and used for planting the selection bed. They should be shelled and graded.

In choosing these ears for the selection bed, it is preferable that they be of one type. The best type of ear and kernel is not the same for all conditions of environment. In localities where the soil is rich and the season long, a large ear with deep, narrow kernels will mature, while in the more northern districts, where the seasons are comparatively shorter, a smaller ear with shallower grains, less of the pinch dent, and more of the flinty characteristics, must necessarily be a more desirable type.

Isolate or plant on south or southwest corner

SIZE AND LOCATION OF SELECTION BED. For the average Iowa farm of 160 acres, a three-acre selection bed is of sufficient size. This should be preferably an isolated field or in the south of southwest corner of the general field. Should there be another field of corn near the south line of your own, then the selection bed may be placed either to the north side of your general field or in the center of it. The seed planted by a neighbor just to the south of your general field may not have been selected as carefully as your own and also might be of a different variety. Therefore, it would be preferable for the pollen from your own general field to fall on your selection bed than to have the pollen from the field adjoining. The prevailing winds in summer are from the south and southwest. This is the reason for locating the selection bed as above. The selection bed should, if possible, be on fall plowed ground, which, if properly cared for in early spring, matures the corn earlier.

PLANTING THE SELECTION BED. The selection bed should be planted with the specially selected seed as soon as the ground has sufficiently warmed up in the spring and the seed bed has been put in proper condition. The corn planter should be used, planting the same number of kernels per hill as in the general field. A good seed bed always pays well for the time taken in its preparation.

Use only especially selected ears

CARE OF SELECTION BED. The selection bed should be cared for in the same way as the general field; cultivating at least 3 times and 4 if possible. It will demand no special attention until the corn begins to put forth its tassels. The tassel is the staminate (male flower); the silk is the pistillate (female flower.) There is one silk for every kernel. Only one pollen grain is necessary for the fertilization of a silk. In the selection bed there will naturally be found numerous weak stalks, barren stalks, and suckers, which, whether or not an ear is produced, will, with few exceptions, produce tassels which will shed their pollen over the field. In order that this pollen may be eliminated from the selection bed, take a sharp knife of good size and go into this patch just at the time when the first tassels begin to appear, cut down all weak stalks, barren stalks, and suckers, cutting them close to the ground. This will not only eliminate the spreading of this pollen, but will be of further benefit to the field by not permitting these worthless stalks to draw nourishment from the soil to the sacrifice of stalks which are producing ears. It is very properly assumed that a strong appearing, mature ear, may be greatly injured for seed purposes by being fertilized by the pollen from weak and unproductive stalks. While the ear that season may not show the influence, yet when used for seed the following year, it may be expected that "the sins of the fathers will be visited on the children to the third and fourth generations." If the pollen from these weak and unproductive stalks is permitted to be shed it will undoubt-

Detassel all weak and barren stalks

Cut suckers off close to the ground

edly be the father of many of the kernels produced on the strong, vigorous looking ears. Weak parentage in the line of our livestock has long been considered undesirable for satisfactory results. It should likewise be eliminated in corn by means of the selection bed.

Reasons for barrenness

CAUSES OF BARREN STALKS. Stalks that bear no ears are called barren stalks. With very few exceptions, they will have a tassel and shed pollen the same as other stalks. Barren stalks are not especially the weak stalks in the field, but very much to the contrary. They may be attributed to several causes, weak seed, insect injuries and diseases, unfavorable soil and climatic conditions, and too thick planting.

Weak Seed. While many of the barren stalks are of strong and vigorous growth, a few are also found much smaller and weaker in appearance. More than anything else, poor seed is responsible for the weak stalks that appear in the field. A large number of the weak stalks are barren.

The following table is given in illustration of this:

Ear No.	Strong Seed. Germination	Stand	Barren	Ear No.	Weak Seed Germination	Stand	Barren
	S. W. B.				S. W. B.		
49	6—0—0	74.3	1.9	50	4—0—2	74.8	3.2
25	6—0—0	75.2	.6	9	2—4—0	75.7	6.3
28	6—0—0	77.1	.0	40	4—2—0	77.6	4.9
34	6—0—0	78.1	1.8	37	4—2—0	79.1	4.8

The ears used in this table are taken from results at 3 county stations in different parts of Iowa.

Weak seed produces weak stalks with poor root development, which are seldom able to yield grain.

Due to a short food supply at time of shooting

Insect Injuries and Diseases. The plant draws the hardest upon the soil at the time of putting forth its shoots and tassels. A corn plant may not have its root system so injured during its early growth, but that the stalk can be very well supplied, and in case of rich ground, a strong, vigorous looking plant may often be produced. Yet at the time when the plant is ready to put forth its shoot and tassel, it is unable to do both because of its roots having been lacerated by insect pests. In such cases, the ear is sacrificed, while with few exceptions the tassel will be present.

The foregoing is especially applicable to the corn root worm and the white grub. The corn root aphis will accomplish the same results. It does not lacerate the roots, but sucks the nourishment. Chinch bugs coming on to corn just before shooting time, often suck the sap away to such an extent as to leave the stalk weakened and consequently barren.

(Courtesy of Iowa State College)
Fig. 161.

CORN PLANT AFFECTED BY SMUT IN VARIOUS PLACES.

A smut spore may alight and develop on the ear. Instead of the plant food being used for the kernels, the mycelium of the smut withdraws it for use in the formation of the smutted mass.

Unfavorable Soil and Climatic Conditions. In light soils not suitable for corn production, a large percentage of barren stalks are produced. The plants in general, under such conditions show a lack of strength. Should this unsuitable condition be accompanied by unfavorable climatic conditions, such as an especially wet string with cool days and nights so unfavorable for the growth of the young corn plants, the amount of barrenness will be increased.

Usually on poor soil

Too Thick Planting. When corn is planted so thick that the soil is unable to supply enough plant food to maintain the stalks and at the same time produce ears, a large number of barren stalks result. From a given area of land, the largest yield of corn will be secured if the amount of seed planted is just within the limit of the ability of the soil to support the resulting plants. Beyond this limit. the ear is sacrificed and the stalks become smaller.

Due to crowding

The following table will show the gradual tendency toward an increasing amount of barrenness as the number of kernels (or stalks) per hill increases.

This is the result of 39 experiments in 12 counties in Iowa, covering in some a period of 3 years (1905, 1906 and 1907)—years of quite varying climatic conditions.

EFFECT OF THICKNESS OF PLANTING ON PER CENT BARREN STALKS.

Kernels or stalks per hill......	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Per cent barren stalks........	3.2	3.4	3.8	4.6	5.6	8.1	9.7	11.6	14.5

Hereditary Influences. There influences are clearly brought out in the great variation in the amount of barrenness noted from individual ears within a given variety of corn, making it possible to materially decrease the percentage of barren stalks by selection.

The following table will illustrate the above heading. In arranging this data the germination test and the per cent stand were selected as nearly alike as possible.

STORY COUNTY 1907.

Ear No.	Test	Percent Stand	Percent Barren
	S. W. B.		
31	6—0—0	61.9	4.6
33	6—0—0	62.4	14.5

HENRY COUNTY 1907.

Ear No.	Test S. W. B.	Percent Stand	Percent Barren
41	5—1—0	83.8	10.8
49	4—2—0	82.9	.6
44	0—6—0	85.7	1.7
36	1—5—0	85.2	26.3
37	0—6—0	80.5	10.7
47	0—6—0	80.5	4.1

MONTGOMERY COUNTY 1907.

Ear No.	Test S. W. B.	Percent Stand	Percent Barren
42	6—0—0	74.3	4.5
43	6—0—0	75.2	7.0
46	6—0—0	81.0	3.5
32	6—0—0	82.4	1.7
62	6—0—0	71.4	3.3
64	6—0—0	71.4	6.0

CAUSES OF SUCKERS.—How Detected. Corn generally sends up but on stalk or culm. Occasionally one or more in addition may appear, branching from the lower nodes, near or below the surface of the ground. These are termed suckers. They may have no root system whatever, drawing their nourishment entirely from the mother stalk. Again, they are found with a few roots leading off from near the place where the sucker is attached to the mother plant. A sucker may or may not produce an ear. It seldom does. However, a tassel is generally present. The presence of suckers may be attributed chiefly to 2 causes.

Usually produces a tassel

Thin Planting. Suckering is not so common on light soil. On such land, thin planting is desirable. Considerable suckering is frequently found where thin planting has been done on rich, heavy land. This is due to the amount of available plant food being greater than that needed to nourish the single stalk produced from the planted seeds. The plant thus in its endeavor to utilize this abundance of plant food, sends forth these additional stalks or suckers. Suckering is greater in seasons most favorable to the growth of the corn. On rich, heavy soils it is better to plant four kernels to the hill, which produce stalks bearing ears, than to plant from two to three kernels and have in addition a large number of suckers which take considerable nourishment from the soil and return no grain. The following table will illustrate this point:

The plant throws out suckers in trying to use the excess of plant food

RESULT OF THIRTY-NINE EXPERIMENTS IN TWELVE COUNTIES IN IOWA.

Kernels or stalks per hill....	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Per cent suckers............	55.0	30.6	19.7	14.3	8.9	6.7	5.7	4.9	4.0

A steady decrease is shown in the per cent of suckers as the thickness of planting increases. Where only one kernel was planted, 55 per cent of suckers developed.

Hereditary Influences. All varieties or strains of corn within a variety do not sucker to the same degree. For example, the Legal Tender corn, a good producer and very popular in southwestern Iowa, is inclined to sucker more than the majority of our dent varieties, while on the other hand, the Silver Mine is freer from this tendency.

Individual ears within a variety differ greatly as to the number of suckers produced. This will be clearly shown in the following table:

STORY COUNTY 1907.

Ear No.	Test	Percent Stand	Percent Suckers
	S. W. B.		
31	6—0—0	61.9	0.8
33	6—0—0	62.4	2.3

MONTGOMERY COUNTY 1907.

Ear No.	Test	Percent Stand	Percent Suckers
	S. W. B.		
42	6—0—0	74.3	13.5
43	6—0—0	75.2	21.7
46	6—0—0	81.0	18.8
32	6—0—0	82.4	28.3
62	6—0—0	71.4	18.7
64	6—0—0	71.4	22.7

SELECTING SEED EARS FROM SELECTION BED. The latter part of September or the first part of October is, in general throughout the corn belt, the proper time for selecting the early maturing seed ears. Having the selection bed in which the best seed has been planted, it will be known just where to go in search of the best seed ears for next year's planting. It will then be unnecessary to walk over the large fields in search of the seed. When selecting the early maturing ears, the stalk on which they are found should be examined likewise.

Requires less time to select next year's seed

Examining Ear and Stalk. A study of the growing ear on the stalk is very important. The contrast in height will be found to be reproduced in a marked degree from year to year; likewise the regularity of rows and uniformity of kernels together with the early maturing qualities. Four feet from the ground to the ear is a desirable height. A lower position is unhandy in husking. If set higher, there is an increased tendency to falling because of wind. A short, thick shank bespeaks vigor and security of the ear from breaking off. Too large shank shows a lack of breeding and is usually accompanied by

Select ears of medium height

a large cob. An upright ear is to be criticised because rain enters the husks and rotting ensues. A moderately drooping ear is to be chosen rather than one in a loosely hanging position.

The parent stalk, if weak and very slender, is undesirable. The best ears are not formed on stalks of this character. This inherited weakness will appear in the next generation. Stockiness at the base, with a gradual decrease in size upward, indicates strength and vigor, stability in storm, and in general more natural strength than a stalk of similar height the same size throughout its length. Excessive foliage may indicate a tendency to produce fodder rather than grain, but usually a heavier yielder is a gross feeder. Only the well matured ears should be selected for seed. An examination of the ears at this period is difficult, because the husks have to be largely removed or pulled back in order to ascertain the type and regularity of the kernel. At this time, kernels need not be taken out to examine their depth or to determine the shelling percentage. Later on, during the process of germination, this feature can be more clearly observed. Yet the shape and type of the ears selected can be noted with definite characters in view, even in the field. Size and maturity are essential points of value. The largest possible ear that will mature is the best for any locality. However, maturity should never be sacrificed for size. A smaller, well matured ear is more desirable for seed than a larger immature ear. From this selection bed may be selected the seed needed the following year for planting the large field; likewise the choicest ears kept for the next year's selection bed.

(Courtesy of Iowa State College)
Fig. 159.
EAR TOO HIGH ON STALK.

Some of the ears from this bed can be planted in large field

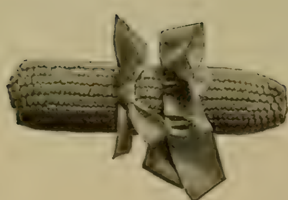
(By courtesy of Iowa State College)

Fig. 160.

STALKS SHOWING EARS AT PROPER HEIGHT.

SELECTION BED.—(Second Year).—In the spring of the second year, greater care and better judgment will be required in order tc advance. The 50 ears now selected should possess a uniformity of type and show strong powers of germination. A repetition of the steps of the first year should be carried on the second. Some criticism of this method for continued use has been made. The argument set forth is fear of inbreeding and consequently a loss in productiveness In a block of three acres properly handled, inbreeding to a harmful extent will not take place for many years, if at all. If the selection bed, as outlined, were carried on by every farmer in the corn belt, it would add millions of dollars to the annual income of the corn-producing states.

Should be used each year



CHAPTER XXI

CORN BREEDING

FROM THE STANDPOINT OF REMAINING PERMANENTLY IN THE BUSINESS

Higher prices may be expected for seed corn

There are some farmers and even large growers of corn who recognize the value of good seed corn, but would rather purchase it each year than endeavor to breed a small patch of their own. This is especially true of men who have a number of tenants. Such men are are willing to pay three dollars per bushel for seed of good quality and vitality. The price of marketable corn and that of beef and pork enables them to do this economically. In other words, breeders of pure bred corn will come to be a part of American agricultural development. The opportunity for advancement in this line of work is limited only by the capabilities of the man.

A number of methods have been tried

Experiment Stations have tried for a number of years a number of different methods in the breeding of corn. The prevention of inbreeding and at the same time fixing type and desirable characteristics without curtailing the yield, are problems which the corn breeder must solve. Because of higher prices received for pure bred corn, the corn breeder can afford to spend more time and money in turning out his product.

A plan is here outlined which is brief and yet covers the main points in question. It is the combination of the desirable methods advocated by practical breeders and theorists. The figures used are merely for illustration and comparison. The scale upon which a breeder caries on operations will necessarily determine the details of the work at hand. The plan is presented as the most successful so far as present knowledge of corn breeding is concerned. Improvements will come and are hopefully looked for.

THE CORN BREEDER'S PLAN. Outside of the work at the various Experiment Stations, there had been little done along the line of corn breeding; nor in fact, in grain breeding in general, including improvement by selection.

The number who may be called "Corn Breeders" in the sense that we speak of our various breeders of live stock, are surprisingly few when we consider the great importance of this crop in its relation to the total annual production of the farms of the United States. Very few corn breeders

It is to be expected of the corn breeder that he take greater care in the selection of his first or foundation stock. Fifty years is a desirable number with which to start. These may be selected in the same manner as with those discussed under "Farmers' Selection Bed." When the 50 ears are determined upon, they should, of course, be the very best that could be secured for the purpose. Too much care can not be taken in selection of foundation stock

FIRST YEAR.—Trial Plot. The entire ear will not be planted as in the former case, but merely a portion of each in accordance with the following outline.

(By courtesy of Iowa State College)

Fig. 162.

PLANTING INDIVIDUAL EARS BY HAND.

Select a piece of ground located as per the directions under "Farmers' Selection Bed." Mark off a piece 50 hills square, the rows having same width as planter, that it may be cultivated with the rest of the field. This will then give a piece of land of 50 rows in width, each row containing 50 hills. Number the rows from one to 50; likewise the ears. One hundred and fifty kernels may now be taken from one side of each ear. The rest of the ear must be very carefully put away where nothing will bother it. Some of them are to be mated the following year; everything depends upon their being safely kept. The 150 kernels from each ear will just be sufficient for the planting of three kernels in each of the 50 hills to the row. The planting Selection of ground for breeding block should be done by hand. It is to be remembered that the kernels from ear No. 1 are to be planted in row No. 1; ear No. 2 in row No. 2, etc., until each ear will be represented in a row whose number coresponds to the number of the ear. The summer care need be no different from that given to the remainder of the field. The barren stalks, weak stalks, and suckers should be eliminated in like manner as described under "Farmers' Selection Bed."

Keep a Record. Each row should be carefully studied. A count of the stand should be made. Note the comparative strength of the stalks produced in each row, the percentage of barren stalks weak stalks, and suckers; also the presence of smut, the height of the ear on the stalk, together with the early maturing qualities. The great contrast in the individuality of different ears of corn as shown in their production will be clearly seen. Complete notes should be made on each row, embodying in detail all the foregoing points mentioned. These notes will be of assistance when it comes to mating the ears the following season. In the fall, the produce of each ear should be harvested separately, and carefully weighed. For general seed purposes this seed may be very properly saved, especially if chosen from the highest yielding rows which show early maturity.

Keep a record from the beginning

Contrast in Yield. It will be found that there is a decided difference in the productivity of ears of corn, even though from all outward appearances they are very similar, and test equally strong in the germination box. The yield per acre may be easily computed, remembering that there are 3,556 hills made by a 3 foot 6 inch planter and 3,240 made by a 3 foot 8 inch planter, the two widths most commonly used in the corn belt. Ears may vary in production as much as from 15 to 100 bushels per acre on similar ground under the same cultivation. Close examination of the original ears will never reveal these facts of yield. The individuality of each ear is unlocked only upon trial under field conditions. The value of this individuality then stands in results per acre.

Yielding power can only be ascertained by trial

Individuality of Ears.

The productive power is now definitely known. For example, ears No's 1 and 50 may have yielded 90 bushels and 100 bushels respectively, while No.'s 30 and 40 may have produced in turn 20 and 35 bushels. The locality and fertility of the soil will determine the standard from which to base selections. Some breeders choose all the ears which yield above 70 bushels. Some set the basis lower. Assuming that, from the original 50 ears, 30 have all kept in good shape and yielded well, and have proved after a test the second spring that their

Ear No.	Breeder	[illegible] Ear 1905	Test	% Stand	% Suckers	% Barren	% Smut	% Seed	% Market	% Nubbins	% Worthless	Weight	Bu. per A.	Breeders 1908	Numbers	
1	Iowa Exper. Station		600-600	62.1	25.0	7.4	3.8	6.3	82.5	11.2	0	62	62			
2	"		600-600	64.0	3.9	4.9	3.9	3.7	88.8	4.7	2.8	88	88	1	11	Selected
3	"		600-600	71.3	30.1	16.1	14.5	11.1	79.0	7.4	2.5	70	70	2	204-205	
9		930	600-600	70.4	33.0	18.1	7.2	16.5	79.7	3.8	0	73	73	4	214-215-216-217	
10	"	911	600-600	84.5	13.7	9.8	5.9	3.5	86.2	8.0	2.3	81	81	1	42	Selected
11	"	847	600-600	65.0	14.7	5.3	2.7	5.4	94.6	0	0	60	60			
12	"	836	600-600	72.1	8.7	3.3	1.1	7.4	92.6	0	0	84	84	2	70-71	Selected
26	Ed. McCulloch.		600-600	78.1	9.0	3.4	7.9	13.3	84.5	11	11	87	87	3	72-73-74	Selected
27	"		600-600	77.2	5.6	5.6	12.4	16.9	68.5	11.2	3.4	81	81	2	45-46	Selected
31	Asa Turner		600-600	82.4	27.6	6.2	6.1	6.7	76.9	6.7	7.7	66	66	1	44	Selected
32	"		600-600	75.9	14.6	11.2	1.1	6.0	90.0	2.0	2.0	75	75	4	219-220-221-222	
33	Grant Chapman		600-600	83.6	10.5	6.7	4.6	11.9	76.9	7.4	1.8	93	93	1	17	Selected
37	W. A. Hook	1152	600-600	82.3	12.4	4.1	3.1	4.8	84.5	6.8	3.9	84	84			Selected
35	Harry Hilton		600-600	76.8	15.3	11	0	5.8	09.8	3.4	0	77	77			
38	Adolph Klopping		600-516	59.0	13.5	0	3.4	10.5	81.6	2.6	5.3	66	66			

Fig. 163.

RECORD OF CORN BREEDING OPERATIONS.

vitality is unimpaired, the real breeding of corn begins.

SECOND YEAR.—Mating Individual Ears in the Breeding Block. Because of their high yield, 90 and 100 bushels respectively, ears No.'s 1 and 50 will be planted together in a breeding block 20 hills square. In the odd numbered rows, 1-3-7-9-11-13-15-17-19, plant kernels from ear No. 1; in the even numbered rows, 2-4-6-8-10-12-14-16-18-20, plant those from ear No. 50. Three kernels per hill is again preferable. These should be planted by hand though some breeders practice planting with a planter. These rows will not usually tassel at the same time. Should they do so, there is little difference which row is detasseled. If any preference is made, the strongest row of plants should be detasseled, thus making them the mother stalks. When the stalks from ear No. 1, that is, the odd numbered rows, begin to tassel before those of ear No. 50, the even numbered rows, then detassel the rows representing ear No. 1, and vice versa. All weak stalks, barren stalks, and suckers should be removed, as in "Farmers' Selection Bed." Silking usually occurs a few days later than tasseling. Hence, the silks of the detasseled rows will be in a receptive state when the pollen of the later tasseling rows is ripened.

Planting the breeding block

(Courtesy Funk Bros.)
Fig. 164.
EFFECT OF INBREEDING.
The two rows in the center are dwarfed because of inbreeding.

It will be seen that these 2 rows have now been mated. The ears from the detasseled stalks should be saved for seed and the ears from the other rows discarded from further breeding operations, because they are inbred. This covers the care for one block 20 hills square. Where extensive breeding operations are carried on, a number of such isolated plots will be necessary.

More than one set of plots necessary

Advantages of the Breeding Block.

1. Inbreeding is prevented.

2. Definite knowledge of the yielding powers of each ear is ascertained.

3. Systematic mating is established, whereby the most desirable characteristics of two ears can be combined and intensified. The sire is known.

(Courtesy of J. W. Damel)

Fig. 165.

DETASSELING CORN.
Pull out the tassel; do not cut it.

How to Detassel. Tasseling time usually comes during the harvest season. The farmer has plenty of work on hand. But just then the most important step in the process of advancement in corn breeding must be made. Every day for from seven to ten days new tassels will appear. Detasseling is a process which requires time and patience. The tassels should always be pulled and never cut. Some farmers go through the patch on foot, bending the stalk over and holding it with one hand near the top joint, pulling the tassel from its place without injuring the plant. In rank growing corn, a man astride a horse that is muzzled to prevent destroying the corn, can pass between the rows and very rapidly detassel. The number of times that the block must be gone over depends upon the rapidity of the appearance of the tassels. When simply detasseling to eliminate the barren stalks, it will be found profitable to cut such stalks off at the surface of the ground.

Remove tassels without injuring plant

THIRD YEAR.—The Increase Bed. The "Increase Bed" is the next step. This will be started the third year. In the breeding blocks mentioned above, which were 20 hills square, there will be 200 hills in each which have been detasseled. Three kernels being planted by hand in each hill, it is safe to assume that from the detasseled stalks in each breeding block, as many as 400 ears will be secured, or at least 4 bushels of ears entirely free for the pollen shed from the tassels borne on their own stalks. This amount of seed will generally be secured from each breeding block. In studying these breeding blocks, very complete data should be taken of both the tasseled and detasseled rows. While the seed from the tasseled rows is not saved

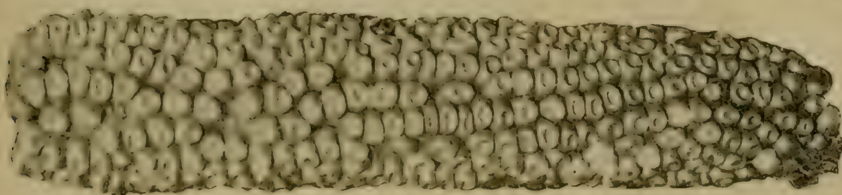
(Courtesy Successful Farming) Fig. 166.

"STALKS A-FOOLIN' 'ROUND ALL SUMMER, DOIN' NOTHIN'."

No. 1 has a fairly good ear, weighing 16 ounces; one stalk per hill on one acre of ground, each producing an ear of this weight would yield 50 bushels and 56 pounds at the rate of 70 pounds per bushel. No. 2 weighs 10 ounces; one stalk per hill would yield 31 bushels and 52 pounds. No. 3 weighs 9 ounces; one stalk per hill would yield 28 bushels and 40 pounds. No. 4 weighs 6 ounces; one stalk per hill would yield 19 bushels and 3 pounds. No. 5 weighs 3 ounces; one stalk per hill would yield 9 bushels and 36 pounds. No. 6 weighs one ounce; one stalk per hill would yield 3 bushels and 12 pounds. No. 7 produced the ear that is not there. Nos. 4, 5, 6, and 7 are worse than worthless in the field, on account of their producing pollen, which is distributed over the field.

to plant in "increase bed," being very largely inbred, yet it is desirable to keep a detailed record of their performances as they are the sire rows in the breeding blocks. It will be found that some of the breeding blocks are yielding much higher than others, and in general the detasseled rows yielding higher than the tasseled rows. From the ears produced on —say two of the highest yielding breeding blocks (breeding blocks No.'s 1 and 5, for example), select 25 to 30 of each. It is very likely

Only seed from detasseled rows is saved



(By courtesy of Funk Bros.)

Fig. 167.
HAND POLLINATED EAR.

that not more than 30 out of the 400 ears will be especially suitable. The two sets of ears must not be mixed, but should be given a germination test, the strong ones then shelled and graded; in fact, prepared in accordance with "Selection and Preparation of Seed Corn for Planting." It will thus be seen that we now have two lots of—say 25 ears each; one lot, the best of the 400 from the detasseled rows in breeding block No. 1 (from ear No. 1, with ear No. 50 as sire); the second lot, the best 25 ears from the detasseled rows in breeding block No. 5 (from ear No. 10, with ear No. 25 as sire). The "increase bed" will now be planted, the following or third year, as follows:

Location, Planting and Care. Select if possible another isolated plot of three acres. The seed from one lot (taken from breeding block No. 1, selected from detasseled ear No. 1, with ear No. 50 as sire), should be put in the planter box on one side only; the seed from the second lot (taken from breeding block No. 5, selected from detasseled ear No. 10, with ear No. 25 as sire), should be put in the other planter box. The three-acre plot should now be planted so that the ears representing seed from lot No. 1 and Lot No. 2, respectively, shall be placed in alternate rows. This will be the increase bed and should be cared for in respect to detasseling in exactly the same way as outlined under the heading "Mating Individual Ears." In addition to this, all the weak stalks, barren stalks, and suckers, should be cut out. While the increase bed is not a mating of individual ears, it is, however, mating the progeny of high yielding individual ears. The rows in the "increase bed" should be numbered. We will then have the odd and even numbered rows as discussed under "Mating Ears in Breeding Block," and will be handled in the same way. The seed planted in the even numbered rows is all the progeny of ear No. 1 (with ear No. 50 as sire); then the seed planted in the odd numbered rows is all the progeny of ear No. 10 (with ear No. 25 as sire). The alternate rows thus representing seed tracing back to the same parentage. Either the odd numbered rows or even numbered rows should be detasseled in accordance with the directions under heading "Mating Individual Ears in Breeding Block." The increase bed is thus a means of continuing the breeding along a definite line, whereby a record of the parent may be had, together with data regarding their performances. This is a method which may be followed in the production of pure bred seed corn with which a pedigree of performance may be given.

Value of breeding block

This is an outline of but one increase bed. As many more may be had as the breeder desires. The increase bed furnishes the very best place for securing seed corn for planting the general fields. Seed corn of this quality would be in great demand in any locality at most satisfactory prices.

CONTINUING INDIVIDUAL EAR TEST AND MATING IN BREEDING BLOCKS. It is well that the corn breeder continue the individual test from year to year. The ears for this purpose may be secured from the increase bed. Such ears, of course, will already have a record back of them. A strict record should be kept when they go to the individual ear test. The breeding blocks of 20 hills square should also be continued from year to year. The corn secured for this purpose may come from two sources:

1. The very best of the ears produced in the breeding block of the previous year. Do not use an ear which has not been tested.
2. Ears secured from the individual ear test.

A trial should be given all ears before being planted in the breeding block

A policy that may well be adopted by all corn breeders, is not to mate two ears of corn in the breeding block until they first have been given an individual ear test as to their performance. Therefore, no individual ear of corn should be taken from the increase bed to mate in the breeding block until it has first been given a trial in the individual row test. By so doing, the corn breeding will be kept at the highest standard. It will be seen that such a system as herein outlined for the corn breeder, while not taking a great deal of extra time, demands the most careful attention of a competent person.

Outline to Be Followed By the Corn Breeder.

The corn breeder's method as herein outlined, is as follows:
First year, trial plot of individual ears.
Second year, trial plot—breeding block.
Third year, trial plot—breeding blocks—increase beds.

In addition to the above will be the general fields which, partly during the third year and entirely so the fourth, may be planted from the pure bred seed from the "increase bed."

Pure breed seed

PURE BRED AND HIGH GRADE SEED. The corn produced in the increase beds may be classed as "pure bred" seed corn. As a definite line of breeding has thus been followed out, the parentage of the ears may be thus traced back to the individual ear row test. The corn breeder will, no doubt, have other of his larger fields in corn, the seed of which was secured from that which was left over from the breeding blocks after he had selected the best of it to put in the "increase beds." In this general field he has done no detasseling, but merely has a mixture of this high yielding corn secured from the various breeding blocks in which he was mating different high yielding ears. The corn produced in these general fields may be classed as "high grade seed." These two terms, "pure bred" and "high grade" may be looked upon a synonymous to the similar terms used with live stock; in one case, as with "pure bred" it is possible to give a pedigree; in the second, it is not. It will thus be seen that when selections made from the progeny of high yielding ears are brought together in a common field, the breeding identity is lost track of; the product, however, may be called "high grade seed." When ears are mated, as in the "increase bed," it is possible to give them definite lines of breeding and it may thus be classed as "pure bred" seed.

High grade seed

SOME POINTS TO BE CONSIDERED BY THE SEED CORN BREEDER. The successful seed corn breeder must be able to dispose of his product. Many men of intelligent observation and love for plant breeding can develop a desirable type of corn. Few men are fitted for salesmen. Judicious advertising solves the question of securing customers. The farmer buys many things because of the wide circulation of farm papers giving descriptions of offered articles. The corn breeder should be very careful, supplying only such seed as may be depended upon to give satisfactory results. This insures patronage in the future. The new law passed by the State Legislature of Iowa, provides that seed corn sold to patrons by seed firms, must show a germination test of 94 per cent. Among the best dealers, this will have a tendency to induce them to adopt better methods of storage and a definite system of testing each ear sent out. It will, in fact, put

(Courtesy of Henry Field)

Fig. 168.

INDICATIVE OF THE GROWTH OF THE SEED CORN BUSINESS IN IOWA.

Fig. 169.

CORN CRATED READY FOR SHIPMENT.

the business of breeding seed corn on a scientific and legitimate basis. More corn is shipped in the ear now than ever before. Much of it is still shelled, especially with the seed companies. Crates containing one bushel each of ear corn are now used by all retailers of seed corn. An attractive crate with the sender's name in a conspicuous place creates interest wherever it goes. A station agent will be much less liable to allow a slatted crate of corn to remain on the platform in a storm, than he would were the corn in a closed box. Mice are less liable to hide in a conspicuous place, such as between the ears of an open crate.

Corn breeding should be put on a scientific and legitimate basis

(Courtesy of Henry Field) Fig. 170.

HAND PICKING SHELLED SEEDCORN.

The corn is carried over a belt.

Finding out limits of a variety

Satisfying patrons over a wide expanse of territory is impossible if only one breed of corn is grown. The sooner the limitation regarding the successful culture of a given type or variety is known to the dealer, that much sooner the corn can be improved to fit the limited district. If the dealer live in southern Iowa, he cannot expect a breed which he has established in that rich, loamy soil to prove satisfactory to growers in southern Minnesota or northern Nebraska; at least not until it has become thoroughly acclimated in these districts, which may take several years. By keeping in touch with each and every purchaser of seed, the results obtained will point to further exploration of that field or its entire abandonment.

(By courtesy of Funk Bros.) Fig. 171.

BUTTING AND TIPPING BY MACHINERY.

(Courtesy of Funk Bros.)

Fig. 172.

INTERIOR VIEW OF A LARGE SEED CORN WAREHOUSE.

COLLATERAL READING:

Crossed Varieties of Corn, Second and Third Years,
Kansas Bulletin No. 17.

Detasseling Corn,
Nebraska Bulletin No. 25

The Farmer as a Corn Breeder,
Article by Thompson, Editor Farmer's Tribune.

Breeding Corn.
Farmers' Bulletin No. 210.

Directions for Breeding of Corn.
Illinois Circular No. 74.

Inquiry Concerning Number of Barren Stalks in Illinois Corn Fields,
Illinois No. 57 (Circular).
Tillering of the Corn Plant,
Nebraska Bulletin No. 57
Breeding Corn,
Farmers' Bulletin No. 267.
Corn Breeding and Registration,
Ohio Circular No. 66.
Improvement of Corn.
Virginia Bulletin No. 165.
Increase the Productiveness of Corn,
U. S. Department Bulletin No. 317.
Indian Corn,
Kansas Bulletin No. 147.

CHAPTER XXII.

CORN BREEDING

MECHANICAL METHODS OF SELECTING SEED CORN FOR IMPROVED CHEMICAL COMPOSITION

With care, corn growers or farmers can learn to pick out protein seed corn by dissecting and examining a few kernels from each ear by means of a pocket knife, selecting for high protein seed the ears whose kernels show a large proportion of horny parts. High protein kernels contain much horny part, with little white starch, while with low protein kernels the reverse is true.

High protein kernels have much horny part

This method is already used by practical corn breeders and with a very satisfactory degree of success. For example, in selecting seed corn by this method, Mr. Ralph Allen, of Tazewell County, Illinois, obtained seed ears for the year 1902, which were 1.46 per cent higher in protein than the rejected ears from the same lot, and for the season 1903, his selected seed ears contained 1.58 per cent protein more than the ears which he rejected.

The method proposed some years ago by Professor Willard, chemist of the Kansas Agricultural Experiment Station, of picking out high protein seed by simply selecting for large germs, enabled one, as a rule, to make some gain in protein; but the gain is very much greater when the proportion of horny part is considered. In fact, from experience at the Illinois Station, it was found that the selection for a large portion of horny part is of very much more trustworthy index of high protein than is the size of the germ. Corn is often found with large germs which is actually low in protein because of a small percentage of protein in the remainder of the kernel. The fact that only 20 per cent of the total protein of the kernel is obtained in the germ is evidence of the uncertainty of obtaining high protein seed corn and of the improbability of making any very considerable gain in protein by this method of selection. This difficulty was well understood by Professor Willard, as will be seen in the following quotation from the Kansas Experiment Station Bulletin No. 197, Page 63.

Large germ not always a sign of high protein

"There are undoubtedly great differences in the protein content of the part of the kernel, exclusive of the germ, and it is conceivable and not improbable that a large germ, though in itself tending to produce high protein content, might be overcome by the low protein of the remainder of the kernel." (Protein is substituted for nitrogen in this quotation).

Of course, if one picks out corn with large germs and at the same time either consciously or unconsciously selects those ears whose kernels contain a large proportion of horny part, he may make considerable gain in protein, but in such case the gain should not be attributed solely to the large germs.

Large germs high oil kernels

The method of selecting seed corn for high oil content on the basis of large germs is certanly well founded, because of the fact that more than 80 per cent of the total oil of the kernel is contained in the germ.

Correlation between oil and protein in kernel

Speaking of the correlation of oil and protein, Dr. Hopkins says: "All of the data gathered tends to prove that as the percentage of protein increases in corn, the starch decreases, while the oil remains almost unchanged, and that we may increase or decrease the percentage of oil or of germ in corn without markedly affecting the percentage of protein. This was the conclusion drawn when 163 ears of corn were analyzed more than 6 years ago. The different strains of corn which we have finally produced in our regular corn breeding work, furnish us excellent material for ascertaining what effect is produced upon the oil content of corn by breeding for a higher or lower protein content and vice versa. What effect is produced upon the protein content by breeding for a higher or lower oil content may also be ascertained.

"In 1909, we planted rows called the 'mixed plot' with 2 kinds of corn in every row, one kind having been bred for 4 years for high oil content, the other (originally from the same variety and stalk) having been bred during the same 4 years for low oil content. These 2 kinds of seed were planted in every row just far enough apart so that the identity of the plants individually could be known as they grew during the season. The corn from each of the 10 rows was harvested in 2 lots, one being corn from high oil seed, and the other lot being from low oil seed. The 2 lots from each row were kept separate, the one being labeled 'Corn from the high oil seed' and the other 'Corn from the low oil seed'."

The percentages of oil and protein as contained in these different lots of corn are shown in the following table:

OIL AND PROTEIN IN CORN HARVESTED FROM THE MIXED OIL PLOT IN 1900.

	Low Oil Side		High Oil Side.	
Row No.	Percent Oil	Percent Protein	Percent Oil	Percent Protein
1	3.93	10.07	5.61	10.06
2	3.78	9.26	6.75	9.05
3	3.73	10.21	5.88	9.12
4	3.75	8.47	5.99	9.65
5	3.89	9.39	5.71	10.08
6	3.80	9.77	5.91	10.23
7	3.60	9.80	5.60	9.91
8	3.58	9.65	5.84	10.32
9	4.22	9.18	5.68	9.15
10	3.27	9.26	5.82	9.32
Average	3.81	9.51	5.78	9.69

This data is considered very reliable, both kinds of corn having been grown during the same season and in exactly the same soil, and each individual sample whose composition is shown is a composite sample representing many ears. The average difference in oil content between the high oil side and the low oil side is 1.97 per cent oil, while the average difference in protein is .18 per cent. Considering the percentage of protein in the corn is twice as large as the percentage of oil, it will be seen that there is less than 5 per cent of a perfect correlation between the oil and protein.

Horny gluten also quite rich in oil

Attention is called to the fact that in selecting seed corn by chemical analysis for high protein, there is a tendency to increase, not only the horny starchy part (which contains more of the total protein than any other part of the corn kernel), but also to increase the horny gluten and the germ, both of which, though small in amount, are rich in protein, and consequently there is a tendency for the oil to be increased not only in the germ, but also in the horny gluten (aleuron layer) which is quite rich in oil. This is the evident explanation as to why there is a slightly higher degree of correlation between oil and protein in our pedigreed strains of corn than there is in ordinary corn which has not been so bred.

Every low oil ear contains a small percentage of germ and every high oil ear a high percentage of germ. Attention is called to the fact that the high oil germ is even richer in oil than would be indicated by the high germ percentage as compared with the per cent of oil and germ in low oil corn, indicating that the breeding for high oil has not only increased the oil by increasing the percentage of germ (which contains most of the oil), but that there is also an increase in the percentage of oil in the horny glutenous part. Similarly, the percentage of oil in the kernel has decreased even more rapidly than the percentage of germ in the low oil corn. These results are very apparent in the table which gives this data.

EFFECT OF BREEDING ON COMPOSITION OF GERMS AND ENDOSPERMS. As already explained, 10 ears were selected for each of the four different strains of corn, low protein, high protein, low oil and high oil, and 25 kernels were taken from each of the 40 ears, the germ being separated from the rest of the kernel, which we call endosperm. After the percentage of germ as determined for each individual ear, the germs from each lot of 10 ears were put together to make 2 samples, each sample representing 5 ears. The endosperms were likewise put together, so that we had duplicate samples of both germs and endosperms for each of the 4 different strains. These samples were analyzed chemically and the results are given in the following table:

CHEMICAL COMPOSITION OF GERMS AND ENDOSPERMS FROM LOW PROTEIN AND HIGH PROTEIN CORN AND FROM LOW OIL AND HIGH OIL CORN.

Variety	Part of Kernel	Percent Protein	Percent Oil
Low Protein,	Germs,	18.05 17.96	33.59 34.60
High Protein,	Germs,	20.85 21.65	34.99 36.02
Low Oil,	Germs,	21.70 21.71	25.01 24.62
High Oil,	Germs,	17.55 17.84	41.76 41.75
Low Protein,	Endosperms,	5.69 5.68	.83 .91
High Protein,	Endosperms,	13.67 13.92	.76 .72
Low Oil,	Endosperms,	9.13 9.14	.52 .51
High Oil,	Endosperms,	10.62 10.10	1.07 1.24

"The results show in a very striking manner the effect of breeding in changing the composition of the different physical parts of the kernels. Thus, the germs from the low oil corn contain about 25 per cent of oil, while those from the high oil contain nearly 42 per cent of oil. As stated above, breeding to change the oil content not only changes the percentage of germ, but it also changes the percentage of oil in the germ. It should also be noted that endosperms from the high oil corn contain about twice as much oil as those from the low oil corn, although the percentage of oil is very small, even in the low oil corn, and this oil is largely contained in the horny gluten."*

Percentage of oil in the germ is also raised

Perhaps the most marked and valuable results are shown in the percentages of protein contained in the endosperms from low protein

*Bulletin 87 of Illinois.

and high protein corn; the endosperm from the low protein corn contains less than 6 per cent of protein, while that from the high protein corn contain almost 14 per cent. These results, together with the ones given previously, would seem to show conclusively that to select high protein seed corn by mechanical examination, we should select principally for a large proportion of the more nitrogenous part of the endosperm; that is, the horny part. To select entirely for large germs will have only a slight effect upon the protein content of the corn, although it will produce a rapid and marked increase in the oil content.

A difference of 8 per cent in protein due to selection

Referring again to the preceding table, it will be seen that the endosperms from the high oil corn contain about 1 per cent more protein than those from the low oil corn. On the other hand, the germs from the high oil corn contain less protein (17.7 per cent) than those from the low oil corn (21.7 per cent), the difference being 4 per cent protein in favor of the low oil corn. These results were to be expected, even from a study of the analyses of the 163 ears reported in Illinois Bulletin No. 55 in 1899, which showed that large germs were naturally even richer in oil than the size of germs would indicate, the increased oil tending to decrease the percentage, though not the actual amount of protein in the germ.

TABLE SHOWING PER CENT OF GERM AND OIL IN HIGH AND LOW OIL CORN.

Ear No.	Low Oil Corn Percent Oil	Low Oil Corn Percent Germ.	Ear No.	High Oil Corn Percent Oil	High Oil Corn Percent Germ.
4,471	2.68	8.05	4,374	7.10	12.90
4,486	2.65	8.13	4,411	7.01	12.73
4,491	2.60	7.92	4,412	6.87	13.73
4,495	2.59	7,39	4,417	7.01	14.50
4,509	2.53	7.06	4,421	7.02	14.65
4,512	2.45	7.89	4,423	6.95	13.83
4,521	2.12	7.13	4,436	7.17	14.10
4,537	2.40	7.57	4,441	7.37	14.53
4,548	2.54	7,83	4,448	6.78	14.35
4,555	2.65	8.47	4,462	6.74	13.03

It will also be seen that high oil corn contains nearly twice as much germ as low oil corn and that the germs from the high oil corn are nearly one and one-half times richer in oil than the germs from the low oil corn, but that, although the high oil germs contain a larger amount of total protein because of their increased size, they are considerably poorer in percentage of protein than the low oil germs.

High oil corn nearly twice as much germ as low oil corn

Attention is called to the fact that, although the physical parts of the corn kernel which contain almost all of the oil, viz; the germ and horny gluten, also contain most of the ash, yet a high percentage of the ash in the germ is associated with a low percentage of oil, and vice versa, indicating that the ash content of the germ (which contains the major part of the ash of the entire kernel), bears a more constant relation to the oil-free material in the germ than to the whole germ. By computing, we find that the oil free germs contain the percentages of ash as given in the following, assuming the oil to contain no ash, which is approximately correct.

Germ contains most of the ash

PERCENTAGE OF ASH IN GERMS.

	In Fresh Germs	In Oil-Free Germs
	10.19	15.34
From Low Protein Corn............	10.16	15.54
	10.12	15.57
From High Protein Corn............	10.07	15.74
	13.13	17.51
From Low Oil Corn................	13.36	17.72
	8.75	15.02
From High Oil Corn...............	8.81	15.12

Breeding for high or low protein produces no marked effect upon the ash content of either the germs or the endosperm, nor does it have any effect upon the oil content of either of these, and only slightly influences the protein content of the germs. The low protein germs contain about 18 per cent of protein and the high germs about 21 per cent. The results show that such breeding produces exceedingly marked effects upon the protein content of the endosperms, the low tein endosperms containing about 6 per cent and the high protein endosperms containing about 14 per cent protein. In this connection it is well to remember that the corn kernel only contains about 11 per cent of germ, while the endosperm amounts to about 89 per cent of the kernel. The significance of this becomes more readily apparent by an examination of the following table, which shows where the protein endosperms containing about 6 per cent and the high protein

PROTEIN IN ONE HUNDRED POUNDS OF CORN.

Names of Parts	In Germs	In Endosperms
Low Protein Corn,		
Per cent of corn...............	9.33	90.67
Per cent of protein............	18.01	5.69
Pounds of protein..............	1.68	5.16
High Protein Corn,		
Per cent of corn...............	11.44	88.56
Per cent of protein............	21.25	13.80
Pounds of protein..............	2.43	12.22
Difference	.75	7.06

We thus find as a result of corn breeding, that in the seventh generation we have a maximum difference of only .75 pounds of protein in the germs from 100 pounds low protein and high protein corn, while in the endosperms of these two kinds of corn, we have a difference of 7.06 pounds protein in 100 pounds of corn. In other words, in changing the protein content of corn, the effect produced in the endosperm amounts to almost ten times the effect produced in the germs.

ACKNOWLEDGMENTS: This chapter has been drawn almost entirely from Bulletin No. 87 of Illinois, the work of Professor Cyril G. Hopkins, about the only complete treatise available. With the idea that the students and farmers of the West would profit by the introduction of these facts directly, we have taken the opportunity to present them as they are, together with the observations of the author.

COLLATERAL READING.

Analyses of Corn, with reference to its improvement,
Kansas Bulletin No. 107.

Improvement of the Chemical Composition of the Corn Kernel.
Illinois Bulletin No. 55.

Structure of Corn Kernel and Composition of its Parts,
Illinois Bulletin No. 87.

Directions for the Breeding of Corn, including Methods for the Prevention of Inbreeding,
Illinois Bulletin No. 100.

Selecting and Preparing Seed Corn,
Iowa Bulletin No. 77.

Ten Years of Corn Breeding,
Illinois Bulletin No. 128.

INDEX

A

B

C

W

Y

Z