CORN

GROWING JUDGING
BREEDING FEEDING
MARKETING

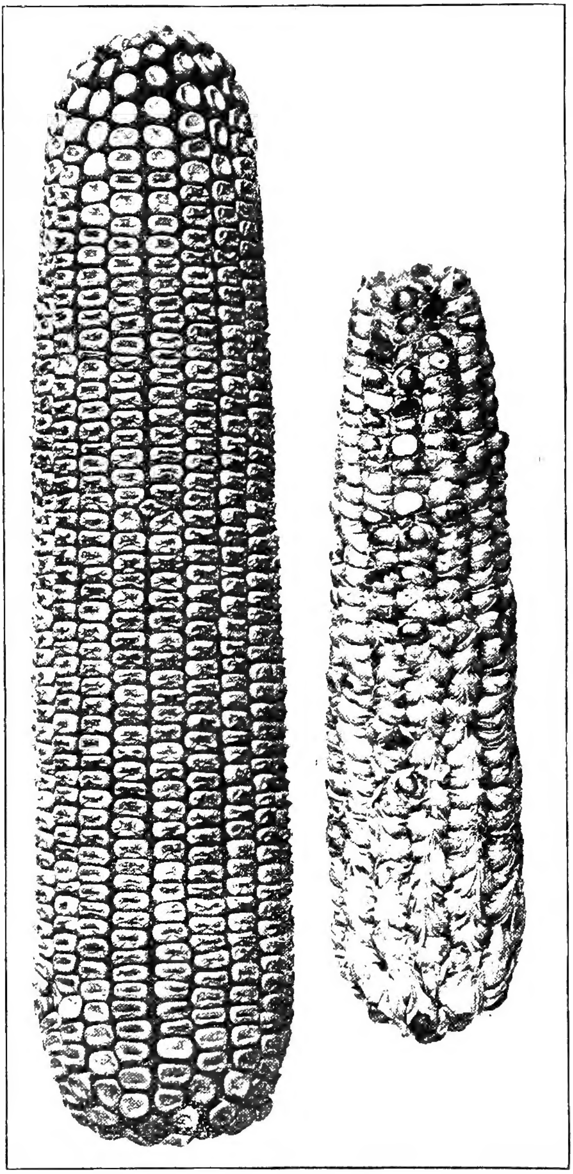

Fig. 1

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.

CORN

GROWING JUDGING
BREEDING FEEDING
MARKETING

For The

FARMER, STUDENT and TEACHER of AGRICULTURE
A TEXT-BOOK for AGRICULTURAL
COLLEGES and HIGH SCHOOLS

By

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

With Best Wishes

P. G. Holden

PREFACE

This work is a completely revised edition of the well known Bowman and Crossley book on Corn which is in such wide use throughout the Corn Belt.

It has been the purpose of the Author to cover more completely with the latest and best available information from the different states, the various phases of corn growing, judging, breeding, feeding and marketing, making it of the greatest possible value to the farmer, to the student, to the teacher and to every one interested in America's Greatest Cereal Crop—Corn.

I am very much indebted to Professor P. G. Holden, who for many years has been my close friend and advisor; to the late Professor B. W. Crossley, who with me put out the first edition of the Corn Book, and to Professor S. A. Forbes, Illinois State Entomologist, who has kindly permitted my using the illustrations of the corn insect pests. To Professor Murl McDonald of the Extension Department of the Iowa State College I am especially indebted for his very able assistance in the preparation of data throughout the book.

—The Author.

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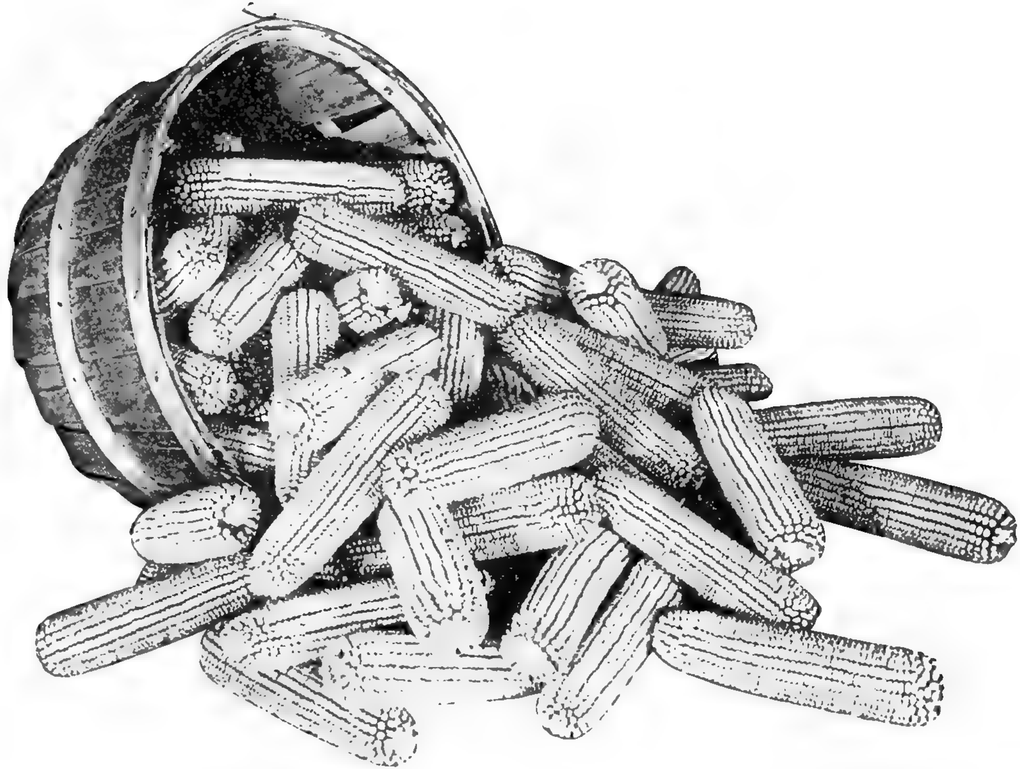


Champion bushel of corn at Iowa Corn Show, Ames, Iowa, 1914. Grown by Willard Zeller, Cooper, Iowa.

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.

Some authorities claim that corn is of Eastern origin, and to substantiate this statement they have attempted to show that the cereal was mentioned 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.

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

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.

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.

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.

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.

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 world's corn crop at present occupies annually 170 million acres. The total area of land devoted to corn growing in the United States in 1914 amounted to *103,435,000 acres. If combined into a single field it would cover the entire land surface of the three states, Iowa, Illinois and Missouri. Since 1870 an acreage equal to 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 acreage of corn has been for the past fifty years uniformly parallel to the increase in the area of farm land. The following chart illustrates this increase from 1866 to 1914 inclusive.

CHART NO. 1.

Acreage in Corn in the United States from 1866 to 1914.

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 1881 to 1890, inclusive, being 55.1 per cent, and the period of slightest variation was from 1891 to 1900, being only 7.3 per cent. Climatic conditions and the state of the general market have been, perhaps, the most important factors in this increase.

*1914 Year Book

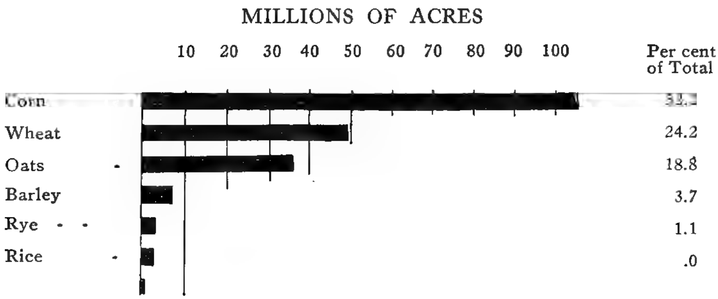
For the past fifty years the acreage devoted to corn growing has been slightly greater than that of all other cereals combined. In fact, 52 per cent of the entire area devoted to cereal crops, including corn itself, has been devoted to this crop. So constant has been this proportion that it has not varied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

The following chart will show the relative acreage of the cereal crops of the United States, taking an average for the five years 1910 to 1914 inclusive.

CHART NO. 2.

Comparative Acreage of all Cereals in the United States

Five-Year Average, 1910-1914 Inclusive.



In considering briefly the acreage devoted to corn growing in each state during the past five years, note the following table, which also shows the acreage devoted to other cereal crops, with the percentage of all improved farm land given to the production of corn and other cereals.

It will be seen that the relative acreage devoted to the growing of corn and the other cereal crops varies widely in the different states. However in those states where the conditions are most favorable to corn growing the per-cent of improved farm land occupied by the crop is very high. Taking into consideration the entire United States, over one-fifth of all improved farm land is given annually to corn, and a little less than one-fifth is given to all other cereals combined.

TABLE NO. 1.

ACREAGE DEVOTED TO CORN AND SMALL GRAIN—AVERAGE FOR FIVE YEARS, 1910-1914 INCLUSIVE.

STATE	Improved Farm Land Acres	Corn Acres	Wheat Acres	Oats Acres	Barley Acres	Rye Acres	Per Cent. of Total Improved Farm Land	
							In Corn	In Small Grain
New England								
Maine	2,360,657	16,600	3,000	135,800	5,200		.7%	6.0%
New Hampshire	929,185	20,200		11,800	1,200		2.1	1.4
Vermont	1,633,965	45,000	1,000	77,400	12,800	1,200	2.7	5.6
Massachusetts	1,164,501	47,000		8,400		3,400	4.0	1.0
Rhode Island	178,344	10,800		2,000			6.0	1.1
Connecticut	988,252	59,600		11,000		7,800	6.0	1.9
Middle Atlantic								
New York	14,844,039	528,800	347,000	1,274,400	78,400	139,000	3.6	12.4
New Jersey	1,803,336	271,400	81,200	69,400		73,800	15.0	12.4
Pennsylvania	12,673,519	1,448,000	1,287,200	1,118,200	7,400	301,400	11.4	21.4
East North Central								
Ohio	19,227,969	3,897,000	1,907,000	1,808,000	29,200	73,000	20.3	19.8
Indiana	16,931,252	4,895,200	2,097,600	1,717,000	8,600	78,800	28.9	23.0
Illinois	28,048,323	10,370,800	2,198,400	4,288,000	50,200	53,600	36.9	23.5
Michigan	12,832,078	1,684,000	875,000	1,503,000	83,800	373,200	13.1	22.1
Wisconsin	11,907,606	1,625,400	188,600	2,269,400	786,200	367,600	13.6	30.3
West North Central								
Minnesota	19,643,533	2,301,200	4,185,000	2,978,600	1,415,600	239,200	11.8	44.9
Iowa	29,491,199	9,913,000	686,800	4,971,600	448,000	43,200	33.6	20.8
Missouri	24,581,186	6,819,400	2,189,000	1,195,000	4,800	15,600	27.8	13.8
North Dakota	20,455,092	340,600	7,927,000	2,242,600	1,187,600	71,000	1.7	55.8
South Dakota	15,827,208	2,509,000	3,653,800	1,567,200	948,000	34,800	15.8	39.2
Nebraska	24,382,577	7,433,800	3,151,600	2,346,400	118,200	84,800	30.4	23.4
Kansas	29,904,067	7,679,000	6,125,200	1,783,000	241,200	36,200	25.7	27.3
South Atlantic								
Delaware	713,538	189,400	113,400	4,000		1,000	26.5	16.6
Maryland	3,354,767	666,600	606,000	45,200	3,800	25,600	19.9	20.3
Virginia	9,870,058	1,964,200	759,600	190,600	9,000	46,400	20.0	10.2

TABLE NO. 1—Continued

ACREAGE DEVOTED TO CORN AND SMALL GRAIN—AVERAGE FOR FIVE YEARS, 1910-1914 INCLUSIVE.

STATE	Improved Farm Land Acres	Corn Acres	Wheat Acres	Oats Acres	Barley Acres	Rye Acres	Per Cent. of Total Improved Farm Land	
							In Corn	In Small Grain
South Atlantic—Cont.								
West Virginia	5,521,757	719,200	236,600	110,200		16,000	13.0	6.5
North Carolina	8,813,056	2,765,600	603,600	224,800		39,600	31.3	9.8
South Carolina	6,097,999	1,872,400	77,800	348,000		3,200	30.7	7.0
Georgia	12,298,017	3,850,600	139,600	408,400		12,600	31.3	4.5
Florida	1,805,408	659,200		45,600			36.5	2.5
East South Central								
Kentucky	14,354,471	3,600,000	743,800	166,000	3,000	20,000	25.0	6.5
Tennessee	10,890,484	3,366,400	705,000	313,000	2,600	16,600	30.9	9.5
Alabama	9,693,581	3,092,800	30,200	308,200		1,400	31.9	3.4
Mississippi	9,008,310	2,969,200	4,800	132,600			32.9	1.5
West South Central								
Arkansas	8,076,254	2,426,000	100,600	217,400		1,200	30.0	3.9
Louisiana	5,276,016	1,857,400		45,000			35.2	.9
Oklahoma	17,551,337	5,121,600	1,706,800	934,800	12,800	4,600	29.2	15.1
Texas	27,360,666	6,920,000	799,400	838,000	6,200	2,400	21.6	6.0
Mountain								
Montana	3,640,309	27,600	672,400	464,200	50,400	8,400	.7	32.8
Idaho	2,778,740	13,200	511,600	331,000	146,200	3,200	.5	35.7
Wyoming	1,256,160	15,600	78,200	200,200	11,000	3,000	1.2	23.3
Colorado	4,302,101	404,400	445,800	298,800	76,000	18,400	9.4	19.5
New Mexico	1,467,191	90,600	59,200	49,000	2,800		6.2	7.6
Arizona	350,173	16,200	27,400	6,400	35,600		4.6	19.8
Utah	1,368,211	9,200	243,000	89,600	24,800	7,800	.6	26.7
Nevada	752,117	1,000	37,800	9,800	11,600		.1	7.8
Pacific								
Washington	6,373,311	31,800	2,139,200	288,200	181,400	7,800	.5	41.0
Oregon	4,274,803	20,200	780,800	359,400	108,200	19,200	.5	29.6
California	11,389,894	53,600	420,000	208,000	1,383,800	18,000	.5	17.8
United States	478,451,750	105,239,600	48,932,600	38,013,800	7,495,600	2,274,000	21.9	20.2

The ten states leading in corn production represent 65 per cent of the total acreage of corn grown in the United States. Since 1900 the total acreage in corn in this country has increased about 35 per cent. The total acreage of the ten states leading in the production of corn shows an increase of 30 per cent over the total acreage in the ten states leading in 1900.

In Illinois we find the highest per cent of land devoted to the production of corn, also the highest total acreage in corn. No doubt the increase in acreage the past ten years has been brought about through improved methods in farming, since we find the greatest increase right in the corn belt. Vast areas which were unfit for cultivation a few years ago have been reclaimed through drainage, and much of this land is today the most productive. As we adopt more careful methods of farming, such as systematic rotation or crops, however, acreage will play a minor role in the increased production of corn, and we must then depend upon a higher average yield. In other words, conditions will demand more bushels of sound corn on each acre devoted to corn production.

WORLD'S PRODUCTION AND DISTRIBUTION

The world's corn crop in 1912, which is the year of the highest total production up to the present time, amounted to 4,369,742,000 bushels. In one year there was produced enough corn to fill a single crib eight feet wide to a uniform depth of eight feet for a length of 32,300 miles. This crib would extend from New York City around the world, and across the United States again to San Francisco, or, if all of this corn were to be piled upon a square mile of ground the pile would form a pyramid over one thousand feet high.

There were concerned in this production five continents, including twenty-two different nations. A careful study of the following table will show the amount of corn produced by each country from 1910 to 1914; also which countries have been the heaviest producers.

TABLE NO. 2. (000 omitted)

WORLD'S PRODUCTION OF CORN BY COUNTRIES.

1910-1914 Inclusive.

Country	1910 Bushels	1911 Bushels	1912 Bushels	1913 Bushels	1914 Bushels	% of total worlds production av. 1910-14 inc.
North America						
United States ...	2,886,260	2,531,488	3,124,746	2,446,988	2,672,804	70.60
Canada:						
Ontario	17,853	18,001	16,466	16,182	13,410	.42
Quebec	860	766	476	586	514	.02
Other	5	6	8	5		**
Mexico	190,766	190,000	190,000	190,000	190,000	4.91
Total	3,095,744	2,740,261	3,331,950	2,653,761	2,876,728	
South America						
Argentina	175,187	27,675	295,849	196,642	204,562	4.70
Chile	1,378	1,221	1,527	1,647	(3)	.04
Uruguay	6,514	3,643	7,963	5,343	(3)	.15
Total	183,079	32,539	305,339	203,632		
Europe						
Austria-Hungary:						
Austria	16,823	11,856	15,058	13,286	(3)	.40
Hungary proper	187,733	137,421	176,694	182,069	(3)	4.41
Crotia-Slavonia	25,589	24,005	24,066	28,955	(3)	.70
Bosnia-Herzegov.	10,051	8,416	8,555	7,559	(3)	.22
Total	240,196	181,698	224,373	231,869	(3)	
Bulgaria	28,360	30,500	28,475	32,000	31,000	.77
France	23,399	16,860	23,733	21,455	22,000	.55
Italy	101,722	93,680	98,668	108,388	105,006	2.62
Portugal	15,000	15,000	15,000	15,000	15,000	.39
Roumania	103,665	110,712	103,921	114,662	110,230	2.83
Russia:						
Russia proper ...	63,089	67,842	62,904	(a)		1.66
N. Caucasia	14,093	14,087	16,704	(a)		.39
Total Russia ...	77,182	81,929	(b) 79,608	72,793	80,608	
Servia	33,204	26,531	22,833	23,621	20,000	.65
Spain	27,366	28,730	25,069	25,140	30,325	.71
Total Europe ...	650,094	585,630	621,680	644,928		
Asia						
British India ...		(3)	(3)	(3)	(3)	
Japan		3,550	3,802	3,559	3,753	.09
Philippine Islands		5,293	7,810	10,224	(3)	.20
Africa						
Algeria	556	554	374	394	(3)	.00
Egypt	70,294	67,903	60,859	57,044	66,744	1.66
Union of S. Africa	20,000	20,000	(4) 30,830	(4) 30,830	(4) 30,830	.70
Total	90,850	88,457	92,061	88,268	97,574	
Australasia						
Australia:						
Queensland	2,588	4,601	3,752	2,604	4,039	.09
New South Wales	7,322	7,833	4,649	5,273	4,496	.10
Victoria	1,195	1,013	818	738	826	.04
West. Australia .	1	1	1		(3)	.**
South Australia .	7	7	2	4	(3)	.**
Total	11,113	13,455	9,222	8,619	9,461	
New Zealand	750	478	278	222	312	.**
Total Australasia	11,863	13,933	9,500	8,841	9,773	
Grand Total ...	4,031,630	3,460,820	4,371,888	3,613,213	(3)	

(a) No official data received. (3) No official report.
(b) Includes Asiatic Russia. (4) Figures from 1911 census.

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

Basing our conclusions on the crop of 1914 we find that 16 countries show an increase in production during the past ten years, two countries show neither an increase nor a decrease, and four show an actual decrease.

The only country which has made any phenomenal increase in the production of corn during the past fifteen years is Argentine Republic. This country has multiplied its production nearly five times since 1899. During the same period the United States shows an increase of 50 per cent. In 1899 Argentina's production amounted to only 3.1 per cent of that of the United States, while in 1914 it reached nearly 6 per cent.

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

TABLE NO. 3.

PERCENTAGE OF WORLD'S PRODUCTION OF CORN BY CONTINENTS. FROM 1900 TO 1914.

Continent	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	Av.	1914
N. America.	79.7	67.7	82.5	77.4	83.0	81.5	77.8	81.2	79.3	78.8	78.9	76.4
Europe	16.7	23.8	13.3	16.2	9.7	12.8	15.9	14.8	15.1	14.5	15.3	16.3
S. America..	2.1	4.5	2.8	5.0	5.7	4.2	5.1	2.4	4.1	5.1	4.1	4.8
Africa	.9	1.3	1.0	1.1	1.0	1.1	.9	1.3	1.2	1.4	1.1	2.3
Australia ..	.3	.4	.2	.1	.3	.2	.2	.29	.29	.19	.25	.2
New Zealand	....	....	....	....	....	.01	....	....	....	....	....	.0

Figures taken from the Report of the United States Department of Agriculture.

In table No. 3, showing relative production by continents, it is seen that North America produced nearly four times as much corn as all other continents combined. Foremost of the remaining countries stand Austria Hungary, Argentina, Mexico, Italy, Roumania and Russia, but the production of these six countries together is only about one-fifth of the production of the United States.

PRODUCTION OF CORN IN THE UNITED STATES

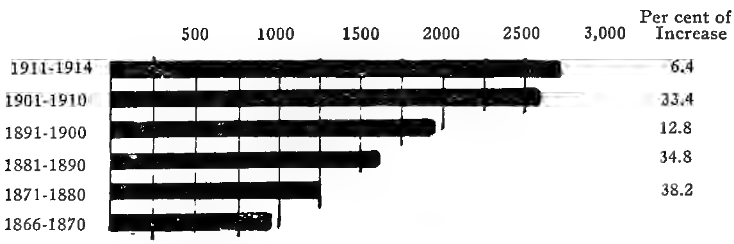
It has been stated previously that the United States produce annually three-fourths of the world's corn crop. In 1912, which was the year of our greatest production, this amounted to 3,124,746,000 bushels.*

The production of this great cereal has from the earliest times kept pace with the widespread 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 TO 1914.

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 1871-1880 and the period from 1891 to 1900, shows the least increase of any decade recorded. The increase for the last five years recorded, however, has been even less, being only 6.4 per cent.

The following table shows the annual increase in acreage and production, the average yield per acre, total value of the 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.

*1914 Yearbook U. S. Dept. of Agriculture.

TABLE NO. 4*.

PRODUCTION OF CORN IN THE UNITED STATES FROM 1866 TO 1914.

Year	Acreage	Yield Bushels		Value	
		Total	Per Acre	Total	Bu. Cts
1866	34,307,000	867,946,000	25.3	411,451,000	47.4
1867	32,520,000	768,320,000	23.6	437,770,000	57.0
1868	34,887,000	906,527,000	26.0	424,057,000	46.8
1869	37,103,000	874,320,000	23.6	522,551,000	59.8
1870	38,647,000	1,094,255,000	28.3	540,520,000	49.4
1871	34,091,000	991,898,000	29.1	430,356,000	43.4
1872	35,527,000	1,092,719,000	30.8	385,736,000	35.3
1873	39,197,000	932,274,000	23.8	411,961,000	44.2
1874	41,037,000	850,148,000	20.7	496,271,000	58.4
1875	44,841,000	1,321,069,000	29.5	484,675,000	36.7
1876	49,033,000	1,283,828,000	26.2	436,109,000	34.0
1877	50,369,000	1,342,558,000	26.7	467,635,000	34.8
1878	51,585,000	1,388,219,000	26.9	440,281,000	31.7
1879	53,085,000	1,547,902,000	29.2	580,486,000	37.5
1880	62,318,000	1,717,435,000	27.6	679,714,000	39.6
1881	64,262,000	1,194,916,000	18.6	759,482,000	63.6
1882	65,660,000	1,617,025,000	24.6	783,867,000	48.5
1883	68,302,000	1,551,067,000	22.7	658,051,000	42.4
1884	69,684,000	1,795,528,000	25.8	640,736,000	35.7
1885	73,130,000	1,936,176,000	26.5	635,675,000	32.8
1886	75,694,000	1,665,441,000	22.0	610,311,000	36.6
1887	72,393,000	1,456,161,000	20.1	646,107,000	44.4
1888	75,673,000	1,987,790,000	26.3	677,562,000	34.1
1889	78,320,000	2,112,892,000	27.0	597,919,000	28.3
1890	71,971,000	1,489,970,000	20.7	754,433,000	50.6
1891	76,205,000	2,060,154,000	27.0	836,439,000	40.6
1892	70,627,000	1,628,464,000	23.1	642,147,000	39.4
1893	72,036,000	1,619,496,000	22.5	591,626,000	36.5
1894	62,582,000	1,212,770,000	19.4	554,719,000	45.7
1895	82,076,000	2,151,139,000	26.2	544,986,000	25.3
1896	81,027,000	2,283,875,000	28.2	491,007,000	21.5
1897	80,095,000	1,902,968,000	23.8	501,073,000	26.3
1898	77,722,000	1,924,185,000	24.8	552,023,000	28.7
1899	82,109,000	2,078,144,000	25.3	629,210,000	30.3
1900	83,321,000	2,105,103,000	25.3	751,220,000	35.7
1901	91,350,000	1,522,520,000	16.7	921,556,000	60.5
1902	94,044,000	2,523,648,000	26.8	1,017,017,000	40.3
1903	88,092,000	2,244,177,000	25.5	952,869,000	42.5
1904	92,232,000	2,467,481,000	26.8	1,087,461,000	44.1
1905	94,011,000	2,707,994,000	28.8	1,116,697,000	41.2
1906	96,738,000	2,927,416,000	30.3	1,166,626,000	39.9
1907	99,931,000	2,592,320,000	25.9	1,336,901,000	51.6
1908	101,788,000	2,668,651,000	26.2	1,616,145,000	60.6
1909	108,771,000	2,772,376,000	25.5	1,652,822,000	59.6
1910	104,035,000	2,886,260,000	27.7	1,384,817,000	48.0
1911	105,825,000	2,531,488,000	23.9	1,565,258,000	61.8
1912	107,083,000	3,124,746,000	29.2	1,520,454,000	48.7
1913	105,820,000	2,446,988,000	23.1	1,692,092,000	69.1
1914	103,435,000	2,672,804,000	25.8	1,722,070,000	64.4

*Taken from Year Book U. S. Dept. of Agriculture, 1914.

TABLE NO. 5

PRODUCTION OF CORN AND SMALL GRAIN BY STATES.

Average for Five Years, 1910-1914 inclusive. (Bushels)

State	Corn (Bushels)	Wheat (Bushels)	Oats (Bushels)	Barley (Bushels)	Rye (Bushels)
New England					
Maine	711,600	75,800	5,338,600	151,000	
N. Hampshire	977,000		444,200	32,800	
Vermont	1,871,400	27,000	3,112,800	416,800	23,000
Massachusetts	2,086,200		296,800		60,400
Rhode Island	443,000		58,400		
Connecticut ..	2,809,600		351,200		147,600
Middle Atlantic					
New York ...	19,569,200	7,080,400	40,754,600	2,099,000	2,409,600
New Jersey ..	10,251,200	1,461,600	2,103,400		1,305,200
Pennsylvania	60,661,000	21,726,200	35,258,800	196.600	5,127,800
East N. Central					
Ohio..........	151,691,000	30,412,600	63,675,800	776,600	1,190,600
Indiana	180,464,200	32,528,400	53,521,400	229,400	1,195,400
Illinois	348,845,800	35,323,400	139,745,400	1,453,600	890,400
Michigan	56,848,000	14,478,000	48,397,600	2,122,400	5,482,800
Wisconsin ...	60,485,800	3,485,400	72,796,800	20,947,000	6,278,200
West N. Central					
Minnesota ...	81,205,000	57,197,600	94,670,000	32,704,400	4,682,800
Iowa	361,771,200	13,221,400	174,036,600	11,985,000	802,000
Missouri	194,253,200	33,747,400	29,501,000	110,600	227,200
North Dakota	8,589,600	83,193,400	56,866,800	22,968,000	1,126,000
South Dakota	64,997,400	35,849,200	37,147,200	16,708,000	543,400
Nebraska	163,641,200	53,165,400	58,076,200	2,144,000	1,289,600
Kansas	120,414,800	94,210,200	46,819,600	3,797,000	567,400
South Atlantic					
Delaware ...	6,539,000	1,955,200	121,400		15,400
Maryland ...	23,532,200	10,028,800	1,284,600	108,200	395,200
Virginia	47,176,000	9,809,400	3,848,600	228,000	577,800
West Virginia	21,251,800	3,144,400	2,632,000		207,800
North Carolina	52,581,600	6,637,000	4,058,000		392,600
South Carolina	34,697,200	882,400	7,404,000		32,800
Georgia	56,807,000	1,570,000	8,300,000		121,200
Florida	9,463,200		760,000		
East S. Central					
Kentucky	94,123,000	9,796,800	3,676,200	82,000	256,000
Tennessee ...	83,310,600	8,647,200	6,791,400	68,800	200,000
Alabama	54,065,600	355,200	6,222,400		16,600
Mississippi ...	57,072,000	60,200	2,628,400		
West S. Central					
Arkansas	49,317,400		5,174,800		13,200
Louisiana	37,649,000	1,219,000	984,200		
Oklahoma ...	66,555,200	30,017,800	21,195,800	291,600	57,000
Texas	130,146,000	11,164,200	25,743,800	156,800	31,800
Mountain					
Montana	758,400	15,674,800	19,826,600	1,589,000	183,800
Idaho	416,200	13,908,000	14,716,600	5,923,000	68,000
Wyoming	338,200	1,983,000	7,302,200	358,400	55,200
Colorado	7,553,800	9,845,600	11,468,200	2,638,000	303,600
New Mexico .	2,120,400	1,274,600	1,665,600	85,400	

TABLE NO. 5—Continued

PRODUCTION OF CORN AND SMALL GRAIN BY STATES.

Average for Five Years, 1910-1914 inclusive. (Bushels)

State	Corn (Bushels)	Wheat (Bushels)	Oats (Bushels)	Barley (Bushels)	Rye (Bushels)
Mountain—Cont.					
Arizona	512,600	781,200	271,400	1,336,800	
Utah	304,400	5,829,800	4,131,200	1,044,000	131,200
Nevada	32,000	1,072,600	444,400	487,000	
Pacific					
Washington	881,800	47,020,000	13,639,200	6,832,600	161,000
Oregon	583,400	17,183,600	13,277,400	3,620,800	323,200
California ...	1,922,000	7,166,000	7,335,200	40,194,000	303,800
United States ..	2,732,457,200	728,224,600	1,157,960,800	183,886,600	37,196,400

By referring to Table No. 4 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 thirty bushels was recorded. It was possible to raise 100 bushels per acre before 1830, and old Agricultural Society Reports show that such yields were about as common then as they are today.

Table No. 5 shows an annual production of 2,732,457,000 bushels of corn, taking an average for the past five years, 1910 to 1914 inclusive, as compared with 728,224,600 bushels of wheat, 1,157,960,800 bushels of oats, 183,886,600 bushels of barley, and 37,196,400 bushels of rye, or a total annual production of 2,107,268,400 bushels for all cereals other than corn.

The census report, together with the report from the United States Department of Agriculture, shows that the corn grown per capita has been steadily increasing since 1850. However there was a slight decline in the per capita production during the last decade.

Note the following table:

TABLE NO. 6

SHOWING POPULATION—TOTAL PRODUCTION OF CORN AND PER CAPITA PRODUCTION. 1850 TO 1910.

Year	Population	Total Production Corn Bus.	Per Capita
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
1910	93,471,648	2,886,260,000	30.8

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.

The average yield in the United States for the past fifty years has been 25.5 bushels per acre.

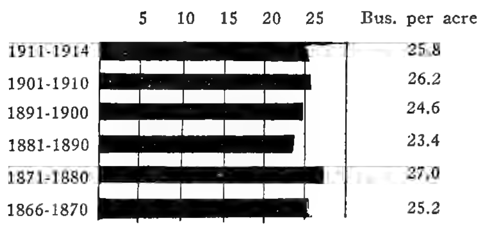
The lowest average yield, for a single year, occurred in 1901. It amounted to 16.1 bushels. It will be remembered that that year was extremely unfavorable for corn growing from nearly every standpoint. The spring was cold and wet and the summer exceedingly warm with little rainfall.

The highest average yield 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.

The following chart shows the average yield from 1866 to 1914.

CHART NO. 4.

AVERAGE YIELD PER ACRE IN THE UNITED STATES, 1866-1914—Bushels



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

TABLE NO. 7

SHOWING BY STATES THE AVERAGE YIELD OF CORN PER ACRE—1866-1910

(45 year average)

Rank		Bushels	Rank		Bushels
1	Vermont	35.8	26	Indian Territory	26.0
2	New Hampshire	35.3	27	Idaho	25.5
3	Massachusetts	35.3	28	Montana	25.3
4	Maine	33.8	29	Nevada	25.2
5	New Jersey	33.8	30	Wyoming	24.0
6	Pennsylvania	33.6	31	Oklahoma	23.4
7	Connecticut	33.3	32	Delaware	23.3
8	Ohio	33.2	33	Washington	23.0
9	Iowa	32.1	34	South Dakota	22.0
10	Indiana	31.9	35	Arizona	22.9
11	New York	31.1	36	Arkansas	22.9
12	Wisconsin	31.0	37	Colorado	22.4
13	Michigan	31.0	38	Tennessee	22.3
14	Illinois	30.8	39	New Mexico	22.3
15	Rhode Island	30.8	40	North Dakota	21.5
16	District of Columbia	30.7	41	Utah	20.5
17	Minnesota	30.0	42	Texas	20.1
18	Nebraska	29.9	43	Virginia	19.9
19	California	29.9	44	Louisiana	17.1
20	Missouri	28.6	45	Mississippi	15.2
21	Maryland	27.4	46	North Carolina	13.7
22	Kansas	27.2	47	Alabama	13.0
23	Kentucky	26.7	48	Georgia	11.1
24	West Virginia	26.3	49	South Carolina	10.2
25	Oregon	26.2	50	Florida	10.2

NOTE—In the above table, North Dakota, South Dakota and Wyoming show an average yield for only twenty-five years; Oklahoma for fifteen years; Montana, Colorado, New Mexico, Arizona, Utah, Idaho and Washington for thirty-five years. Other states were figured on a forty-five year basis.

In the preceding Table No. 7 we find the states listed in the order of their average yield per acre, covering a 45 year period. Vermont stands first with an average yield of 35.8 bushels, and Florida and South Carolina take last place with only 10.2 bushels. Thus we see that in order to have a creditable average it is necessary for a large number of the states to stand high in order to make up for those which tend to pull down the average.

If any definite conclusions may be derived from the foregoing table we might say that the district of highest 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 gradually decreasing.

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

TABLE NO. 8

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

	1910	1900	1890	1880	1870	1860	1850
North Atlantic ...	3.6	3.4	3.4	5.2	8.8	8.0	9.6
South Atlantic ...	9.1	6.3	6.2	7.4	11.4	16.0	21.2
North Central	63.5	72.8	75.3	73.2	57.7	48.4	37.5
South Central	23.5	17.3	14.8	14.0	21.8	27.4	31.6
Western	.3	0.2	0.3	0.2	0.3	0.2	.01

At present the North Central district produces nearly two-thirds of the entire annual yield of our country. The South Central district follows with a trifle less than one-fourth of the total yield. Thus it is seen that the North Atlantic and Western sections combined produce but about one-tenth of our annual crop.

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

	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 table on production we are 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 1910. It further shows the percentage of total crop produced by each state for the same period.

TABLE NO. 9

Rank of Each State in Production of Corn 1850-1910
Showing also Percent of Total Production for Each Period

To Find Rank or Percent of Production of any State for Given Year follow darts

State	Rank	1910	1900	1890	1880	1870	1860	1850	Rank	State
Illinois	1	13.2	14.9	14.8	16.6	17.1	13.7	10.0	1	Ohio
Iowa	2	11.0	14.4	13.7	15.7	9.1	8.8	9.9	2	Kentucky
Missouri	3	8.7	8.6	12.2	11.5	8.9	8.7	9.7	3	Illinois
Nebraska	4	6.6	7.9	10.2	6.6	8.7	8.5	8.9	4	Indiana
Indiana	5	6.4	7.8	9.3	6.4	6.7	7.6	8.8	5	Tennessee
Texas	6	5.8	6.7	5.4	6.0	6.6	6.2	6.1	6	Missouri
Kansas	7	5.4	5.7	5.1	4.2	5.4	5.0	6.0	7	Virginia
Ohio	8	4.6	4.1	3.7	3.7	4.6	4.6	5.1	8	Georgia
Kentucky	9	3.3	2.8	3.3	3.6	2.7	4.0	4.9	9	Alabama
Tennessee	10	3.0	2.5	3.0	2.6	2.4	3.7	4.7	10	North Carlina
Oklahoma (3)	11	2.9	2.0	2.0	2.0	2.3	3.6	3.8	11	Mississippi
Arkansas	12	2.2	1.9	1.6	1.8	2.3	3.5	3.4	12	Pennsylvania
Michigan	13	2.1	1.8	1.6	1.7	2.2	3.4	3.0	13	New York
Mississippi	14	2.1	1.7	1.4	1.7	2.2	2.4	2.8	14	South Carlina
Georgia	15	2.1	1.7	1.4	1.6	2.2	2.1	1.8	15	Maryland
Pennsylvania	16	2.0	1.5	1.4	1.5	2.1	2.0	1.7	16	Louisiana
Alabama	17	2.0	1.4	1.3	1.4	2.2	2.0	1.5	17	Arkansas
Louisiana	18	1.8	1.4	1.2	1.4	1.9	1.8	1.5	18	New Jersey
North Carolina	19	1.8	1.3	1.2	1.3	1.8	1.6	1.5	19	Iowa
Minnesota	20	1.8	1.3	1.2	1.2	1.5	1.5	1.0	20	Texas
Virginia (4)	21	1.7	1.3	0.7	0.9	1.1	1.2	1.0	21	Michigan
South Dakota (5)	22	1.7	1.2	0.7	0.8	1.1	0.9	0.5	22	Delaware
Wisconsin	23	1.6	a. 1.2	0.6	0.8	1.0	0.7	0.4	23	Massachusetts
South Carolina	24	1.4	0.8	0.6	0.7	1.0	0.5	0.3	24	Vermont
New York	25	0.8	0.8	0.6	0.6	0.6	0.3	0.3	25	Florida
West Virginia	26	0.7	0.7	0.6	0.6	0.6	0.3	0.3	26	Wisconsin
Maryland	27	0.7	0.7	0.4	0.2	0.4	0.2	0.3	27	Connecticutt
New Jersey	28	0.3	0.6	0.2	0.2	0.3	0.2	0.3	28	Maine
Florida	29	0.2	0.4	0.1	0.1	0.2	0.2	0.3	29	New Hampshire
Delaware	30	0.2	0.2	0.1	0.1	0.2	0.2	0.1	30	Rhode Island
Connecticutt	31	0.1	0.2	0.1	0.1	0.2	0.2	0.1	31	New Mexico
North Dakota	32	(2)	0.1	0.1	0.1	0.2	0.2	(2)	32	Dist. of Columbia
Vermont	33	(2)	(2)	0.1	0.1	0.2	0.1	(2)	33	Minnesota
Colorado	34	(2)	(2)	0.1	0.1	0.1	0.1	(2)	34	California
Massachusetts	35	(2)	(2)	(2)	0.1	0.1	(2)	(2)	35	Utah
California	36	(2)	(2)	(2)	(2)	(2)	(2)	(2)	36	Oregon
New Mexico	37	(2)	(2)	(2)	(2)	(2)	(2)		37	
New Hampshire	38	(2)	(2)	(2)	(2)	(2)	(2)		38	
Maine	39	(2)	(2)	(2)	(2)	(2)	(2)		39	
Oregon	40	(2)	(2)	(2)	(2)	(2)	(2)		40	
Washington	41	(2)	(2)	(2)	(2)	(2)	(2)		41	
Rhode Island	42	(2)	(2)	(2)	(2)	(2)			42	
Utah	43	(2)	(2)	(2)	(2)	(2)			43	
Arizona	44	(2)	(2)	(2)	(2)	(2)			44	
Idaho	45	(2)	(2)	(2)	(2)	(2)			45	
Montana	46	(2)	b. (2)	(2)	(2)	(2)			46	
Wyoming	47	(2)	(2)	(2)					47	
Nevada	48	(2)	(2)	(2)					48	
	49		(2)	(2)					49	
	50		c. (2)						50	
	51		(2)						51	
	52								52	

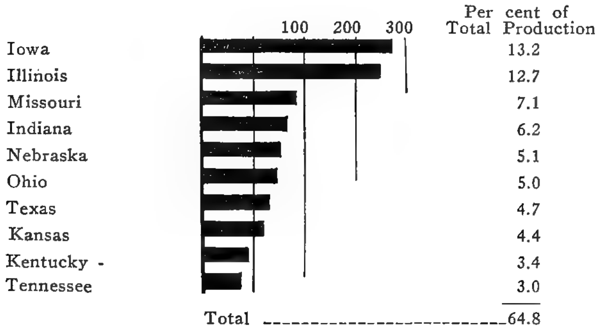
(2) Less than one tenth
(3) Included in Indian Territory prior to 1890
b Hawaii only time reported
(4) In 1850 & 1860 Virginia included West Virginia
(5) Included in Dakota Territory prior to 1890
a. Indian Territory-reported in 1900
★ Time State first reported
c. Dist. of Columbia-last time reported

Taking the states ranking from one to five, inclusive, in 1910 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 1910, 13.2 per cent. Iowa stood seventeenth place in rank in 1850, first in 1890, and first in 1913. Missouri ranked sixth in 1850, and third in 1910. Nebraska, when first reported in 1860, ranked thirty-first, and in 1910, ranked fourth. Indiana fell from fourth place in 1850 to fifth place in 1910.

Considering now just the ten states leading in production in 1913 let us note first the following chart:

CHART NO. 5

PRODUCTION OF CORN IN THE TEN LEADING STATES 1910-1914 INCLUSIVE—MILLIONS OF BUSHELS



Together these ten states produced 64.8 per cent or nearly two-thirds of the entire crop. Iowa, which was the heaviest producer, furnished 13.2 per cent of the entire crop, or 361,771,000 bushels. Illinois stood second with 12.7 per cent of the entire crop, or 348,846,000 bushels.

Missouri ranked third with 7.1 per cent of the entire production or 194,253,000 bushels. Indiana followed in fourth place with 6.2 per cent, or 180,464,000 bushels. Nebraska in fifth place produced 5.1 per cent of the entire crop, or 163,641,000 bushels. Ohio ranked sixth with 5.0 per cent of the entire crop, or 151,691,000 bushels.

Texas ranked seventh with 4.7 per cent of the entire crop or 130,146,000 bushels. Kansas stood eighth with 4.4 per cent, or 120,415,000 bushels. Kentucky stood ninth with 3.4 per cent, or 94,123,000 bushels. And tenth Tennessee with 3.0 per cent, or 83,311,000 bushels. The standing of the other states may be taken from the preceding charts.

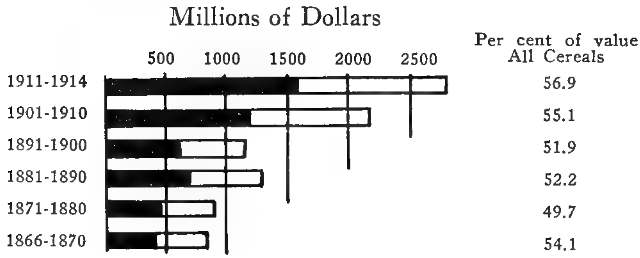
As has already been intimated, the future increase in the production of corn in this country depends upon something more than increased acreage. We must now look to our seed selection, cultivation and crop rotation.

VALUATION OF THE CORN CROP

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 1914 the crop was valued at $1,722,070,000. If this crop were to be paid for in silver it would require twenty-two trains of 100 cars, each of 40,000 pounds capacity, to haul the silver. Or if these silver dollars were placed face to face as one would arrange them in a pile, it would form a solid silver rope over 2,000 miles long.

CHART NO. 6.

THE VALUE OF THE CORN CROP AS COMPARED WITH THE ENTIRE VALUE OF ALL CEREAL CROPS IN THE UNITED STATES, 1866-1914.



Black portion of bar represents value of corn. Entire length of bar represents value of all cereals.

NOTE—The valuations designated in the above chart represent an average for periods indicated to 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.

The value of the annual corn crop from 1866 to 1914 may be ascertained by referring to Table No. 4, on page 12. It is governed largely by production, varying slightly with the demand.

The highest average price paid for corn in this country is recorded for 1901, and corresponds to the year of lowest average yield. An average taken over any number of years for yields per acre and price per bushel shows a marked co-relation between the two. Yet this statement must be qualified to meet the changing conditions of the times. For instance, the average price during the last ten years has been higher than for any previous decade following 1870. The average yield per acre for the past fifty years has been 25.5 bushels, and the average price for the same period has been 41.6 cents. This means only $10.60 total income from each acre devoted to corn as an average for fifty years.

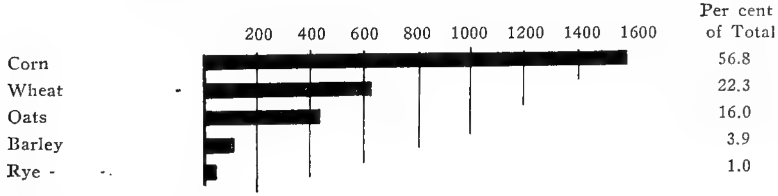
By referring to the annual report of the Department of Agriculture, the average price in the different states varies greatly. The highest average price for the past year (1914) is recorded for Arizona and it amounted to $1.20 per bushel, while the lowest price of 50 cents per bushel is found in South Dakota. A close study of this table covering a term of years, 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 the period 1910 to 1914 inclusive note the following chart:

CHART NO. 7.

VALUATION OF THE CORN CROP AS COMPARED WITH OTHER CEREAL CROPS IN THE UNITED STATES

1910-1914 inclusive. Millions of Dollars.



Let us now consider from a similar standpoint each of the states concerned in the production of corn, taking an average of five years, 1910-1914 inclusive. We will note first the comparative value of this crop as related to that of all other cereal crops. The states will be considered separately. Throughout the corn belt the annual value of the corn crop approximates about 25 per cent of the total value of all farm products including livestock, dairy products, etc.

TABLE NO. 10

VALUE OF CORN AND SMALL GRAIN. AVERAGE FOR FIVE YEARS, 1910-1914 INCLUSIVE.

STATE	Corn (Dollars)	Wheat (Dollars)	Oats (Dollars)	Barley (Dollars)	Rye (Dollars)	Per Cent of Total Value of Cereal Crops	
						Corn	Small Grain.
New England							
Maine	$ 585,000	$ 77,400	$ 2,837,000	$ 120,800	$	16.1%	83.9%
New Hampshire	758,400		242,400	26,600		73.7	26.3
Vermont	1,421,400	27,000	1,636,800	319,400	20,200	41.5	58.5
Massachusetts ..	1,669,800		157,600		59,000	88.5	11.5
Rhode Island ...	410,800		30,400			93.1	6.9
Connecticut	2,248,000		180,800		135,200	87.7	12.3
Middle Atlantic							
New York	14,619,200	6,969,400	18,962,800	1,569,000	1,932,200	33.2	66.8
New Jersey	7,196,200	1,452,400	1,000,800		1,044,600	67.3	32.7
Pennsylvania ..	40,656,600	20,647,200	16,032,000	132,200	3,953,600	49.9	50.1
East North Central							
Ohio	82,295,200	28,696,000	24,554,600	480,200	906,000	60.1	39.9
Indiana	90,807,400	30,021,200	19,148,200	141,600	873,000	64.4	35.6
Illinois	174,416,400	32,203,600	50,034,400	933,000	660,400	67.5	32.5
Michigan	35,244,800	13,431,400	19,050,600	1,424,800	4,105,600	48.1	51.9
Wisconsin	35,151,000	3,112,800	27,503,000	14,204,000	4,553,200	41.5	58.5
West North Central							
Minnesota	39,287,600	49,012,600	31,256,600	18,764,800	3,033,800	27.8	72.2
Iowa	170,792,000	11,158,200	57,501,200	7,366,600	545,000	69.0	31.0
Missouri	107,950,800	30,290,600	11,433,000	72,800	182,600	72.0	28.0
North Dakota ..	4,711,400	67,801,200	17,784,200	11,124,000	726,600	4.6	95.4
South Dakota ..	30,576,400	28,970,200	11,960,400	8,530,600	350,000	38.0	62.0
Nebraska	77,736,400	42,824,600	20,388,800	1,014,000	841,600	54.4	45.6
Kansas	62,427,800	81,046,400	18,387,200	1,778,400	428,800	38.0	62.0
South Atlantic							
Delaware	3,735,000	1,865,000	57,000		12,800	65.8	34.2
Maryland	14,546,800	9,581,400	615,000	69,800	319,800	57.8	42.2
Virginia	34,387,800	9,798,600	2,029,200	167,400	494,800	73.3	26.7
West Virginia .	15,856,600	3,230,800	1,353,000		183,000	76.9	23.1

TABLE NO. 10—Continued

VALUE OF CORN AND SMALL GRAIN. AVERAGE FOR FIVE YEARS, 1910-1914 INCLUSIVE.

STATE	Corn (Dollars)	Wheat (Dollars)	Oats (Dollars)	Barley (Dollars)	Rye (Dollars)	Per Cent of Total Value of Cereal Crops	
						Corn	Small Grain
S. Atlantic—Cont.							
North Carolina	$ 43,751,400	$ 7,251,200	$ 2,524,400		$ 399,800	81.1%	18.9%
South Carolina	31,130,000	1,138,800	5,116,600		48,400	83.0	17.0
Georgia	48,078,200	1,948,200	5,658,000		170,200	86.0	14.0
Florida	7,676,000		531,000			93.5	6.5
East South Central							
Kentucky	57,644,400	9,483,600	1,780,600	62,600	231,200	83.3	16.7
Tennessee	53,262,200	8,625,800	3,385,200	56,400	195,800	81.3	18.7
Alabama	43,001,000	418,200	4,093,800		20,200	90.4	9.6
Mississippi	42,769,000	62,200	1,631,600			96.2	3.8
West South Central							
Arkansas	34,634,000	1,143,600	2,642,000		12,800	90.9	9.1
Louisiana	25,933,800		572,800			97.8	2.2
Oklahoma	36,802,000	20,807,800	8,420,000	160,400	51,800	55.6	44.4
Texas	93,603,600	10,775,800	12,414,400	126,400	32,800	80.1	19.9
Mountain							
Montana	589,000	11,764,200	7,494,800	882,200	118,000	2.8	97.2
Wyoming	233,800	1,684,000	3,231,000	234,400	41,200	4.3	95.7
Idaho	302,400	9,825,800	5,465,400	3,183,600	43,400	1.6	98.4
Colorado	4,709,400	7,945,000	5,048,800	1,496,400	186,800	24.3	75.7
New Mexico	1,718,800	1,205,800	878,400	62,600		44.4	55.6
Arizona	552,000	873,600	180,800	1,061,000		20.7	79.4
Utah	232,000	4,535,200	1,869,800	596,200	82,600	3.2	96.8
Nevada	33,200	1,024,800	261,400	381,800		2.0	98.0
Pacific							
Washington	677,200	36,199,800	5,845,400	3,831,200	120,400	1.4	98.6
Oregon	451,000	13,943,600	5,676,200	2,142,600	277,200	2.0	98.0
California	1,652,600	6,764,200	4,053,200	26,993,800	259,400	4.1	95.9
United States	$1,595,419,400	$ 629,639,200	$ 442,909,400	$ 109,511,600	$ 27,654,200	56.9%	43.1%

THE PRINCIPAL CORN GROWING COUNTRIES OTHER THAN THE UNITED STATES

MEXICO

The Awakening In Agriculture In Mexico

Dr. Pehr Olsson-Seffer was commissioned in 1906 to investigate Mexican Agricultural conditions. In his 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, such as has been done over the corn belt of the United States.

A great many ranchers in Chihuahua and Durango have for some time employed improved methods and selected their seed corn. President Diaz was always interested in the farmers. A leader in the greater movement is Mr. Zeferino Dominguez, a Mexican owner 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. The greatest good will come with increased facilities for irrigation.

The Peonage System

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.

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.

The Production of Corn in Mexico

Mexico is second among all corn growing countries from the standpoint of acreage, yet the production is insufficient for domestic needs and several million bushels are imported annually from the United States. Some sections, such as Chihuahua and Colima, seem well suited naturally to corn production, while in other localities irrigation is essential.

The temperature may fall below the freezing point in December, but the mean annual temperature ranges from 60 to 75 degrees, Fahrenheit. The rainfall varies from about 10 inches in Lower California to 50 or 55 inches in Colima. The average yield of corn is given at 15 to 40 bushels per acre. The flint types are grown mostly, but in some sections a soft starchy variety is produced. The price per bushel ranges from 56 cents to $1.40, or even higher.

The method followed by the Indians in corn production is very primitive. First, the land is burned over to get rid of trees, brush and weeds. The corn is then planted without further preparation of the land. A pointed stick serves to make the hole into which the seed is dropped and covered over with a little dirt, either by hand or foot. Perhaps the weeds are cut once during the season with a hoe. Aside from this, no cultivation is given.

In other places, wooden plows, or even disc plows are used on 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 are given with the plow. The corn, when ripe, is topped over the ear, and the toppings used for fodder. After the first frost, the ears are stripped by hand and thrown into a basket carried upon the back of a peon. Cattle are then turned into the field to pick what is left.

In addition to the flint and dent varieties, some pod corn is grown. "Mäis de Riego," or irrigated corn is planted after the frost when the soil is warm, 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 planted. The "mais poblano," planted 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 planted.

CORN PRODUCTION IN SOUTH AMERICA

Aside from Argentine Republic and Brazil, very little data is available on corn production. In 1912 Chile reported one and a half million bushels, and Uruguay eight million bushels. However, some corn is grown in practically all of the South American countries, mostly of the flint type on account of the weevil which causes considerable damage in the grain when stored.

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.

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 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.

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.

No fear of frost presses the farmers in regard to selecting the seed corn early, and 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.

In Argentina corn culture has in recent years made great strides. From three million acres in 1900, plantings have been rapidly extended, and a recent estimate of the Argentine Department of Agriculture puts the land seeded for the crop maturing in the spring of 1914 at 10,250,000 acres. A distinctive feature of corn growing in Argentina is that the bulk of the crop is raised for export. Preeminently a pastoral country, the vast fields of alfalfa, and a mild climate that permits grazing in a great part of the pastoral zone practically the year round, minimize the demand for corn as an animal food; considerably less than 100 million bushels meets the annual domestic requirements for all purposes. As during the past two years the production has amounted respectively, to 296 million and 197 million bushels, Argentina has figured as the most important single source of supply for the great importing nations of Europe. Exports to all countries out of the banner crop of 1912 amounted to 190 million bushels. If the present rate of increase in culture be maintained, the Republic would doubtless be in a situation eventually to supply single handed the entire import demand of all European states.

Within the last few years increasing quantities of corn have been imported into the United States from the Argentine, most of which has been consigned to the Corn Products Refining Co., of New York, for manufacturing purposes. The importations, however of the 1913 crop have exceeded those of former years, the total importations from July 1, 1913, to February 13, 1914, as reported by Bradstreet's being 7,132,980 bushels, approximately 85 per cent of which was discharged at Atlantic ports, and the remainder at Gulf ports.

Argentine being the corn belt of the Southern Hemisphere, the crop matures approximately six months in advance of corn in the United States, so that export shipments begin during the early part of June. The duration of the voyage from the Argentine to the United States under favorable conditions is approximately 30 days.

While the total production of corn in the Argentine under the most favorable conditions is considerably below the production in the state of Illinois, less than half of the Argentine crop is consumed within the Republic, so that the Argentine exports have greatly exceeded those of the United States during the past few years.

The Argentine corn is handled in burlap bags containing from 130 to 135 pounds, in direct contrast to the corn from the United States, which is exported mainly in bulk. The most common method of discharging cargoes at United States ports is to hoist with crane and tackle from 12 to 15 bags at a time and shift them to barges or lighters alongside the vessel, where the corn is inspected as the bags are opened. From seven to fifteen days are usually required to unload a cargo, depending largely on the condition and quality of corn and the weather.

Corn as grown in Argentina consists almost exclusively of the hard, flinty varieties with medium to small kernels, mostly yellow in color. North American varieties like the Hickory King, a white corn, and Queen, a yellow variety, have been tried with success. The character of the corn, having both small cobs and small kernels, results in a much lower moisture content in the Argentina shelled corn than is normally contained in the large dent varieties of the United States.

As a result of the small size of the kernels, the Argentina corn can not carry, without increased danger of deterioration, as high a percentage of water as the larger dent corns of the United States. On the other hand, the hard and firm texture of the Argentina corn is such that it can be "conditioned" to much better advantage than our dent corns.

During the summer of 1912, through the courtesies of the Corn Products Refining Company and the grain inspection department of the New York Produce Exchange, several cargoes of corn from Argentina were examined at the time of discharge at the port of New York. The average results of mechanical analyses on 157 samples from four of the cargoes, representing a total of 638,000 bushels, are contained in Table 11. The data shown in this table represents new corn of the crop of 1912.

TABLE NO. 11

*SHOWING AMOUNT OF MOISTURE IN ARGENTINA CORN.

Steamship	Date of Arrival at New York	Days in Transit	No. of Samples Taken	Bushels in Cargo	Moisture Content	Weight per Bushel	Per Cent Sound Corn	Per Cent Dirt, Chaff, Cob, etc.
A	Oct. 19	35	55	180,000	14.55	60.87	93.84	0.10
B	July 8	27	48	260,000	14.80	60.10	95.28	.17
C	Aug. 4	45	28	66,000	17.02	57.75	63.74	.28
D	Aug. 5	34	26	132,000	15.43	60.01	90.02	.17
Total			157	638,000		60.05	90.50	.16

Average moisture content of four cargoes, 15.10 per cent.

From Table 11 it will be seen that the average moisture content of the total 638,000 bushels was 15.1 per cent, the weight per bushel more than 60 pounds, the percentage of sound corn 90.5 and the dirt, chaff, cob, etc., approximately one-sixth of one per cent.

During the months of December, 1913 and January, 1914, samples to the number of 591 were secured from 16 different cargoes of Argentina corn as discharged at New York and at Gulf ports. The average moisture content of these samples (old corn of the 1913 crop) was 13.7 per cent, or 6.6 per cent less than the average moisture content of corn shipped from country stations in central Illinois during December, 1913, and January, 1914, the latter being new corn of the 1913 crop. From the standpoint of moisture content alone this represents a difference in value of approximately 5⅝ cents per bushel, based on a New York price of about 70 cents per bushel, not giving consideration to the increased danger of deterioration of high moisture corn. While the average moisture content of the Argentina corn is low, a consider-

*Agricultural Outlook, March 18, 1914.

able quantity is damaged, musty, sour and heating when discharged. This is evidenced by the fact that of the 591 samples previously referred to, the maximum moisture content was 41.6 per cent, the minimum being 9.2 per cent.

A considerable quantity of Argentina corn is likewise infested with weevil. Samples of screenings from practically all of the cargoes have been submitted to Dr. F. H. Chittenden, in charge of Truck-Crop and Stored Product Insect Investigations of the Bureau of Entomology, but no new species have been found.

A wide diversity of opinion exists as to the chemical composition of Argentina corn as compared with the dent varieties of the United States. While the data available are not sufficient to justify the drawing of any definite conclusions, the results of the chemical analyses of a limited number of samples of Argentina corn is superior, from the standpoint of chemical composition, to our dent corn as loaded for export at our Atlantic and Gulf ports as shown in Table 12.

Table 12 shows the average results of the chemical analyses of 98 samples of Argentina corn, representing four cargoes with a total of 638,000 bushels of the crop of 1912, as discharged at New York, together with the average of the analyses of 129 samples of North American corn, representing two cargoes of the 1910 crop and two cargoes of the 1911 crop with a total of 910,146 bushels as loaded for export.

*TABLE NO. 12

CHEMICAL COMPOSITION OF FOUR CARGOES OF ARGENTINA FLINT CORN AS DISCHARGED AT NEW YORK AND FOUR CARGOES OF NORTH AMERICAN DENT CORN AS LOADED FOR EXPORT, CALCULATED TO A WATER FREE BASIS.

Item	Argentine Corn Crop of 1912 as Imported at New York	North America Corn Crops of 1910 and 1911 as Loaded for Export
Ash	1.72	1.43
Ether extract (oil)	5.52	4.07
Protein	11.01	9.81
Crude fiber	1.99	2.18
Pentosans	6.02	6.19
Invert sugar	.30	.38
Sucrose	1.08	1.13
Acid calculated as acetic	.33	.28
Undetermined	72.03	74.53

Chemical analyses of the individual sample made by Cattle Food and Grain Laboratory of the Bureau of Chemistry.

From Table 12 it will be seen that the ether extract or oil was

*Agricultural Outlook, March 18, 1914.

approximately 1.5 per cent greater in the Argentina corn than in the United States corn, while the protein was 1.2 per cent greater. In the consideration of these analyses it is necessary to note that they represent commercial corn and are therefore not comparable with the analyses shown in text books, which are based on selected, hand shelled samples.*

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 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 price is about seventy-five cents per bushel. The flint type is almost universally grown. The temperature and rainfall is quite variable and cultivation practices 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.

CORN PRODUCTION IN EUROPE

In the Eastern hemisphere the principal maize growing regions are southern Europe, Asia, the Mediterranean countries of Africa and the Union of South Africa.

In southern Europe the crop is grown for the grain on an expanse of territory extending from west to east across the entire continent and reaching northward from the Mediterranean and Black Seas to latitudes including Switzerland and a small part of southern Germany. The value of the luxuriant semi-tropical foliage of the plant has, moreover, extended its cultivation for fodder into countries where the seasons of warm sunshine are too short for the grain to mature, and hence maize is grown for forage to a greater or less extent in many countries of northern Europe even as far north as Scotland.

In southern Europe the crop is cultivated for grain on an aggregate of about 30 million acres, the total annual production usually ranging between 600 million and 700 million bushels. The variety raised

*By J. W. T. Duvel, Crop Technologist, in Agricultural Outlook Mar. 18, 1914.

is for the most part the small grained yellow flint, designated by English-speaking people as "round maize" in distinction from the "flat" or large-grained dent variety, consisting of white and yellow mixed, which reaches European markets from the United States.

In Portugal, corn, known in the vernacular as "milho," is cultivated on a much larger scale than any other cereal and constitutes, among other uses, the chief food of the peasant class.

Spain and France have each over a million acres under maize. Concentrated in the northern part of the former country and southern part of the latter there are extensive districts where it is the chief grain cultivated and the principal reliance of the peasants for human food.

"Granoturco," the Italian name for corn, is grown annually in Italy on an extent of about four million acres, and in two provinces, Lombardy and Ventia, on a somewhat more extensive scale than is wheat; polenta, a dish prepared from corn, is in parts of the kingdom the staff of life of the masses.

Upward of a million bushels are raised annually in Greece, and in 1910 the annual output of European Turkey was officially returned as 22 million bushels.

Corn culture in Europe, however, is largely centralized in a group of countries comprising Austria Hungary, Roumania, Servia, Bulgaria, and in the southern governments of Russia. In this territory upward of 20 million acres are planted annually and the normal yield is approximately 50 million bushels.

The important position the crop occupies in the agriculture of these countries is indicated by the fact that in Hungary proper, the principal corn-growing country of Europe, and in Bulgaria, the acreage is second only to that of wheat, while in Roumania, where the grain is known as "porumb," and in Servia, where it is called "cucuraz," it is more extensive than that of any other cereal.

Excepting Austria-Hungary, whose annual production is a few million bushels short of domestic requirements, corn is grown in the rest of this territory in surplus quantities. Aggregate exports usually ranging between 50 million and 80 million bushels a year, are made from Roumania, Bulgaria, Servia and Russia to Austria-Hungary, Italy, Spain and chiefly to the non-producing states of north Europe.*

The total production of corn in Austria-Hungary in 1910 exceeded that of 1890 by 50 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

*Chas. M. Daugherty in Agricultural Outlook March 18, 1914.

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.

CORN PRODUCTION IN ASIA

Outside of America and Europe the most extensive corn-growing area in the world is in Asia, notably in Turkey, southern Asiatic Russia, British India, French Indo-China, the Philippines, China and Japan. Although the crop in none of these countries attains the proportions of a principal one, there are localities in most of them where its culture is of great local importance.

In Asiatic Turkey an official report indicated over 900,000 acres under cultivation in 1911, and in 1911 a small area of 150,000 acres was returned in Asiatic Russia—in Ferghana, Samarkand and Syr-Daria.

In British India, where in some districts food made from corn is the chief article of native diet, over six million acres are planted yearly.

An annual area of over one million acres is grown in the Philippines and upward of 130,000 acres in Japan.

Statistical record of the area and yield in China and Indo-China is non-existant. It is known, however, that the grain is grown to a considerable extent in parts of China, and in the northern part its value as a human and animal food is supplemented by the general use of the stalks as fuel. In the French colony, Indo-China, the growing popularity of the culture is indicated by the fact that the annual imports into the mother country from this possession increased from 571,000 to 3,710,000 bushels during the period 1906 to 1911.

CORN PRODUCTION IN AFRICA

Corn is grown quite generally on the Continent of Africa, but, excepting that it is an important article of food among the native tribes of the central colonies, definite information respecting the extent of its culture is limited to the countries along the Mediterranean and to the Union of South Africa.

In Egypt, the principal producing country, the area (about 1,900,000 acres) is more extensive than that of cotton; the grain constitutes the chief food of the Egyptian fellah and enters almost wholly into domestic consumption.

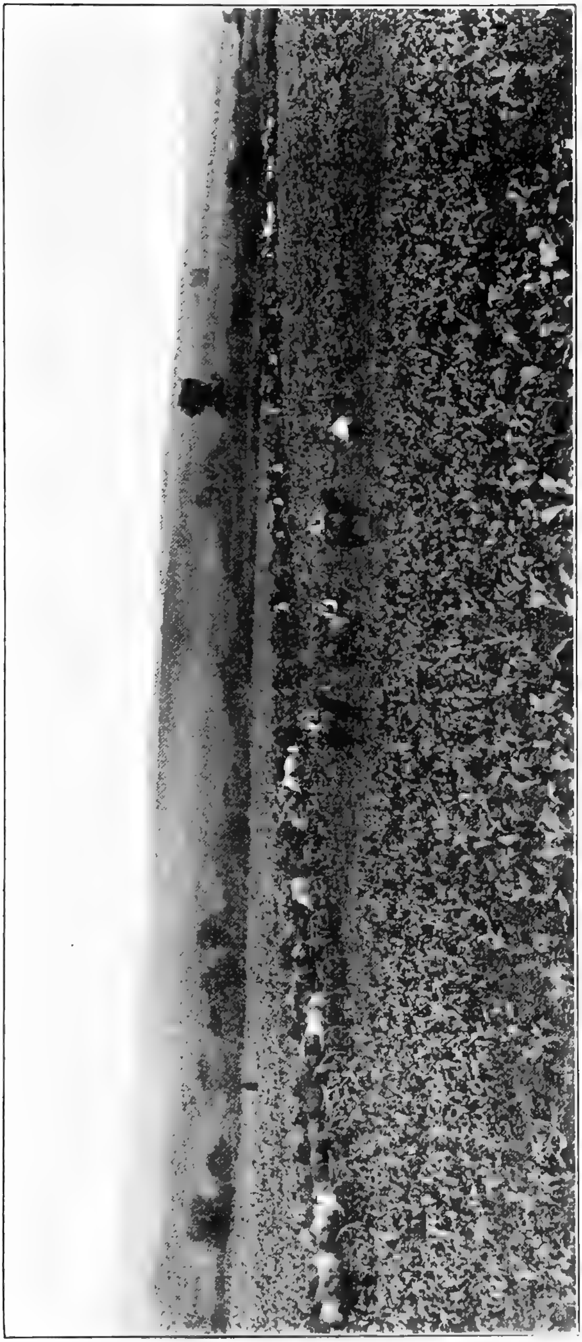
Small areas are also cultivated in Tunis, Algeria, Tripoli and Morocco.

In the Union of South Africa the raising of "mealies", the local name for corn, has in late years been attracting much attention; the acreage, notably in Natal, has been much extended and, at the taking of the census of 1911, the total South African production was found to have increased to over 30 million bushels. In normal years a few million bushels are now available for export.

Corn, it may be added, is grown on a small scale in the northern latitudes of Australia and New Zealand, and in many islands throughout the world for which few statistics are extant.

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 late David Rankin of Tarkio, Missouri, Directing the Cultivation of a Thousand Acre Field

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:

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.

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.

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.

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.

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.

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.

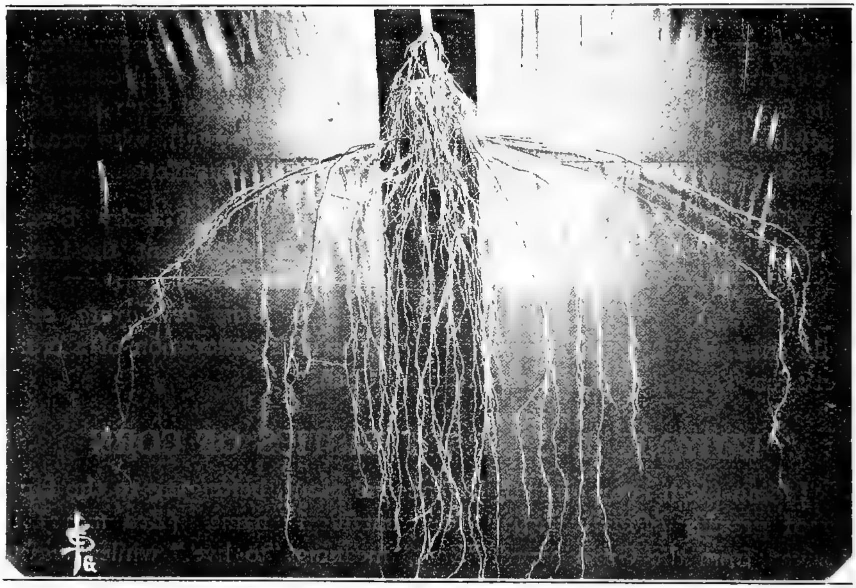
Zea canina (Watson) sometimes known as *Maiz de Coyoto,* or a wild corn, is a hybrid form from fourth or fifth generation of a cross between Teosinte and Black Mexican Corn.

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."

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.

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 cells and acts as a protection to that portion. As it wears away, new cells are supplied from behind by the growing point.



THE FIBROUS ROOT SYSTEM OF CORN.

Many of the finer cross roots were lost in removing the plant from the soil. Note how the roots extend outward and downward.

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 lay 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.

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.

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 deeply because of injury to surface roots.

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

*Bulletin 43, N. D. Experiment Station.

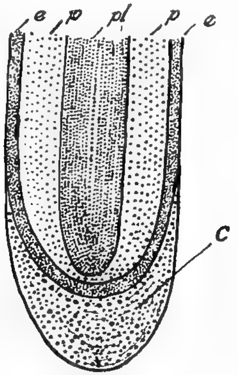
food. From 22 to 28 brace roots usually appear at each node. If the weather is stormy and the corn has a tendency to blow over, these brace roots grow very rapidly.

BRACE ROOTS

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.

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.



A longitudinal section through the root tip of shepherd's purse, showing the central vascular axis (pl), 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.

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 cortex and 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 *structure must be quite fine. A root will not cross a large interspace between lumps of earth.

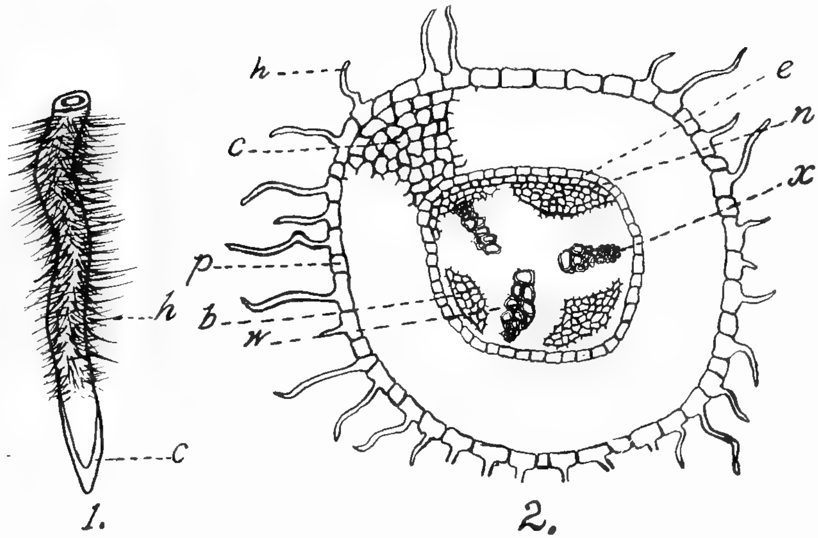
(2) Corn roots draw almost entirely upon the *capillary* water of the soil. In case of extreme drought they may possibly use some of the *hygroscopic* moisture. Very little, if any of the *gravity* water, that which is drained from the soil in tiling, is utilized by the plant.

(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.

*The words structure and texture are often used synonymously. The structural peculiarities are those which interest the geologist, the textural belong more properly to the mineralogist. But the usages of geologists differ in the employment of terms of this kind, and there can be no precise limit drawn, separating structures from textures. (Century Encyclopedia.)



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.)

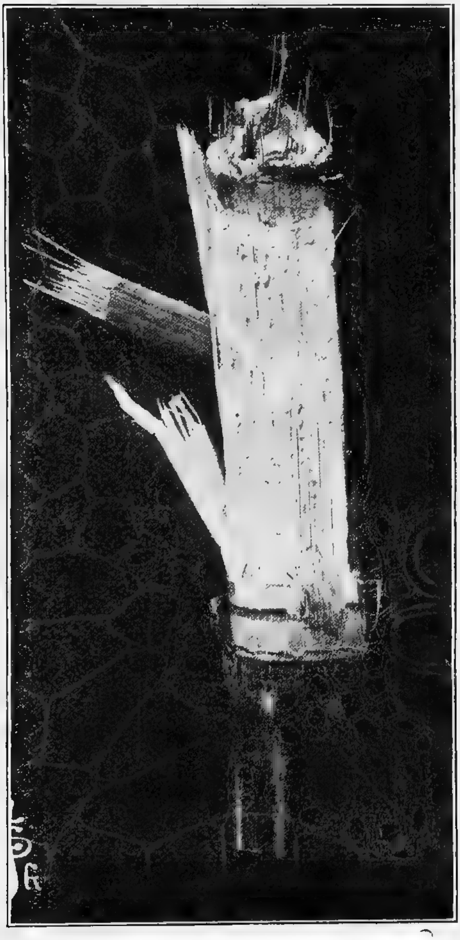
STALK.—Structure of Stem. The stem varies in height from 18 inches to 24 feet, according to variety and conditions influencing growth, as climate and soil. It is made up of a series of sections known as *internodes,* which vary in length from a few inches at the base to more than a foot at the top. They 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.

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

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.

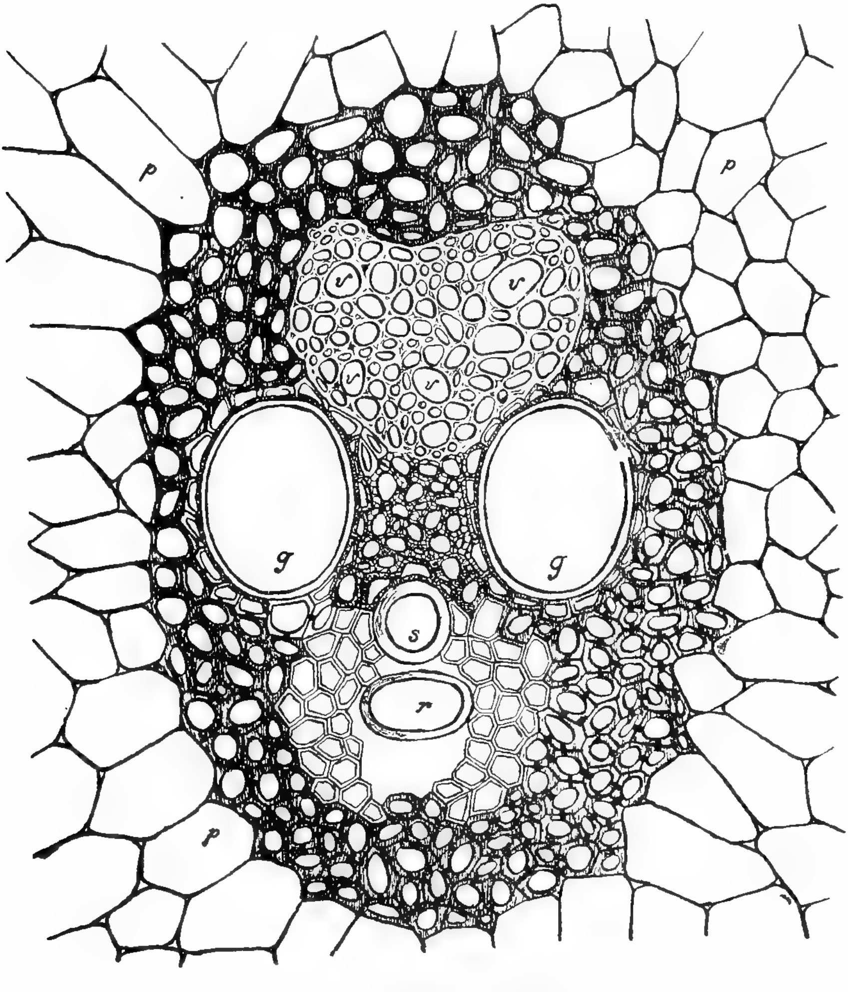


Section of corn-stalk showing pith, fibro-vascular bundles, and epidermis.

(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.

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

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



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 vessels 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.

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.

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 midrib. 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.

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.

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 or 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.

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.

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.

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.

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.

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.

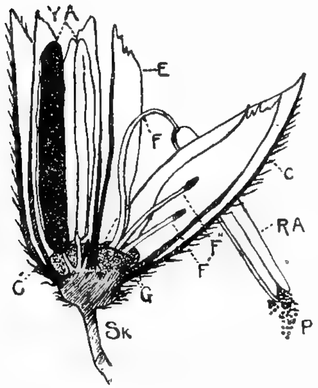
(3) Seasonal influences. Often in a growing season of plenty rainfall, the early corn will remain green and continue growing late in the summer before blossoming. A sudden drouth at the time of rapid growth forces the date of blossoming upon the corn.

(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,* 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 present a greenish, glandular, 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-

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 sacs, making a total of 20,250,000 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 20,250 grains for each ovary, if each stalk produced but one ear, or 10,125 in case of two ears, counting 1,000 ovaries per ear.



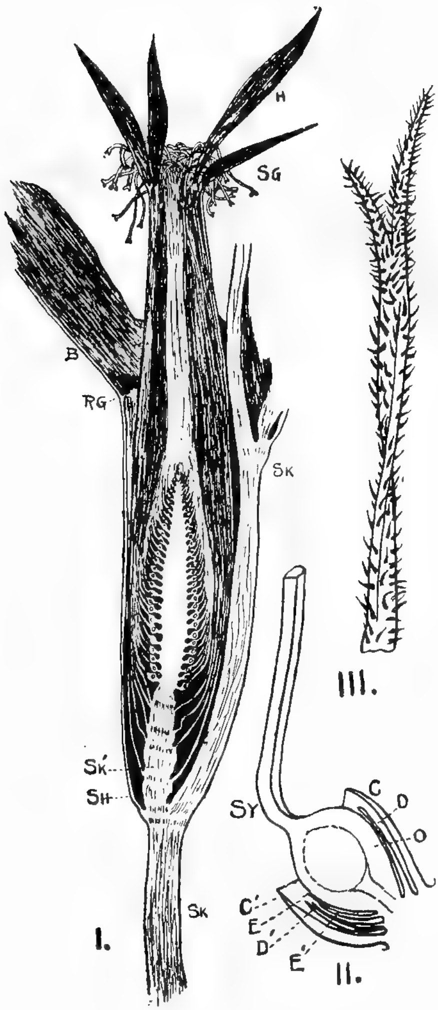
A spikelet from the tassel cut lengthwise to show its two flowers, the one on the right fully open, the other not yet mature. Sk, stalklet; C, C', outer bracts; D, E, inner bracts of the open flower; G, lodicules, which by swelling spread the bracts apart; F', F'', filaments cut across; F, filament bearing 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 hairs which, together with a sticky or mucilaginous secretion present, aid in collecting pollen grains.

The remainder of the silk to its attachment is the *style,* which is slightly angular and is tubular. 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.

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

EAR IN SILK.
(Entire Tassel.)



Maize. 1. A young ear cut through the middle lengthwise. Sk, Sk, the main stalk; Sk', the branch stalk 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 husks.

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.

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

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 **embryo* (germ) before the endosperm or the body of the kernel is filled out. Later, the cellular structure (endosperm) surrounding the embryo 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.

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.

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

*This term embryo is sometimes loosely applied to that portion of the embryo which produces the roots, stems and leaves. This is incorrect, the terms germ 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.*

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.

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.*

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.

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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 awaken 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 embryo of the matured seed.

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.

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.

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.

(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.

(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.

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.

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. was maintained, but during six hours out of each twenty-four, the temperature was 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.

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.*

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.

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.

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) Nitrogen.
        - (2) Phosphorus.
        - (3) Potassium
        - (4) Calcium.
        - (5) 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 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.

FUNCTION OF WATER.

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 "hygroscopic" water within their reach. The root system receives this moisture and passes it from cell to cell into the tubes of the central cylinder.

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.

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 stomata 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.

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

the leaves of the plant.*** "It is probable that formaldehyde is first 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 ($C_{12}H_{22}O_{11}.H_2O$) 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."

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.

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.

TABLE NO. 13

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 22nd	July 24th	July 26th	July 30th	Aug. 3rd	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

TABLE NO. 14

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	43	
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	

TABLE NO. 14—Continued

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. 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, besides 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 analogous to the same term used in connection with animals. Plant foods are rather the raw materials 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.

(2) Nitrogen.

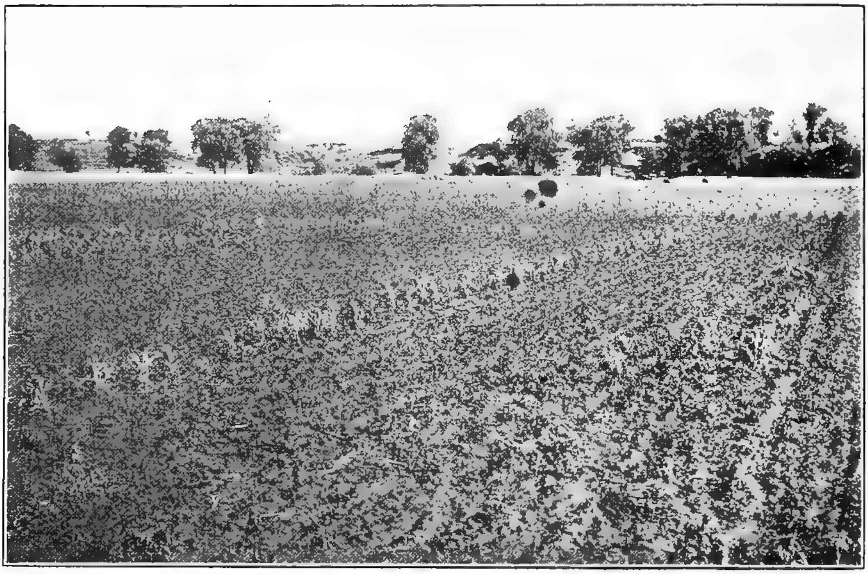
Free nitrogen as such cannot be assimilated by any green plant. Small quantities of ammonia and nitric acid are washed down by rains into the soil and are taken up by the roots. Certain bacteria, however, some living free in the soil and others in nodules of legumes fix the free nitrogen of the atmosphere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

(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-



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) **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.

(2) **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 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. In many sections of the corn belt it has already been found profitable to add phosphorus to the soil in the form of some commercial fertilizer.

(3) **Potassium.** Potassium, usually spoken of as potash, K2O, the oxidized form, requires less serious consideration from the standpoint of its ultimate depletion in the soil than either nitrogen or phosphorus. 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.

*"Agricultural Botany," Percival.

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.

(4) **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.*

(5) **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.

TABLE NO. 15

SHOWING AMOUNT OF PLANT FOOD IN PRINCIPAL FARM CROPS.

	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 "

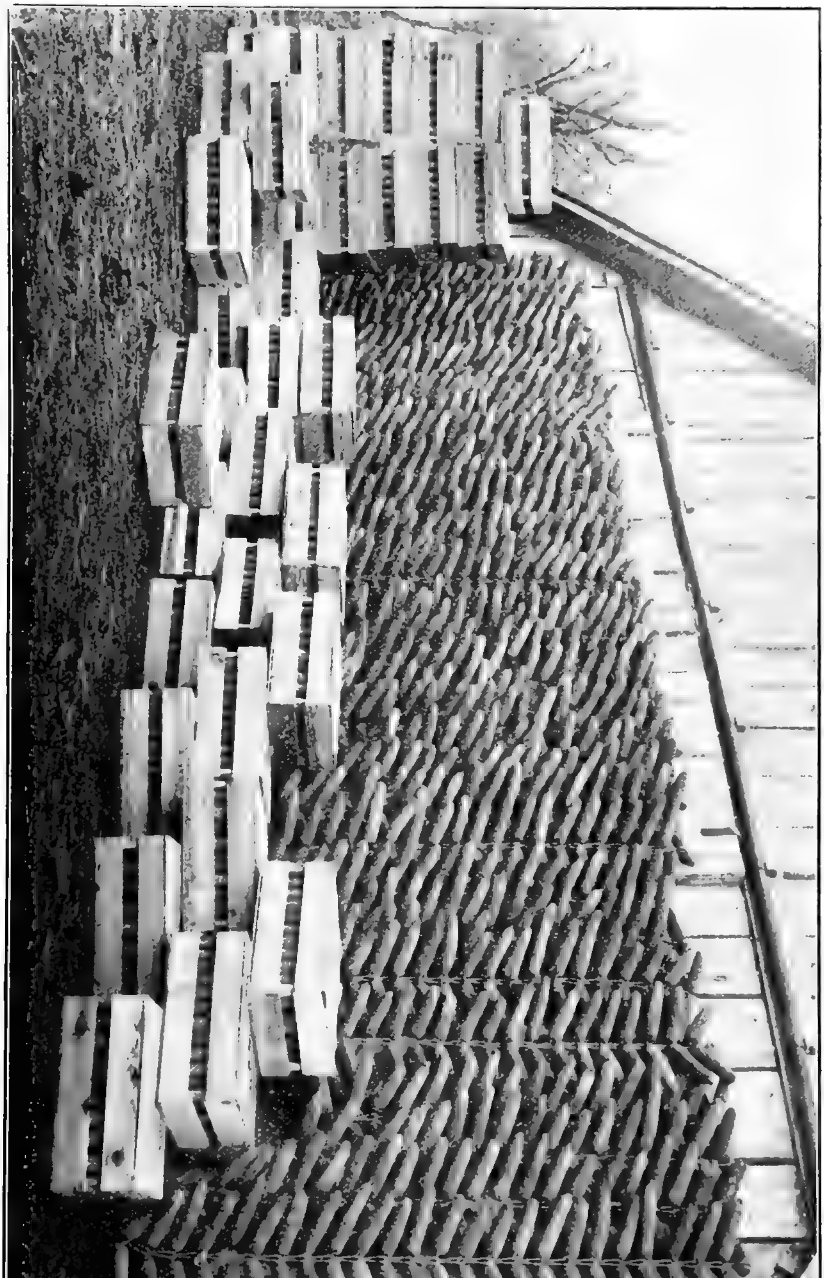
The table showing the amount of different elements taken from the soil by the principal crops is taken from circular No. 68 of the Illinois Experiment Station.

COLLATERAL READING:

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

Water Requirements of Corn.
Utah Bulletin No. 86.

*"Agricultural Botany," Percival.



Sixty-five bushels of choice Blackhawk Reid's Yellow Dent seed corn selected from the First Prize Acre in Blackhawk County, Iowa, 1914, (Howard-Bowman Farm) which yielded 109 bushels, showing the result of eleven years of careful selection of this corn in that county.

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).

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.

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 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 wonderful 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

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. 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. Difference of altitude is said to retard plant growth and to delay the awakening season between one-half and one day for each hundred feet of ascent and vice versa.

The length of the growing season is in general the most important factor in determining the size of the stalk produced. The long season of the south induces 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 coarser and more 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 is 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 and Illinois are very marked, while beyond the borders of these states the differences are still more no-

*Hunt's "Cereals in America," Page 203.

ticeable. The dependence of yield upon climate is seen when the average production per acre for the state of Iowa for a term of years is considered. Under similar conditions, aside from climate, the yield for Iowa has varied from 14.8 bushels to 45.8 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 soil 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.

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.

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

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

**The relation of climate to variety and type of corn grown is taken up fully in Chapter VI.

of those crops which tends more than any other to maintain a uniform composition and to vary less under environment. It is this characteristic 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.

The following table is inserted here as a basis for the discussions which are taken up. It shows the figures from which charts Nos. 8, 9, 10, 11 and 12 were made.

TABLE NO. 16

Showing Average Yield of Corn, Mean Annual Temperature and Rainfall of Iowa for 25 Years, 1890-1914 inclusive.

CORN YIELD—AVERAGE IN IOWA FOR 25 YEARS

Year	Average	Year	Average
1890	28 bu.	1903	31
1891	38	1904	36
1892	29	1905	37.2
1893	35.7	1906	41
1894	14.8	1907	29.5
1895	38	1908	35.9
1896	39	1909	34.6
1897	29	1910	39.8
1898	34.5	1911	32.9
1899	36.3	1912	45.8
1900	43.3	1913	34.9
1901	26.2	1914	38.0
1902	34.0 bu.		

Average....................34.5 bu.

MEAN ANNUAL TEMPERATURE AND RAINFALL OF IOWA FOR 25 YEARS

Year	Temp.	Rainfall	Year	Temp.	Rainfall
1890	48.0	31.30	1903	47.2	35.39
1891	47.3	32.90	1904	46.3	28.51
1892	46.6	36.58	1905	47.2	36.56
1893	45.7	27.59	1906	48.4	31.60
1894	49.7	21.94	1907	48.0	31.61
1895	47.2	26.77	1908	49.5	35.26
1896	48.6	37.23	1909	47.4	40.01
1897	47.8	26.98	1910	48.6	19.87
1898	47.7	31.34	1911	49.5	31.37
1899	47.3	28.68	1912	46.4	28.89
1900	49.3	34.05	1913	49.7	29.95
1901	49.0	24.41	1914	49.1	31.93
1902	47.7	43.82			

*Yearbook Dept. Agriculture, 1901.
**See Page 130, Results at Wisconsin Experiment Station where fertilizer was used.

TABLE NO. 16—(Continued)

MONTHLY MEAN PRECIPITATION IN IOWA FOR 25 YEARS

Year	May	June	July	August	Average
1890	3.56in.	7.76in.	1.98in.	3.41in.	4.18in.
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	6.35
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
1908	8.34	5.66	3.66	4.77	5.59
1909	4.34	6.41	4.77	1.81	4.33
1910	3.41	1.99	1.86	3.88	2.78
1911	3.76	1.82	2.27	3.32	2.79
1912	3.33	2.74	3.71	3.78	3.39
1913	6.24	3.31	1.82	2.68	3.51
1914	3.31	5.57	2.27	2.19	3.33
Average	4.50	4.38	3.80	3.51	4.05

MONTHLY MEAN TEMPERATURE IN IOWA FOR 25 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
1908	59.4	67.1	73.0	70.0	67.4
1909	57.9	69.1	72.3	76.1	68.8
1910	55.4	69.5	74.5	71.9	67.8
1911	64.9	75.7	75.5	71.7	71.9
1912	62.7	66.2	74.6	71.0	68.6
1913	59.4	71.5	76.1	76.6	70.9
1914	62.2	72.2	76.6	73.7	71.2
Average	59.9	69.5	73.9	71.9	68.6

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 early 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 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. Chart No. 12 shows the relation of yield to the total rainfall of the growing season, for 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.

Charts 8 and 9 do not show close correlations between yields and precipitations for May and June. The explanations for these discrepancies have already been given.

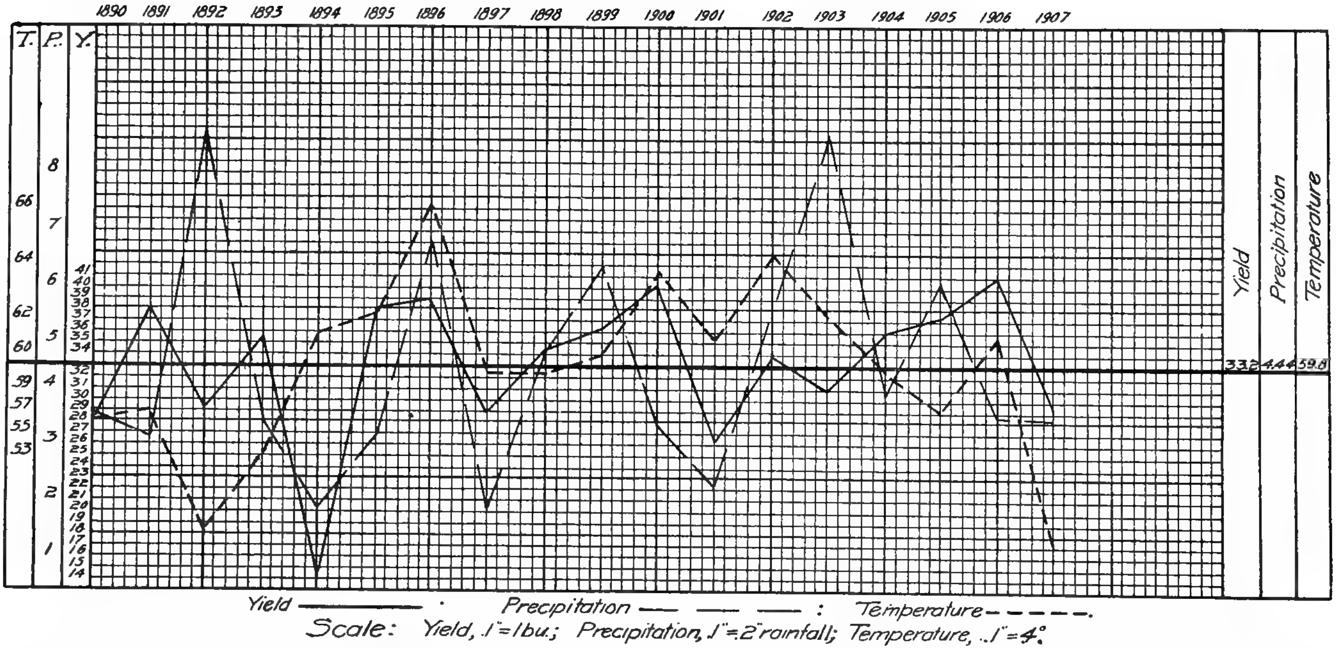


CHART NO. 8 Showing precipitation of May, 1890 to 1907 inclusive. The average temperature of May for the eighteen years was 59.8° Fahrenheit, the average precipitation was 4.44 inches. Note high precipitation in 1892 with low temperature. In that year the yield of corn for the state was below normal. The same was true in 1903.

(Taken from Iowa Weather Report.)

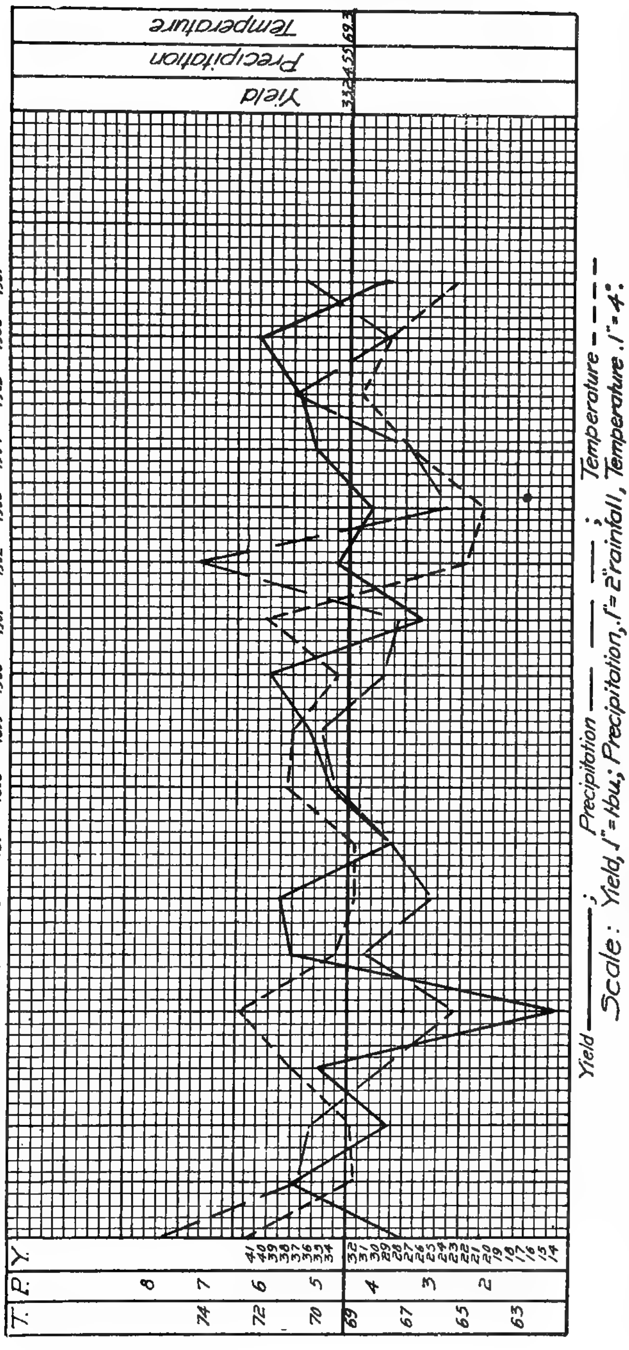


CHART NO. 9 Showing precipitation and moisture for June, 1890 to 1907 inclusive. Low precipitation in June with high temperature as in 1894 accompanied low yield of corn. High precipitation in June with low temperatures as in 1901 accompanied a correspondingly low yield of corn.
(Taken from Iowa Weather Report.)

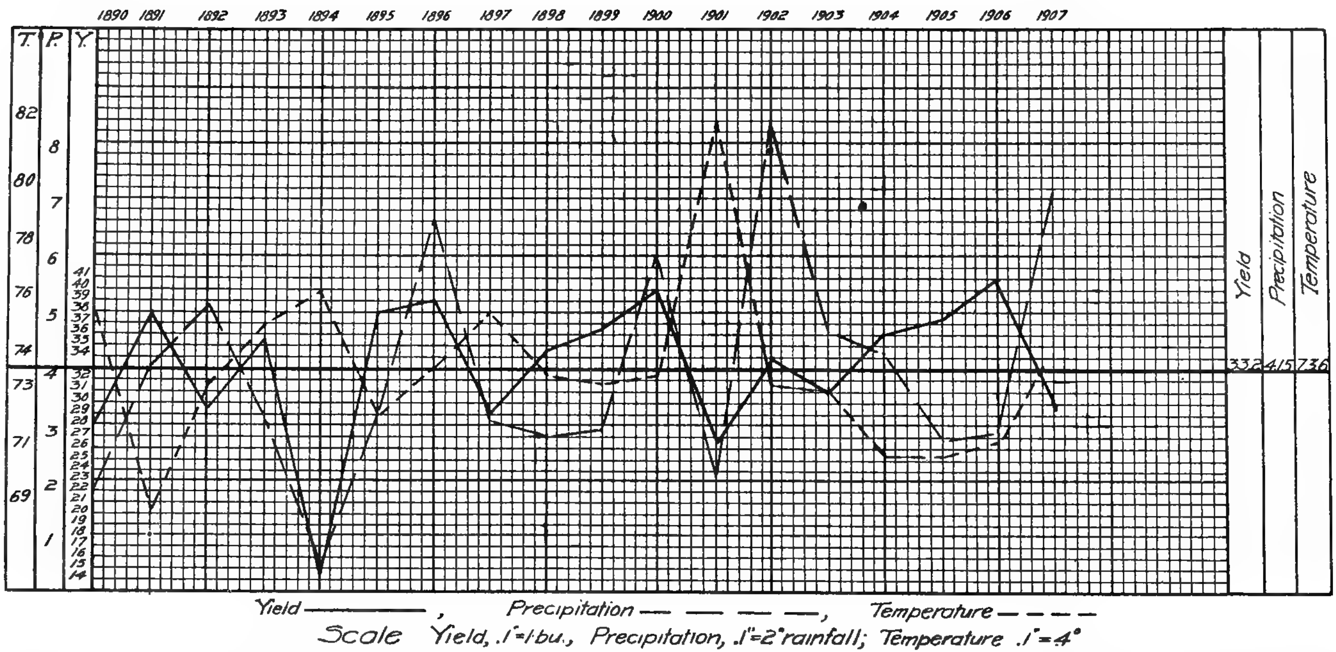
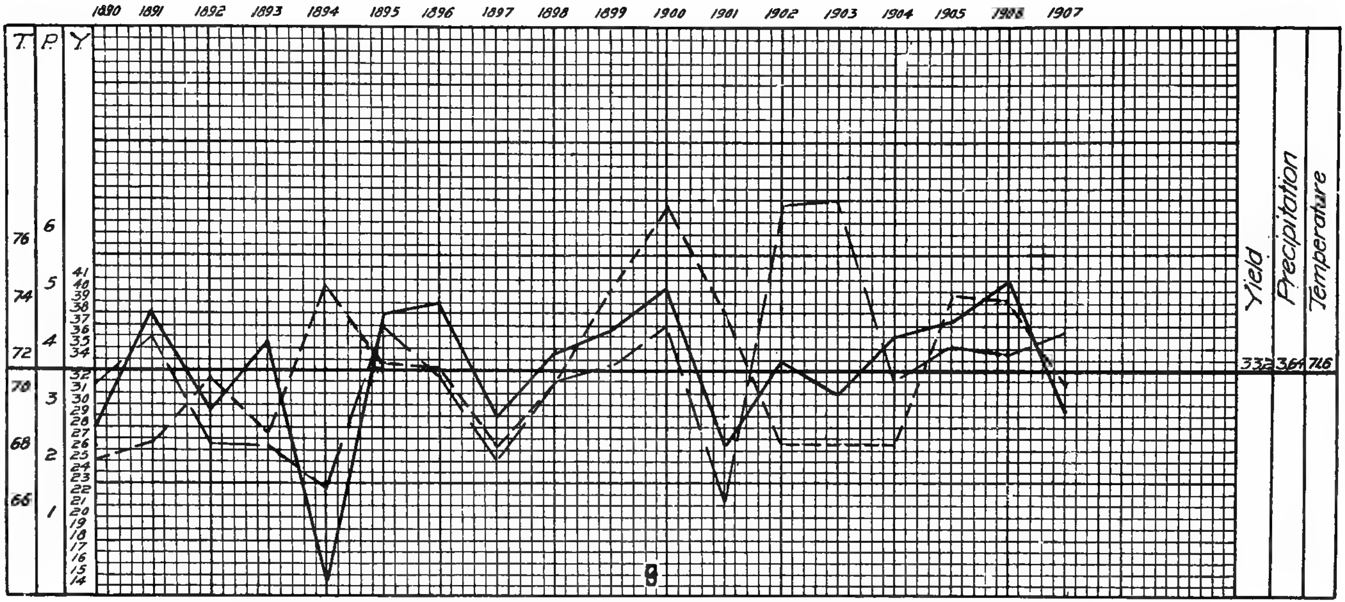


CHART NO. 10 Showing precipitation and temperature for July, 1890 to 1907 inclusive. Note very low precipitation of 1894 with high temperature and low yield of corn for that year. In 1902 the precipitation was high but the temperature was low. The season was wet and cold, hence a low average yield of corn.

(Taken from Iowa Weather Report.)



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

CHART NO. 11 Showing precipitation and temperature for August, 1890 to 1907 inclusive. In 1894 note the effect of the low precipitation with high temperature on the yield of corn for that year. A shortage of moisture in August is very harmful to the corn crop. The high yield of 1900 and 1906 are accompanied by plentiful moisture and fairly high temperature.

(Taken from Iowa Weather Report.)

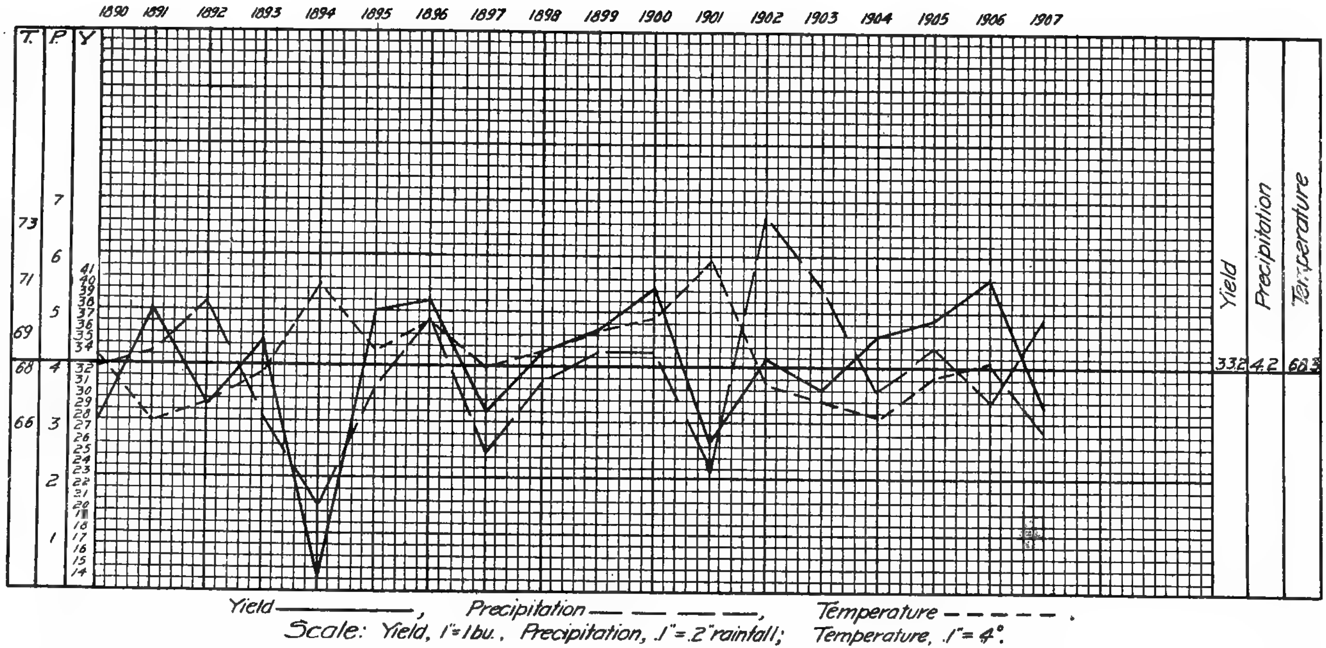


CHART NO. 12 Showing average temperature and precipitation for the month of May, June, July and August, 1890 to 1907 inclusive, in Iowa, with corresponding average yield of corn. Note that the relation between yield and precipitation is especially close. The low yield of 1894 was accompanied by meager rainfall. The temperature was high. The season was dry and hot. In 1895 and 1896 the yield greatly increased with the increase in moisture, the temperature being about normal. Although the precipitation of 1892, 1902 and 1903 was high, reference to the charts for May and June show excessive rainfall accompanied by low temperature, and the average yield of corn for these years was low. 1893 shows a fairly high average yield of corn with a low precipitation, but the month of April preceding was marked by an unusually heavy rainfall which helped to make up for the shortage during the growing season.

The correlations of yields and rainfall for July and August, especially the latter, shown by charts 10 and 11, 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 not only yield, but habit of growth as well. A wet season favors larger and continued growth, while a dry one induces 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 TEMPERATURE TO CORN GROWING

Corn is a semi-tropical plant and requires for its maximum growth 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. Heavy rainfall is accompanied by a low average temperature. 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.

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*Report Iowa Weather and Crop Service (1902)
**The effect of moisture and its relation to the corn crop will be further discussed in Chap. VIII.

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 is 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, so that the supply of humus is maintained.

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.

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;

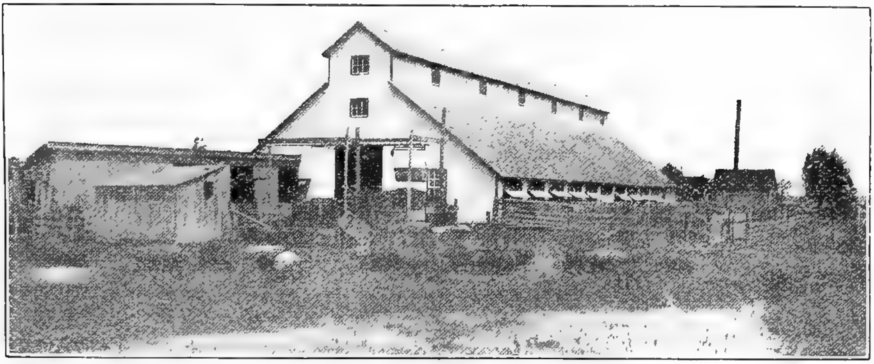
(2) That corn on different fields may make very nearly equal growth, while differing materially in percentage of protein produced;

(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. 198—9.

(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."



HOG BARN, WITH LITTER CARRIER DEPOSITING MANURE IN BACK, 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.

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

*15th Bi. Report Kansas Station, Board of Agriculture, Page 895.

(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. Humus as defined by Hopkins includes only that part of the organic matter that has passed the most active stage of decomposition and has completely lost the physical structure of the materials from which it is made. Deterioration in the physical condition of a soil is accompanied by soil washing and lessening of its water-holding capacity.

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

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 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.

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.

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.

*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, including some legume. 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.

(5) To supply more economically the necessary protein to balance the corn ration.

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

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.

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.

*At the Indiana Experiment Station for 24 years, corn and wheat were grown in rotation with each other in comparison with the same crops rotated with oats, roots, grass and clover. No manure or fertilizer was used. In 1909 after 20 years of cropping with the legume rotation, the yield per acre was 61.1 bushels as compared with an average yield of 25.4 bushels with the corn and wheat alone.

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.

TABLE NO. 17

YIELDS FROM FIELD AT URBANA, TYPICAL CORN BELT PRAIRIE SOIL**

Crop Years	Crop System	15-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, 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.

*Indiana Bulletin. Nos. 55 and 64.

**Illinois Bulletin No. 125 (May 1908.)

*"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."

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.*

Considering the last six crops in an experiment which has been conducted in Illinois for twenty-nine years, and comparing three cropping systems, continuous corn; corn and oats; and corn, oats and clover, the value of a rotation including a legume is well marked. The total value of six continuous corn crops was $58.08. The total value of the last six crops in the corn and oats rotation (three crops of corn and three crops of oats) was $79.01, and the total value of the last six crops of the corn, oats, clover rotation (two crops corn, two crops oats, two crops clover) was $92.09.

Rotation compared with continuous corn shows a difference in favor of the rotation of approximately $34.00 per acre for the last six crops.

The average value of each of the six corn crops under continuous cropping with corn was $9.68 as compared with an average value of $27.16 for the two corn crops included in the last six years of the crop rotation plots, or an average value of $15.35 for all crops from the rotation plots.

Corn alone is not a balanced ration. With an abundance of carbohydrates and fat-producing compounds additional protein is needed in feeding for the most economic gains. This can be produced on the farm in the form of leguminous crops, more cheaply than it can be purchased in the commercial concentrates, hence, crop rotation.

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

(1) Increase plant food content of soil.

(2) Aid in making plant food already in soil more readily available.

(3) Improve physical condition of soil.

*Illinois Bulletin No. 125

(4) Add humus to the soil and increase its moisture holding capacity, also allowing freer circulation of air through soil.

(5) Increase bacterial content of soil.

*"It is probably fair to assume that as an average, 80 per cent of the plant food contained in a ration passes on into the manure, and if the manure is economically handled, a large portion of this plant food can be gotten back into the soil, though as a matter of fact, it is pretty difficult to avoid considerable loss, no matter how well the manure is handled. A little carelessness may easily result in the loss of more than half its value, since two-thirds of the nitrogen and four-fifths of the potash in a ration are voided in the urine, and unless the liquid manure is saved by absorbent bedding and a tight floor, the loss of these elements is particularly heavy. The possible losses through heating and leaching are equally serious and must be guarded against with the utmost care.

"The question is often asked what manure is worth, but it is evident from the foregoing statements that no definite value can be assigned. It is variable and depends upon the ration from which the manure is made, the age and kind of animals, and the care given it, and in general is closely proportional to the care. One ton of manure of average composition contains plant food which it would cost $2.25 to replace in the form of the cheapest fertilizing materials, and that valuation is perhaps as fair as any."

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.

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 supplies 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.

*Indiana Circular No. 25, Revised Edition
**Minnesota Bulletin No. 89

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 previous year. For the years 1905, 1906 and 1907, manure was ap plied 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.*

Another test was conducted in Oklahoma** showing the effect of manure on the corn crop with a three-year rotation including corn, oats, and wheat followed by cow peas. To one set of plots manure was added at the rate of 13.4 tons per acre in February, 1900, while another set was left untreated. The average yield from the three crops of corn 1900, 1903 and 1906 where manure was added was 36.18 bushels of corn per acre and 2.28 tons of stover. From the unmanured plots, the yield of corn was only 26.33 bushels and of stover 1.73 tons.

TABLE NO. 18

SHOWING THE EFFECT OF MANURE ON YIELD, AND WATER REQUIREMENTS OF CORN ON DIFFERENT TYPES.

(Nebraska Experiment Station.)***

Character of Soil	Dry weight per plant (grams)		Water requirements per gram of dry weight (grams)	
	Unmanured	Manured	Unmanured	Manured
Infertile (15 bu.)	112.75	375.81	549.50	350.30
Intermediate (30 bu.)	184.39	413.63	478.90	341.30
Quite fertile (50 bu.)	270.09	472.55	391.80	346.60

To the infertile soil, capable of producing 15 bushels of corn per acre, the addition of manure reduced the water requirements of the plant 36.3 per cent, and multiplied the crop yield. In the case of the more fertile soil, capable of producing from 30 to 50 bushels of corn per acre, the benefit was less noticeable, but by no means negligible.

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

*Iowa Bulletin No. 96.
**Oklahoma Bulletin No. 87
***Nebraska Bulletin, Vol. XIV, Article VI.

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.

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.

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.

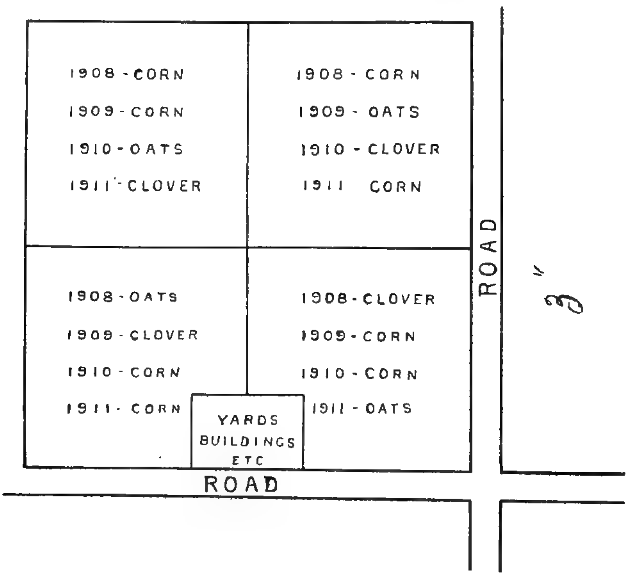
"What other crops should be rotated with corn is a problem which every farmer must largely work out for himself according to his particular conditions, remembering that to get the best results a rational rotation must be practiced; that is, the corn crop must be alternated with some other suitable crops. What these other crops should be and how many different ones should be included in the rotation will depend upon a number of factors, among which are the kind of farming carried on, the kind of soil and its degree of fertility, the kinds of crops which the local conditions will best produce and the extent to which they may be profitably used in the system of farming followed. One cardinal principle, however, must never be forgotten, and that is

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

that some kind of a legume, usually clover, should have a prominent place in the rotation.

"Broadly speaking, the three-course rotation of corn, wheat or oats, and clover will usually be found most suitable on the better class of soils, using cow peas in the place of clover, when the latter fails, putting manure on the corn and, in some states, commercial fertilizer on the wheat. In order to provide the necessary manure and profitably use the legume, every corn grower should be a feeder of live stock. On the less fertile soils, or those otherwise not so well adapted to corn, a longer rotation will be advisable, as for instance, corn, small grain, clover and grass, using legume cover crops and liberal applications of manure and fertilizer.

"Another rotation and one which is well adapted to keeping up or improving the fertility of the soil and seems well worth trying wherever soy beans or cow peas will do well, is a four-course one consisting of corn, soy beans or cow peas, small grain and clover. In this case both corn and small grain may follow legumes which are admirably adapted to precede them. There is abundant evidence which goes to show that whatever rotation is adopted, the corn should always follow a legume, as there is nothing else that will so well or so cheaply fit the soil to produce corn."*



The diagram here given shows in a very simple way the outline and position of a suggested crop rotation. The name of each crop

*Indiana Circular No. 25 Revised Edition.

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.

A four-year rotation as indicated would demand a liberal feeding of the crops and careful application of the manure. Timothy is usually sown with clover and the field generally left for two years. Some farmers eliminate oats as much as possible by drilling wheat in the standing corn or after the corn is cut for fodder.

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Nebraska Bulletin Vol. XXIV Article VI.

Oklahoma Bulletin No. 87.

Indiana Circular No. 25, Revised Edition.

CHAPTER VI.

SELECTION AND PREPARATION OF SEED CORN FOR PLANTING

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, Missouri, Indiana and Nebraska was respectively 34.9, 34.8, 28.1, 37.1 and 25.3 bushels for the past ten years, 1905 to 1914 inclusive.

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.

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.

The results of eight years of trial at County Experiment Stations located on the county farms in different parts of the State of Iowa are very sriking on the point of buying foreign seed. There were 80 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.

TABLE NO. 19

*HOME GROWN VS. IMPORTED SEED. (Summary of eight years test in Iowa)

Farmers	5072 samples
Outside breeders	603 samples
Dealers	543 samples
Average yield of all Farmer's samples	56 bu. per acre
Average yield of Outside Breeders' seed	53 bu. per acre
Average yield of Dealers' seed	42 bu. per acre
One-tenth best Farmer's (507 samples)	67 bu. per acre
One-tenth poorest farmer's (507 samples)	42 bu. per acre

The home grown seed did the best in every way, even taking an average of all home grown seed, good and bad alike, and comparing the results with the imported seed. Taking the best one-tenth of the home grown seed, however, the average yield was 67 bushels per acre as compared with 53 bushels per acre from the seed secured from outside breeders and 42 bushels per acre from seed secured from seed corn dealers.

At the Nebraska Station six leading varieties of corn were compared for two and three years, the seed in one case being native grown and in the other from Iowa or Illinois.

Table showing yield of corn from acclimated seed and from seed from other regions, at the Nebraska Experiment Station.

TABLE NO. 20

**ACCLIMATED SEED VS. IMPORTED SEED. (Nebraska Experiment Station)

Name and place of origin	1903 Bush.	1904 Bush.	1905 Bush.	Average Bush.	Diff. Bush.
Silver Mine (Neb.)		70.0	76.1	73.0	
Illinois		65.1	63.4	64.2	8.8
Leaming (Nebraska)		95.2	69.8	82.2	
Illinois		76.6	72.3	74.4	8.1
Snowflake White (Neb.)	73.7	84.8	74.5	77.7	
Iowa	68.7	72.8	67.1	69.5	8.2
Boone Co. White (Neb.)		76.2		76.2	
Illinois		68.9		68.9	7.3
Early Yellow Rose (Neb.)	68.1	67.9	75.1	70.3	
Iowa	62.1	76.9	63.5	67.5	2.8
Reid's Yellow Dent (Neb.)		83.8	64.2	73.7	
Illinois		82.8	60.8	71.8	1.9
Average					6.2

In every case in the above tests the native seed of the same variety as the imported seed gave the better yield, the average difference being 6.2 bushels per acre in favor of home grown seed.

*County Demonstration Station Reports, Iowa.
**Nebraska Bulletin No. 126.

HARVESTING SEED CORN—The Time. It is generally agreed that seed corn should be picked before danger of a killing frost. It is doubtful if the selection should be delayed later than October 1st, even in the central corn belt. *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 medium, 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.

The risk of leaving seed corn in the field after danger of frost is shown from the results of tests conducted at the Iowa State College. Note the high per cent of moisture in the corn in October. If left in the field this corn is bound to be damaged by frost.

TABLE NO. 21

SHOWING AMOUNT OF MOISTURE IN CORN AT DIFFERENT DATES

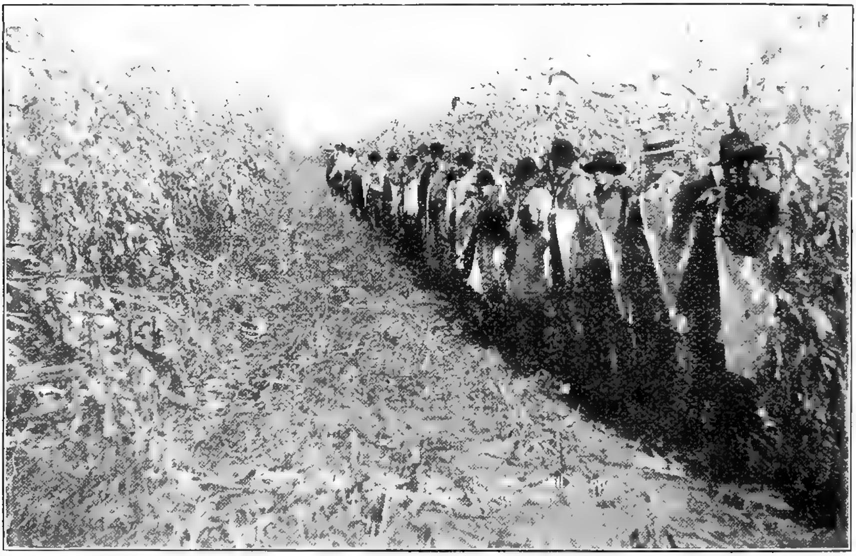
Time Gathered	Per cent of Water
September 20	54
September 27	51
October 6	45
October 13	43
November 7	28

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. Of course in the southern states the danger of freezing is not of such importance, but the proper time to pick the

*Geo. M. Chappel, Iowa Crop Service.

seed must be observed to avoid injury from moulding, sprouting and insect pests. Seed corn should not be left in the field after it has properly matured.

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



GATHERING SEED CORN IN THE FIELD

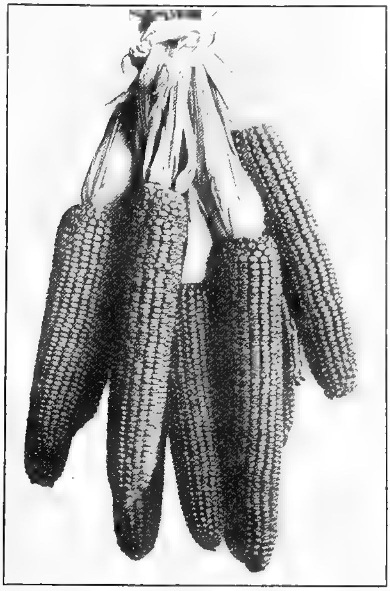
planting of an acre. From three to five bushels of corn is as much as may be expected to be found in a single day. These bushels, however, will contain the most valuable seed ears that the field has to offer. A small plot of selected corn simplifies this process, as the best ears may then be found in a comparatively small area.

During this process, consideration of the strength and character of parent stalk, height of ear and size of shank should be noted. The characteristics are quite generally reproduced. Stalk should be of good size at base, gradually tapering, not necessarily tall. Strong, vigorous stalks of medium height, in general produce best ears. 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 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 ears 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.

2 1

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.



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 to tie with a string, as shown on page 104. 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, but often results in mouldiness, especially if stored in this way during a damp or wet fall.

SHOWING EFFECT OF PLANT SELECTION.

With this thought in view, the Ohio Station conducted a test in 1906 in which ears selected from plants growing in the field under normal conditions of stand, and as nearly normal in other environment as it was possible to judge, were compared with other ears of the same variety and selected from the same field, but selected from the wagon, no attention being given to the stand in the latter instance. The ears selected from the wagon were superior in size and in general appearance, as might be expected.

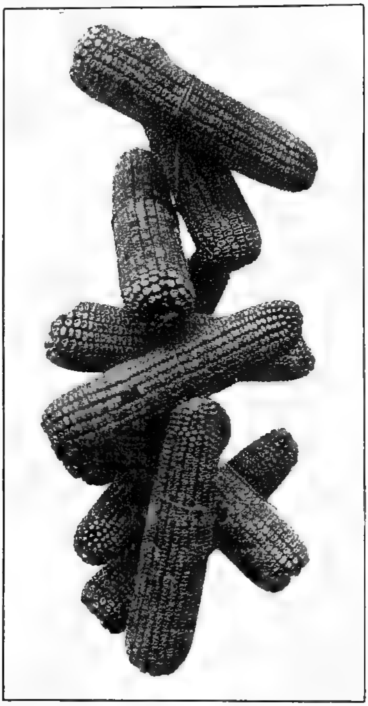
Eight tenth-acre plots were planted from the two selections, four plots of the plant selected seed and four of the seed selected in the ordinary way. These plots yielded as follows:

TABLE NO. 22

PLANT VS. ORDINARY SELECTION*

Plot No.	Method of selection	Yield per acre Bushels
49	Ordinary	68.64
40	Plant	76.57
51	Plant	70.56
52	Ordinary	68.53
55	Ordinary	69.07
56	Plant	71.43
57	Plant	71.43
58	Ordinary	70.82
	Average of Plant selection plots	72.49
	Average of Ordinary selection plots	69.26
	Gain for Plant Selection	3.23 bu.

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

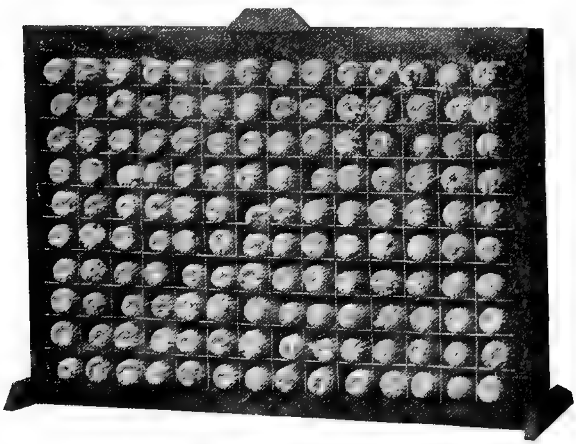


Ears tied too closely together on string for best results. A common error in storing seed corn when single string method is employed.

*Ohio Circular No. 71

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.

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.



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. More recently several types of wire hangers have been put on the market employing practically the same principle as the above.

LAYING IN THE FIRST EAR

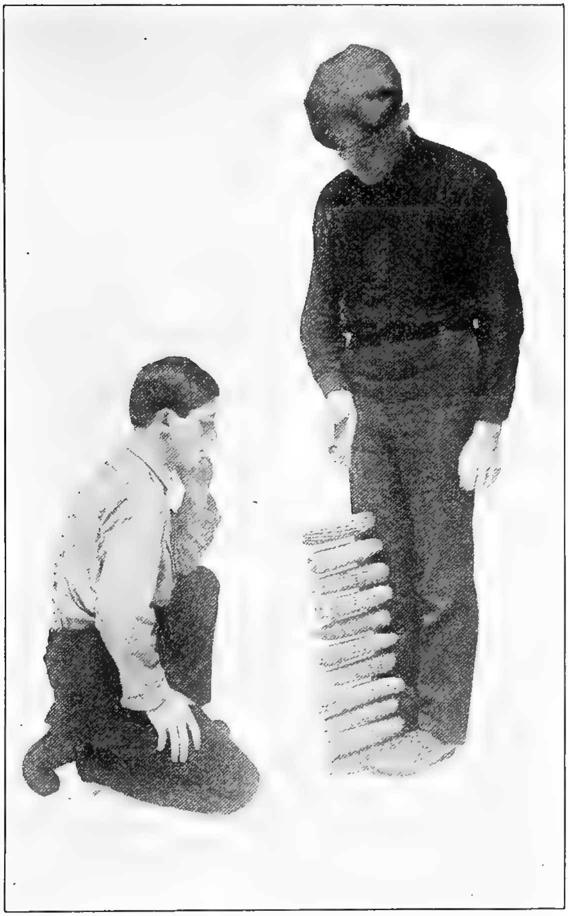
This method, known as the double string method of tying up seed corn, is rapid and efficient. Note that the strings held in the left hand are longer than those in the right. Also that the strings in the right hand are held wider apart. As the strings pass around the ear they are about equally distant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

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 equally 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.

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.

TABLE NO. 23

SHOWING PER CENT OF MOISTURE IN KERNELS AND COB

Date	Kernels	Cob
September 14	41.78 Per cent	58.58 Per cen
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), of the Iowa State College, shows the large amount of water present in early gathered seed corn. It shows that the cob contains the greater percent 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.

SEED EARS ON WIRE HANGERS

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.

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.

THE EFFECT OF MOISTURE AND FREEZING UPON THE VITALITY OF 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.

*Research by W. F. Schnaidt.

TABLE NO. 24

SHOWING EFFECT OF MOISTURE AND FREEZING UPON VITALITY

Number of ear	Per cent of moisture	Per cent of perfect vitality before treating	Per cent of perfect vitality after treating	Amount of loss	Per cent 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**

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

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

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

Early and rapid drying of seed increases its ability to withstand freezing.

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 table shows the results of extensive tests conducted by Experiment Station of Iowa State College in 1910. Each ear of corn represented in the experiment was given several germination tests, using different kinds of seed corn testers, and the table shows the average results of all tests made. In each test six kernels were taken from each ear. After being graded according to the strength of germination, each lot was planted in the field under uniform conditions and in different parts of the field. The record of stand was taken in the fall, and the product of each plot was carefully weighed and recorded. Check plots were planted to verify the records taken. The evidence given herein was further corroborated by a similar test conducted during the following year.

TABLE NO. 25

SHOWING DECREASE IN PER CENT STAND AND YIELD WITH DECREASE OF VITALITY AS MEASURED BY THE GERMINATION TEST*

Total No. of Ear Tests	Germination S W D	Per cent Stand in Field	Yield Bus. per Acre	Per cent Decrease in Stand	Decrease in Yield Bus.
769	6—0—0	72.3	75.1		
472	5—0—1	58.5	65.4	13.8	9.7
425	4—0—2	52.4	58.6	19.9	16.5
347	3—0—3	41.5	50.1	31.8	25.0
340	2—0—4	34.1	42.1	38.2	33.0
297	1—0—5	27.7	39.4	44.6	35.7
259	0—0—6	26.6	34.7	45.7	40.4

S=Strong W=Weak D=Dead

From the seed ears showing all six strong sprouts, the average yield was 75.1 bushels per acre. From the seed ears with one kernel out of the six kernels tested, failing to sprout in the test, the yield in the field was reduced 9.7 bushels per acre. Seed ears from which two of the six kernels tested failed to sprout yielded 16.5 bushels per acre less than the strong ears. Where three out of the six kernels failed to sprout the average yield from the seed ears shows a decrease of 25 bushels per acre. With four of the six kernels failing to sprout the yield from these seed ears was reduced 33 bushels per acre. From seed ears where five of the kernels failed to sprout in the test the average yield was reduced 35.7 bushels per acre, and where all six kernels failed to grow a decrease in yield of 40.3 bushels per acre was found. The yield recorded from ears which failed to germinate when tested is explained by the presence of kernels scattered through the ears which have escaped injury. However one would not wish to plant such ears which so greatly reduce the yield.

Covering a period of seven years the results of the farmer's variety tests in Iowa in twenty-eight counties and covering 55 tests show the condition of the seed corn being planted each year, and serve further to demonstrate the relation of the germination test to the yield of corn in the field. In these tests the seed corn used was taken from the planter boxes of farmers right in their fields while planting. The seed was planted by hand, three kernels per hill, with exactly the same preparation of seed bed, uniform soil, and same cultivation. Each sample was planted in different parts of the field in order and careful records were kept of stand and yield. Furthermore, several germination tests were made of each sample and the average test recorded. The following table gives a summary of the data:

*Iowa Bulletin No. 135

TABLE NO. 26

*SHOWING RELATION OF GERMINATION TEST TO STAND IN THE FIELD AND YIELD

Number of Samples	Germination Percent Strong	Per cent Stand in Field (fall)	Yield per Acre (Bus.)
All 3550 samples tested	88	69	57
Best one-tenth (358)	92	77	68
Poorest one-tenth (358)	79	56	43

The above table shows conclusively that the germination test properly conducted is a safe indication of the power of the seed to produce in the field.

Another test including 4000 individual ears tested and planted as in the above experiment, serves further to prove the relation between the germination, stand in the field and actual yield.

TABLE NO. 27

*SHOWING VALUE OF INDIVIDUAL EAR TEST

Number of Ears	Germination % Strong	% Stand in Field (fall)	Yield per Acre (Bus.)
All 4000 ears tested	86	69	56
Best one-fourth (1000 ears)	91	77	68
Poorest one-fourth (1000 ears)	77	57	42

The above test covers five years, 109 experiments in twenty-seven counties.

The value of the germination test has been already emphasized, but further data relating to the relation of stand in the field to actual yield is given in the following table:

TABLE NO. 28

*SHOWING RELATION OF STAND TO YIELD. (Result of eight years test in Iowa)

Number of Samples	Per cent Stand	Yield per Acre (Bushels)
28	20 to 30	28
86	30 to 40	34
184	40 to 50	42
548	50 to 60	48
1001	60 to 70	54
1581	70 to 80	58
1158	80 to 90	62
190	90 to 100	64
Average	71.7	56

It is of special significance to note that in the above tests only 28.2 per cent of the seed actually planted by the 4776 farmers represented, gave a stand of 80 per cent or better. The average stand of all tests being only 71.7 per cent.

While definite data could not be secured from all states, a poor stand of corn in the field is given universally as the greatest cause of a low average yield, and the germination test has been everywhere urged as the only practical means of detecting and eliminating the weak and dead unproductive seed ears.

*County Demonstration Station Reports, Iowa.

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.

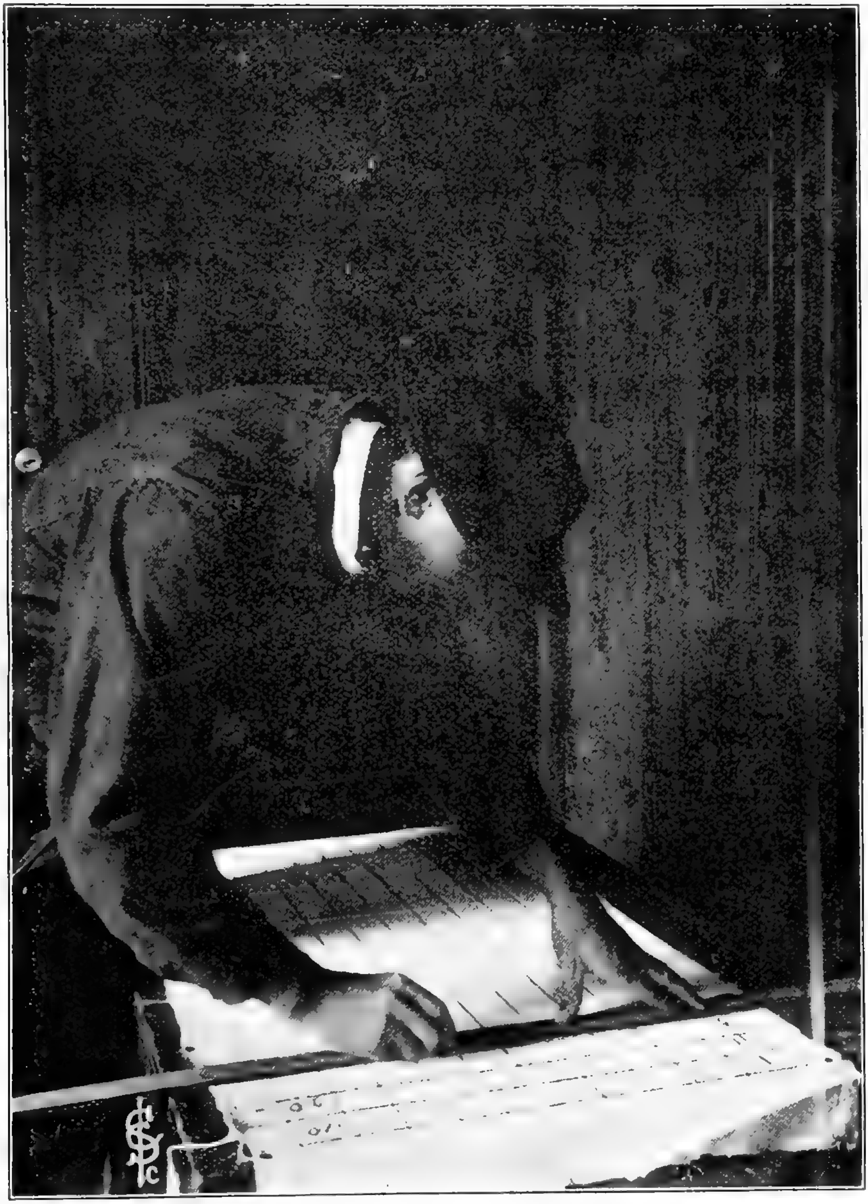
The Time to Test. Some corn growers make a practice of running a preliminary test during the month of January. This is done in order to find out whether or not all the seed is badly damaged. Should such be the case, other seed could be procured and tested before planting time. The method has a sound basis and should be followed more closely. One of the serious difficulties in the way is the liability of 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.

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 plant, leaving the seed room free.

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.

PACKING THE SAWDUST IN THE GERMINATION BOX

The brick is used because the corners can be filled uniformly.



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.

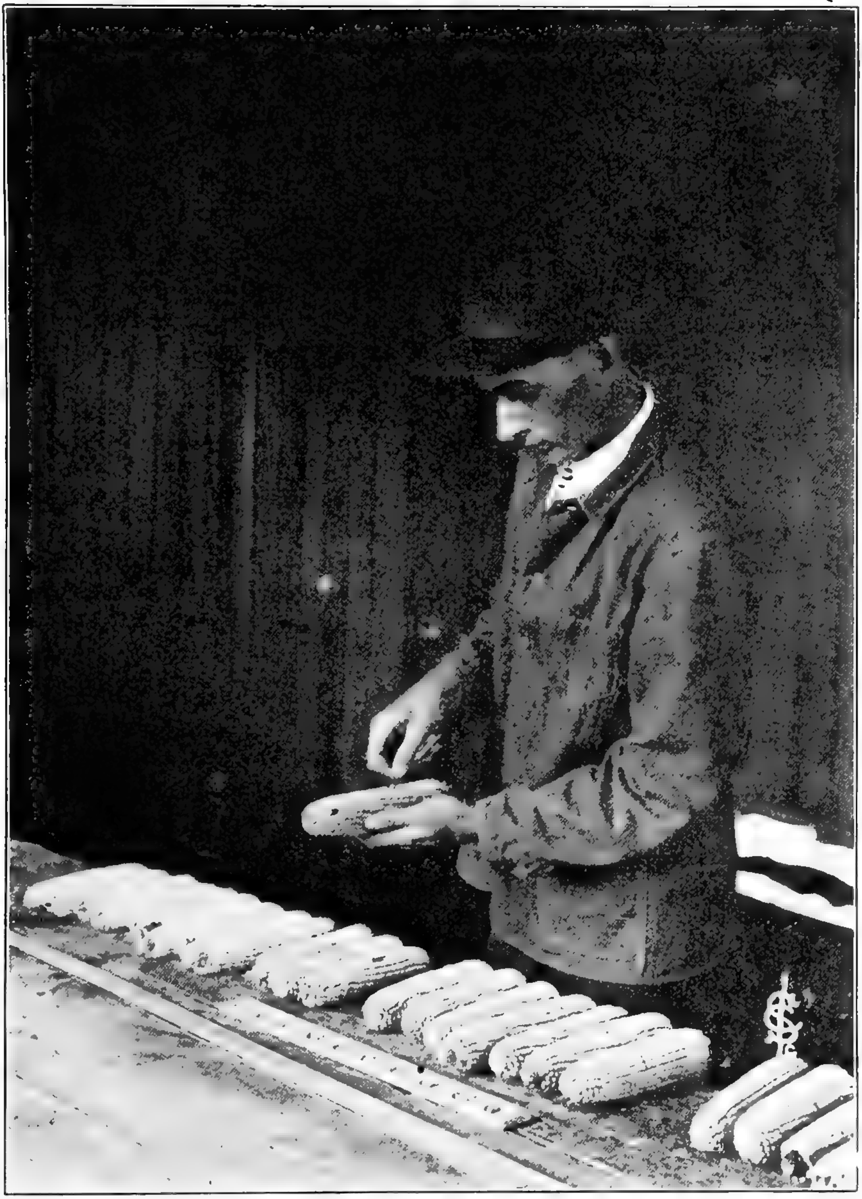
Take a piece of new white muslin, which should be a little larger than the box, and mark off two hundred squares, each 2x2 inches. Corn having especially broad kernels may require squares 2x3 inches. This may be done with black or blue crayon. The squares may be numbered from 1 to 200, beginning in the 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.

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.

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-



REMOVING THE KERNELS WITH A KNIFE.

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

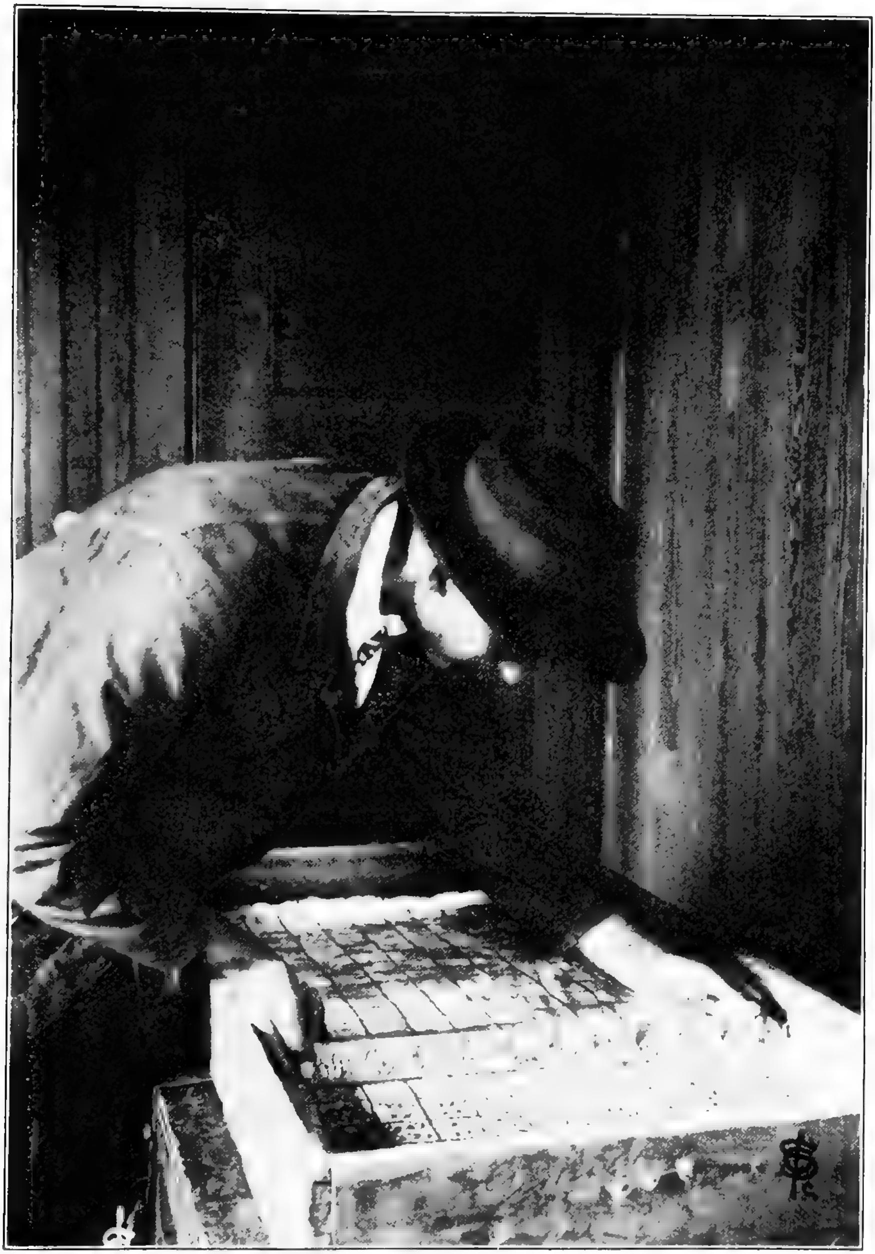
cate low vitality; as for example, a moldy cob or dark colored germ, giving evidence of having been injured, probably by freezing. These should be cast aside at once. Ears which show a lack of breeding may be discarded immediately, also. Having laid the ears out in rows on the floor, where they are held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

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.

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

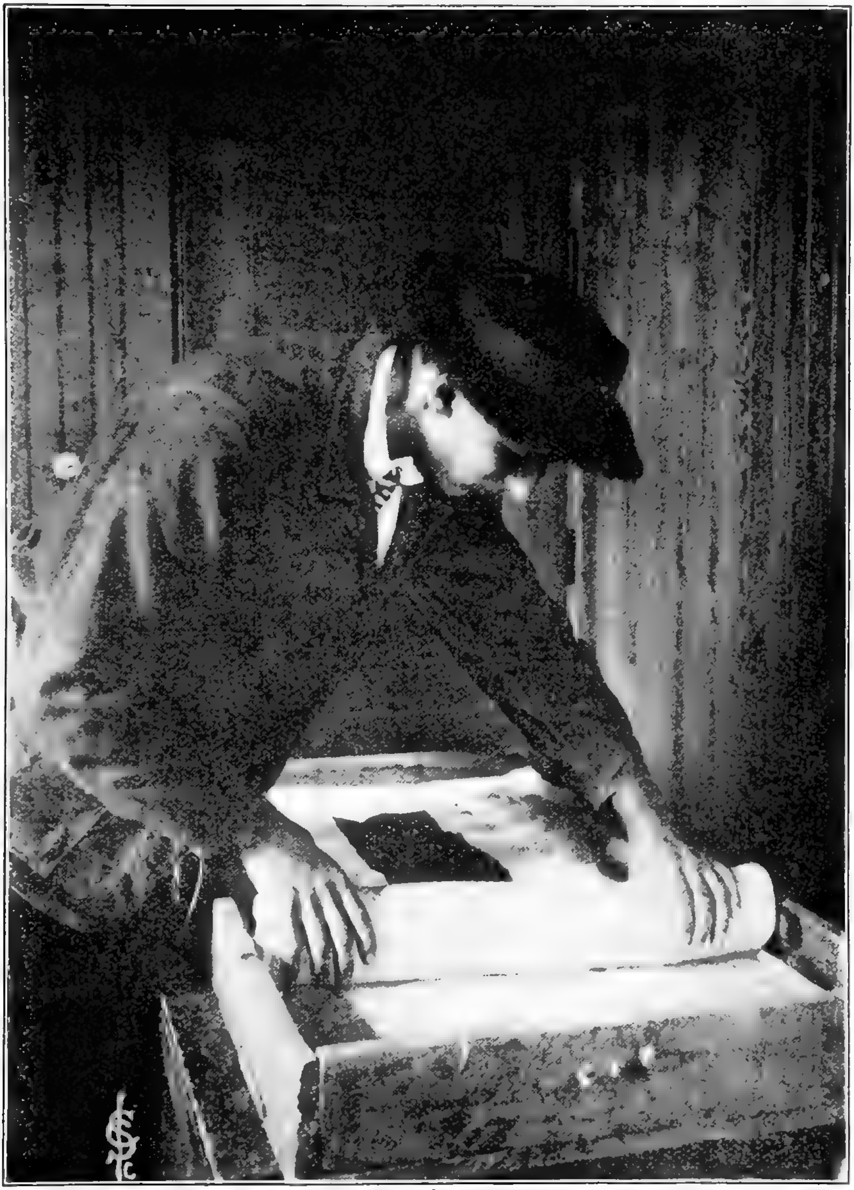


TRANSFERRING THE KERNELS TO THE TEST BOX.

This method is rapid and deposits the kernels in the right squares according to the numbers. Kernels should then be arranged in regular order.

FOLDING OVER THE EDGES OF THE UPPER AND LARGER CLOTH.

Be sure to keep the corners square and the sawdust well packed into them.



ROLLING BACK THE TOP COVERING OF SAWDUST PREPARATORY TO READING THE TEST.

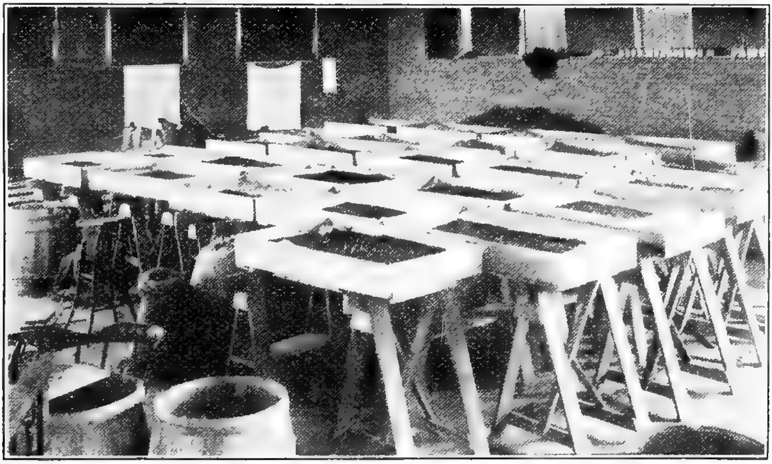
Note that the single cloth immediately over the kernels is not displaced.

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.

EARS LAYING OUT AFTER THE KERNELS HAVE BEEN TRANSFERRED TO THE GERMINATION BOX.
Every tenth ear is numbered.

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.

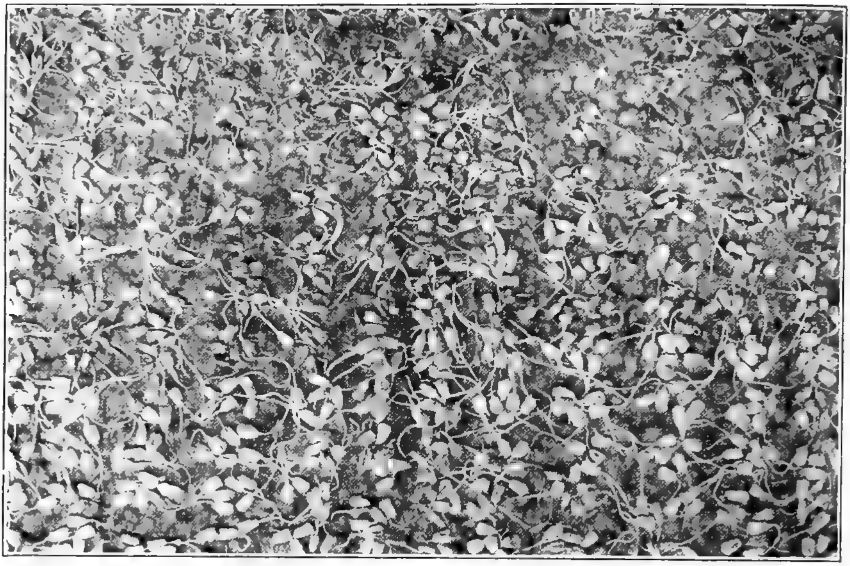


AN EXTENSIVE TEST

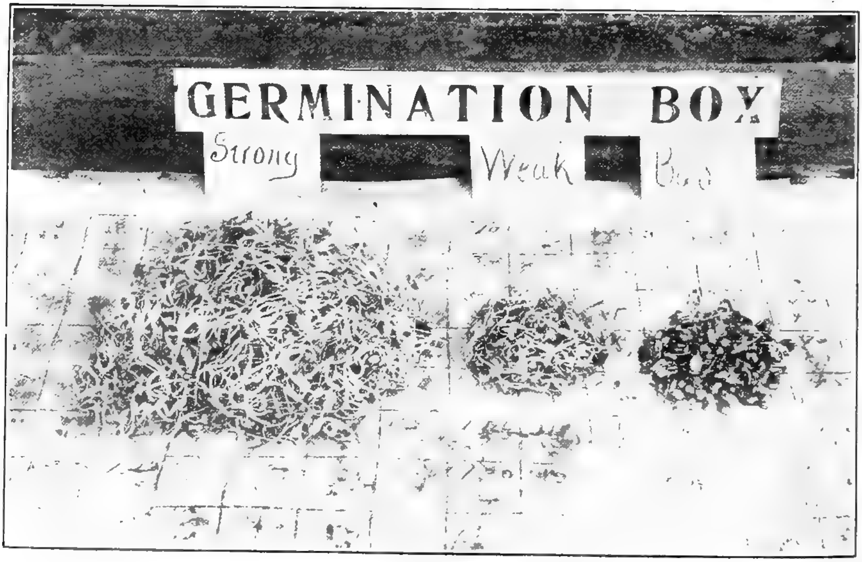
More uniform temperature can be obtained when the boxes are elevated.

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.

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



THE WRONG WAY TO PLACE KERNELS IN A GERMINATION BOX.
The result of test is difficult to ascertain. (See page 121.)



AFTER READING THE TEST

COST OF TESTING—The cost of testing seed corn involves the following factors:*

1. Time required to prepare the tester to receive the corn.
2. Time required in placing the corn in the tester.
3. Attention required by the tester after the test is begun.
4. Time required to read the test.
5. Possibility of seeing all parts of the roots and shoots as an aid in determining relative vigor.
6. Amount of corn which may be tested at one time.
7. Comparative cost of tester.
8. Durability of tester.
9. Compactness and lightness in moving tester from one place to another.

The following statement taken from a personal letter from a seed corn grower who tested every ear of seed shows the approximate cost of testing seed corn with the sawdust box. Remember though that the germination boxes, cloths, etc., used in these tests and figured in the cost of testing may be used over several times.

"Yours at hand and contents noted. It cost me to test my corn last winter, as nearly as I can figure, about 28 cents per bushel.

"I used boxes 34x4 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

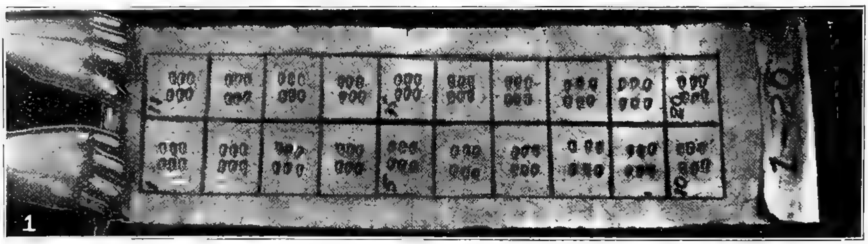
Thirty-six bushels	$10.05
One bushel, almost	.28"

*Iowa Bulletin No. 135

THE "RAG DOLL" METHOD OF TESTING SEED CORN

The "Rag Doll" test commends itself for convenience, simplicity, economy* and accuracy. With reference to the accompanying illustrations, it may be explained as follows:

(1) Using bleached muslin one yard wide, tear into strips (crosswise) about nine inches in width. Each strip (9x36 inches) will serve for testing twenty ears of corn. Mark off the strip with heavy crayon,



1 The "Rag Doll" filled and ready to roll.

first lengthwise in the middle and then crosswise in squares of about two and one-half inches each. Squares may be numbered as shown

*In No. 6 of the illustrations there are twenty-five dolls or approximately five bushels of seed in test. This required only six yards of muslin which may be used time after time. With the "Rag Doll" there is no dirt or litter, and comparatively little room is required.

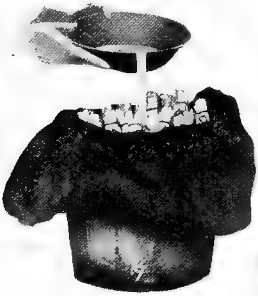
2—The "Rag Doll" filled, rolled and ready to soak.

in illustration. This will leave about six inches of extra space at each end of the doll.

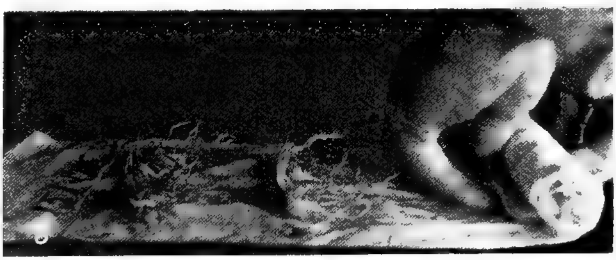
Moisten the cloth and spread out on a board or table in front of the ears to be tested. Take six kernels from each ear as directed for the "sawdust box test." Arrange kernels in order with tips all pointing the same direction and crosswise of the doll.

3—Soaking the "Dolls". 4—Draining. 5—Bucket prepared for packing "Dolls". 6—"Dolls" packed.

(2) When the squares corresponding to the numbered ears have all been filled, take some moist sawdust, strip of burlap, blotting paper or other material and roll in one end of the doll for a central core to provide freer circulation of the air and better moisture facilities. Complete the rolling of the doll. Roll fairly compact. The kernels will be held in place within the doll by the moist muslin.



7—Sprinkle the "Dolls" occasionally.



8—Unrolling the "Doll". Showing sprouts curled because kernels were placed wrong.

On the outside of the doll, mark the number of ears it includes as 1-20, 21-40, etc. Tie the doll in the middle, not too tightly. A rubber band is best. Bands may also be placed about each end of the doll until after soaking as an extra precaution against loss of any of the kernels.

(3) Soak the dolls in water over night. (8 to 10 hours, preferably.)

(4) Drain the dolls for a short time after soaking

(5) Pack the dolls in a bucket, tub or box. Place some bricks or other material in the bottom to provide free circulation of air and to insure proper drainage. Then line with wet cloth or burlap.

(6) Pack dolls on end (with crowns of the kernels to the top), and fold wet cloth used in lining the bucket or box over the top.

(7) Set the bucket in a warm place. It is well to moisten the dolls by sprinkling occasionally with warm water in order to keep them from getting too dry.

(8) The test should be ready to read in from five to six days. If the doll is unrolled with ordinary care the sprouted kernels will all remain in place. The last illustration (No. 8) shows a doll being unrolled in which the kernels have been placed wrong, being parallel with the cloth strip. Notice that the sprouts are curled. This could have been avoided by arranging the kernels crosswise of the doll and then packing the doll with the crowns of the kernels to the top.

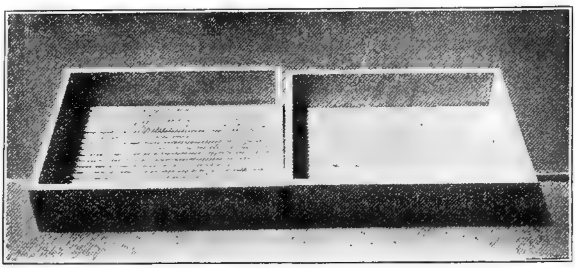
The cloths may be used many times, but should be scalded each time after being used, to kill mold, etc.

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 butts 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.

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.

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.



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

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.

The Experiment Station of Indiana conducted a test showing the importance of grading the seed, the results of which are recorded in the following table:

TABLE NO. 29

EFFECT OF GRADING SEED CORN. (Records made in 100 drops)

No. of Kernels Dropped	Middle Kernels only	Whole Ear	Deep and Shallow Kernels Mixed	Deep Kernels only	Shallow Kernels only
1		1 time			2 times
2	8 times	6 times	5 times	4 times	2 times
3	92 times	66 times	75 times	92 times	95 times
4		25 times	18 times	4 times	1 time
5		1 time	2 times		
6		1 time			

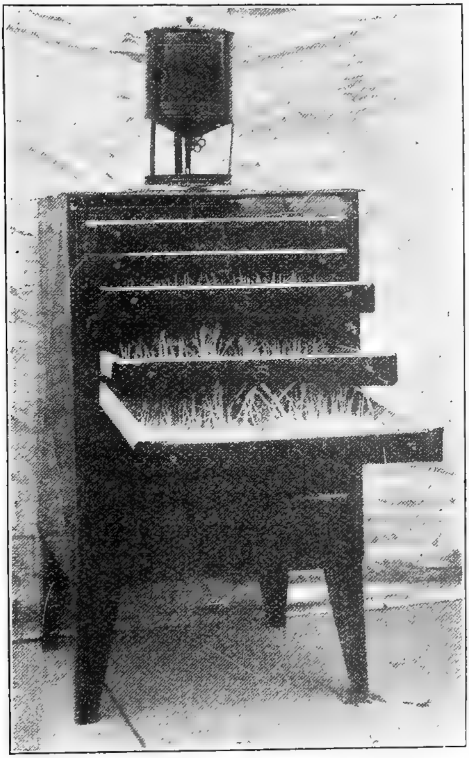
*In each case it was desired to drop three kernels per hill, and several plates were tried. A satisfactory stand with the butt and tip kernels mixed in the seed was found impossible. The same was true when deep and shallow kernels were mixed. When the butt and tip kernels were removed and the ears with the deep and shallow kernels shelled separately, the drop was about perfect.

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 EAR

Indiana Bulletin No. 110 (Revised Edition)

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.

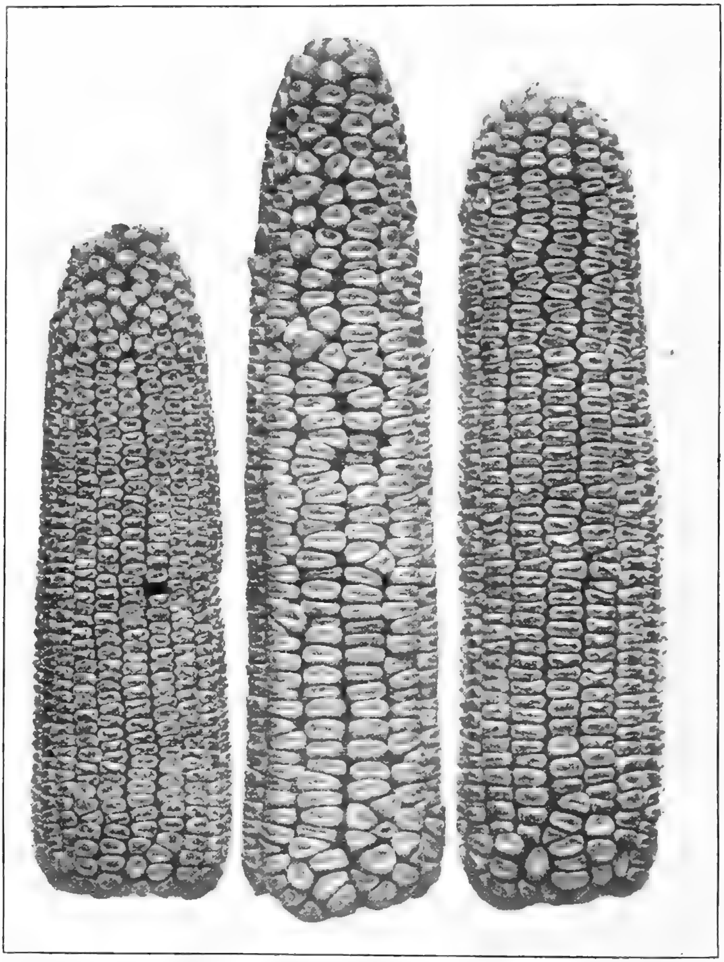
The germination test, of course, did not prove their presence. There will be more or less mice eaten grains and kernels cracked by the sheller. Hence it will pay the smaller grower to have the children sort these out and the larger farmer can economically afford to hire it done. To facilitate this process, a convenient method is to pour the shelled 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.



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.



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

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 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 together. 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 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 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.

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.
Testing Seed Corn.
Iowa Bulletin No. 135.
Nebraska Bulletin No. 126.
Indiana Circular No. 2.
Ohio Circular No. 71.
Indiana Bulletin No. 110, (Revised Edition)
County Demonstration Station Reports, Iowa.

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.**

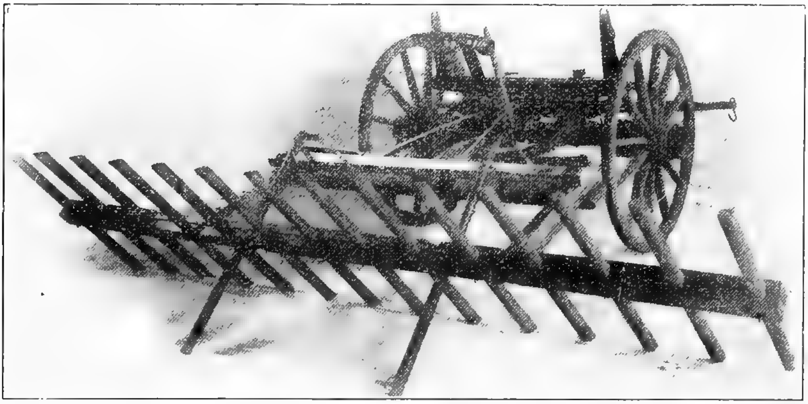
   A. Time of Planting.
   B. Depth of Planting.
   C. Distance Between Rows.
   D. Number of Stalks Per Hill.
   E. What is a Perfect Stand?
   F. Replanting of Corn.

5. **DRILLING CORN.**

6. **LISTING.**

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

PREPARATION OF THE GROUND BEFORE PLOWING. Small grain stubble lana 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 evapoıated 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.



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

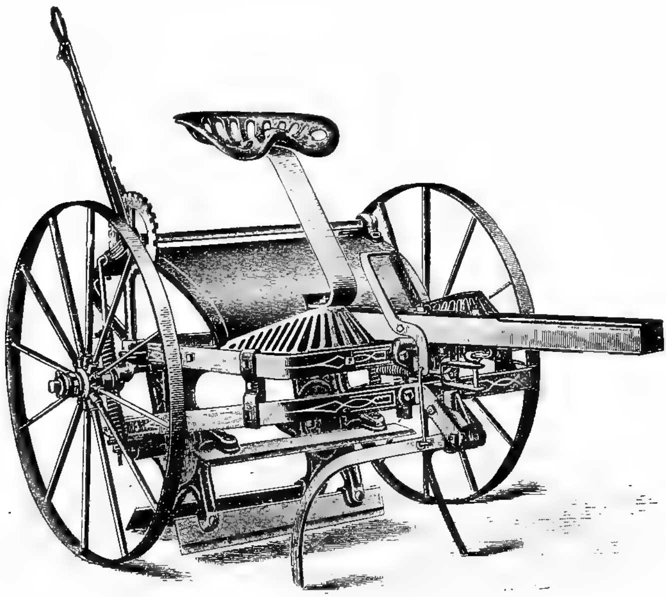
Where the ground is low and subject to overflow, often weeds grow so rank after harvest as to necessitate their being mowed before any plowing is done. In localities which practice the short rotation of corn and oats or corn and wheat the stubble is often covered with barnyard manure before plowing. 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 wih the soil.*

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

*In case of a heavy growth or application of coarse organic material to be plowed under, it is generally recognized that the practice of discing is advisable.

during the winter and when spring comes the bare stalks remain 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 the humus and fertilizing materials, which are largely lost through the process of burning the stalks before planting. The



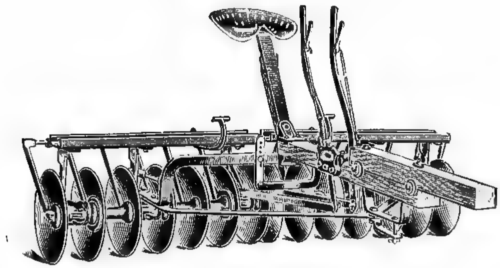
SINGLE ROW STALK CUTTER.

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.

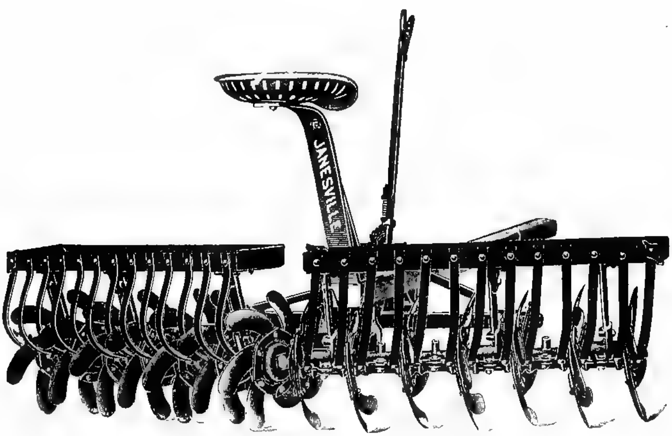
The single-row stalk cutter is little used at present because, except for cutting the stalks, it does very little toward loosening the surface of the soil. Its only claims of practical value are: first, the fact that being of light draft, it can be used early when the ground is not yet dry enough for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



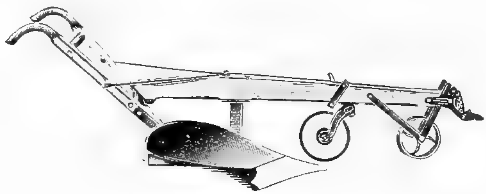
FULL DISC HARROW.
The most commonly used in Iowa.

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 prevents the loss



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 structure reunites with the several capillary tubes, thus re-establishing the course of the moisture upward.

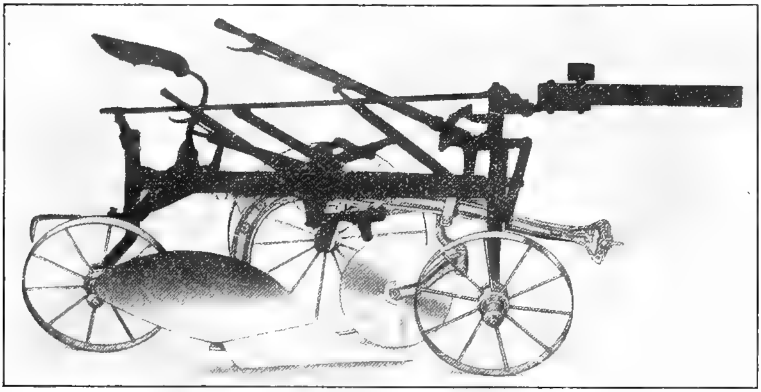


BREAKING PLOW.
Used in plowing sod. Notice that the moldboard is very sloping.

Weeds and grass allowed to grow up in corn-stalk land in the 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, thus interfering with the capillary moisture. Second, weeds also utilize a large amount of available plant food, 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.

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-



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.

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 structure. The disc also disturbs and destroys many hibernating injurious insects.

PLOWING THE GROUND.—The Objects of Plowing Are: To alter the structure 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.

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 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. Besides indicating pride and interest in plowing, a clean land side and a consistent floor of even width and depth insures a complete alteration of structure. Instead 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.

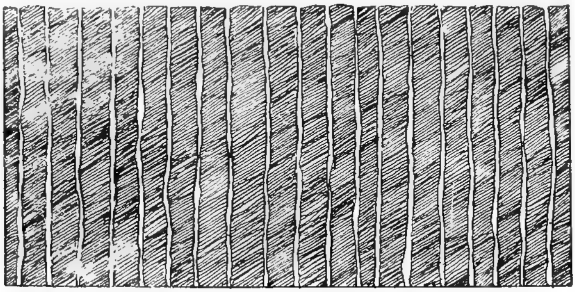


DIAGRAM SHOWING THE DIRECTION OF THE CAPILLARY TUBES AND STRUCTURE OF THE SOIL EARLY IN THE SPRING AFTER THE SURFACE HAS DRIED OUT AND NO CULTIVATION HAS BEEN DONE.

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.

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.

Deep plowing. For a deep, rich soil, deep plowing is very generally considered best if done in the fall. Fred McCulloch, of Hartwick, Iowa, reports 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 consider-

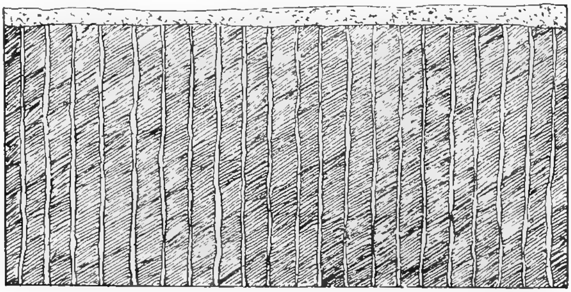


DIAGRAM SHOWING THE SURFACE SOIL STIRRED SLIGHTLY AND A MULCH ESTABLISHED.

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.

able depth. Plowing should not be of the same depth from year to year, for 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.

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-estab lished 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.

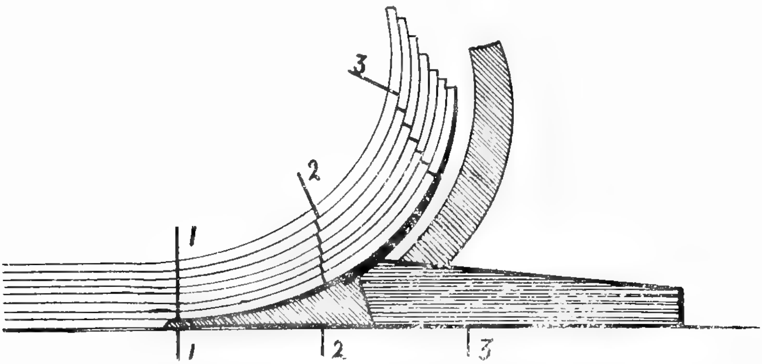


DIAGRAM SHOWING THE EFFECT OF THE MOLD BOARD UPON THE CAPILLARY TUBES IN THE SOIL.

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.

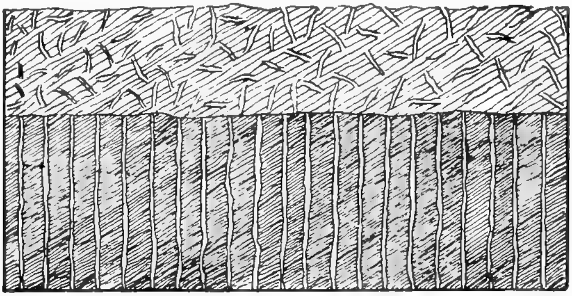


DIAGRAM SHOWING THE POSITION OF THE CAPILLARY TUBES AFTER A FIELD HAS BEEN PLOWED TO A DEPTH OF 4 TO 6 INCHES.

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 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

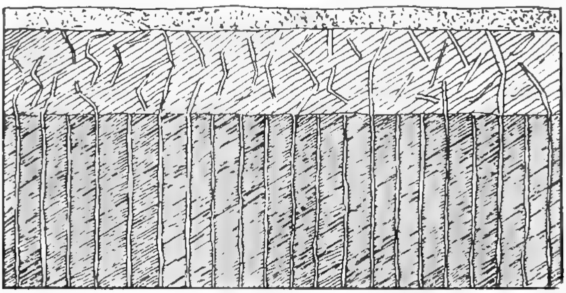
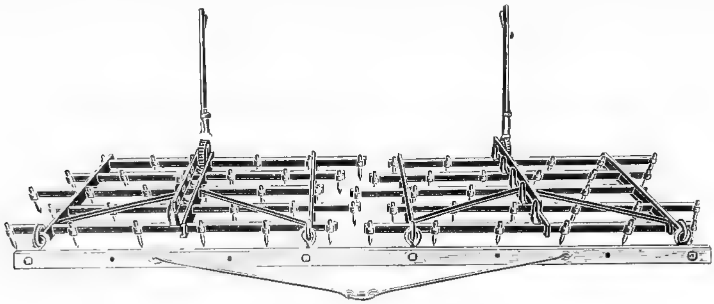


DIAGRAM SHOWING WHAT EFFECT DISCING, HARROWING AND ROLLING HAS UPON THE PLOWED FIELD.

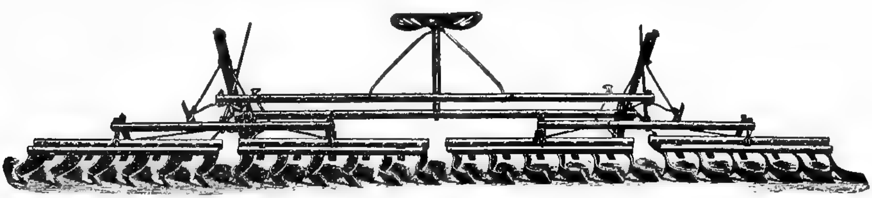
Of course the surface is made much finer. But the disc reaches down to greater depths and begins to settle the loose earth upon the furrow-bottom. The packing gradually re-establishes the capillary connection. The fact that spring plowing requires some time during the early part of the season to accomplish 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.



TWO SECTION, 60 TOOTH, 10 FOOT SMOOTHING HARROW
The teeth are adjustable by the use of the levers.

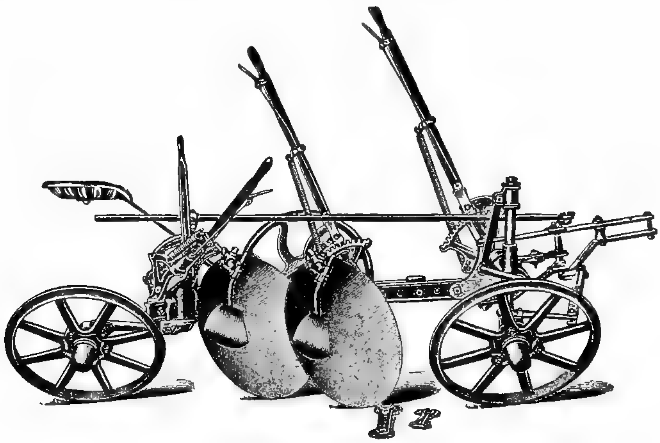
In fact, fall plowed ground should contain more moisture for the growing crop the following season than that land plowed in the spring. With fall plowing the rain and moisture may better penetrate the sub-soil. Because of the rough surface much moisture is held which might otherwise be lost. Not infrequently 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



CURVED KNIFE HARROW.
Although not in general use, this harrow has the advantage of the running cut, which is especially valuable in pulverizing sod.

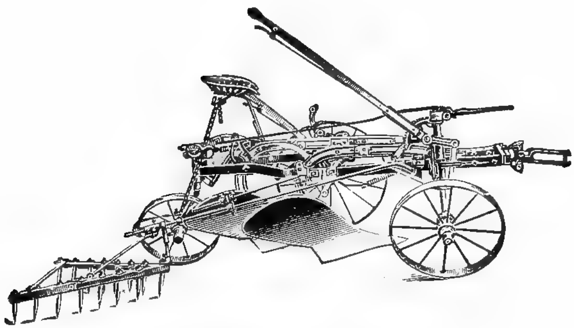
well. Fall plowed land which has been thus neglected may be expected to contain less moisture than had the ground been plowed in the spring. By the use of the disc and harrow in early spring on fall plowed ground, a surface mulch can be established which will prevent this excess evaporation and insure 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.

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



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 10 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 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.

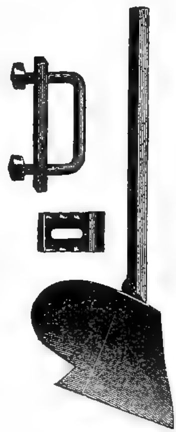


GENERAL PURPOSE PLOW.

Mold board is set at sufficient angle to allow the use of this plow in sod or stubble.

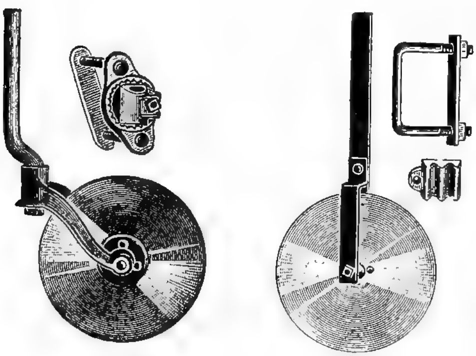
Plowing Sod. The virgin sod land of the corn belt is rapidly becoming a thing of the past. A study of statistics of wild hay meadow shows a steady decrease in acreage. In such land the breaking plow is used to some extent in peeling back a shallow furrow in the fall, a deeper plowing to follow in the spring. Little alteration of structure 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 cultivation of the crop is difficult the first year, the mat of grasses on the surface is usually burned before plowing, because the sod is slow in reconnecting the capillary tubes and "firing" of the corn often results during the summer because of this condition.



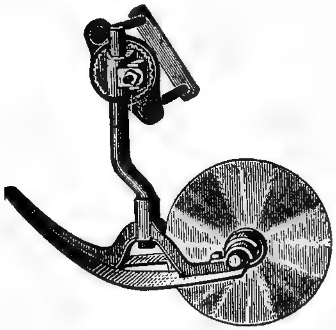
STEEL JOINTER.
Used to tear up stiff sod just in front of the mold board.

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 sown the first year.



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 structure of the soil. 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 structure 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.



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.

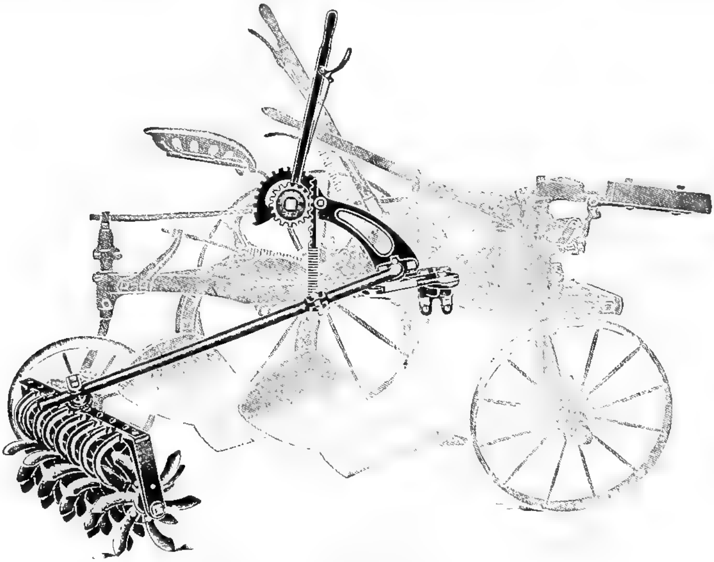
First, the rush of farm work requires it. There will be plenty of corn-stalk land which canot be plowed until later because of being so wet. Wet sod, although it turn up slick on the bottom of the furrow slice, will not bake and become cloddy because of the presence of such an abundance of humus.

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.

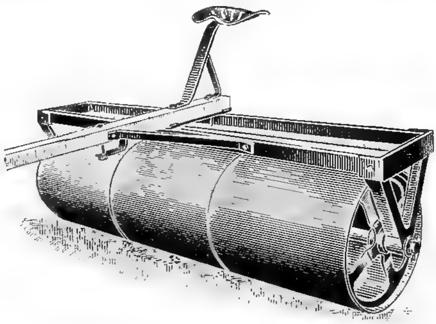
The time of plowing sod in the spring varies widely. Throughout the Corn Belt this time ranges from the fore part of March to the fifth of April. However most of the sod, especially blue grass, is plowed in the fall, and then disced and harrowed before planting.

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-



ROTARY DISC ATTACHED TO PLOW.
Because it pulverizes the soil right off the mold board there is no chance for the formation of clods.

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



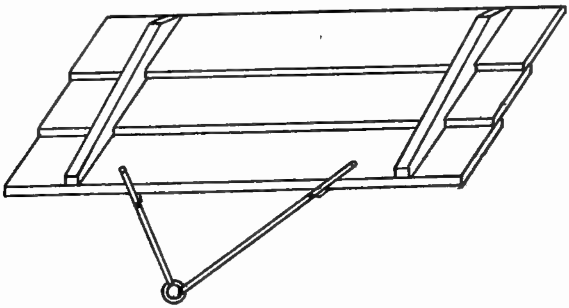
SMOOTH STEEL ROLLER.

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.

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.

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.



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.

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.

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.

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.

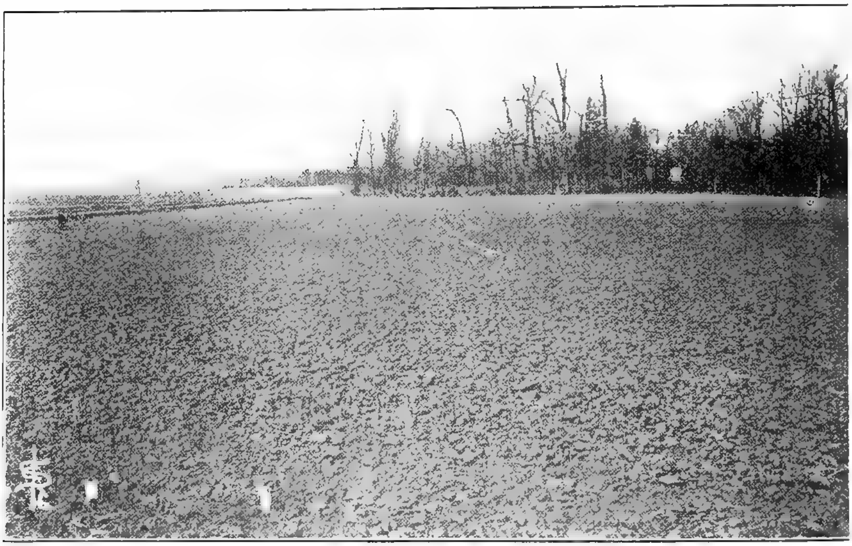
Large, four-section harrows covering 18 to 22 feet of surface are now largely used even on smaller farms, because of the high price of farm labor. One man and four horses can harrow between 30 and 40 acres in a single day. Because the harrow covers territory so rapidly and leaves the ground in such a 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.

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.

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.

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 secure 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.

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



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.

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

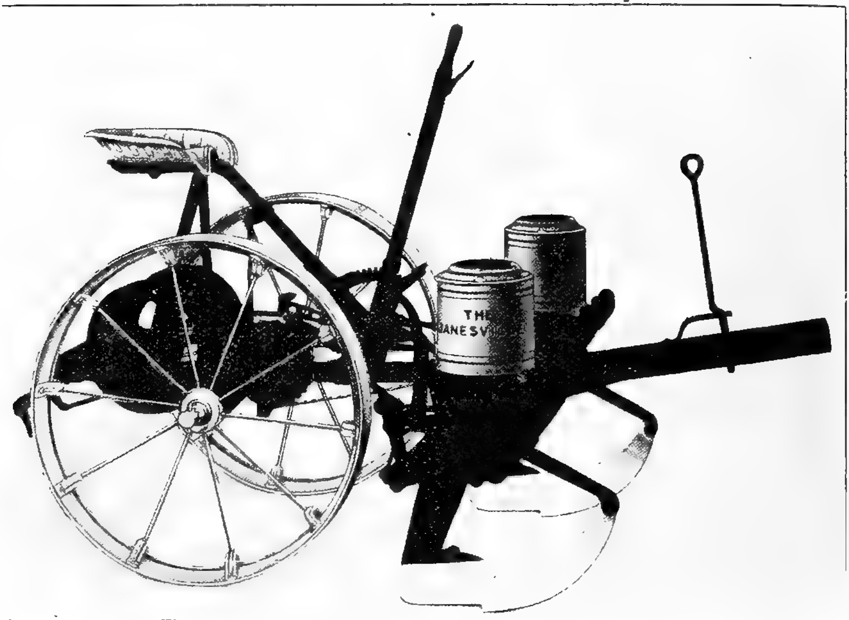
First. The uneven surface reduces the velocity of the wind near the ground.

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.

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.

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-openers 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.



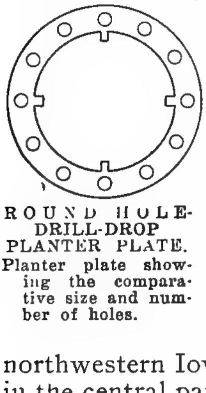
CORN PLANTER.
Showing the long curved runner furrow-openers and concave wheels.

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.

Time of Planting. The best yields and most mature corn are produced by planting corn *early*. Years of experience has 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. Soil conditions have as much to do in determining the date of planting as does the weather. For example, farmers on the Missouri loess soil 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.



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

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

TABLE NO. 30
TIME OF PLANTING

STATE	SEASONS	EARLIEST	BEST	LATEST
*Iowa	General	Apr. 25-28	May 5-15	June 1
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
South Dakota	3	May 1	May 15-25	June 10
*Minnesota	General	May 1	May 10-22	June 1-10
*Wisconsin	General	April 28	May 8-20	June 1-5

*Farmer's estimates.

The effect of early and late planting is well illustrated in the following tables No. 31 and 32, taken from a report of the Ohio Experiment Station.* The highest yield of corn was secured with early planting, May 4 to 10. (See Table No. 31.)

TABLE NO. 31

YIELD FROM EARLY AND LATE PLANTING

Date of planting and bushels shelled corn per acre

Year	April 24-29 Bu.	May 4-10 Bu.	May 14-17 Bu.	May 25-28 Bu.	June 2-6 Bu.
1908	30.16	56.02	61.68	50.66	40.88
1909	100.19	98.94	91.08	81.34	62.88
1910	42.45	37.14	37.27	27.67	20.19
1911	67.04	75.96	73.76	54.83	43.95
1912	65.87	64.12	61.99	49.38	44.95
1913	77.43	78.75	76.64	65.36	53.04
6-yr. Av.	63.85	69.49	67.37	54.87	44.32

A moisture determination made at husking time with a Brown-Duval tester showed the corn from the early planting to be much better matured. (See Table No. 32.) Throughout the corn belt early planting means an increased yield, and better matured corn. This is not necessarily true however with extremely early planting.

TABLE NO. 32

MOISTURE—EARLY AND LATE PLANTING

(Date of planting and per cent of moisture in fall.)

Year	April 24-29 Per cent	May 4-10 Per cent	May 14-17 Per cent	May 25-28 Per cent	June 2-6 Per cent
1908	17.0	16.5	18.6	23.9	30.0
1909	26.5	27.4	28.1	29.9	37.8
1910	27.2	28.7	27.3	30.0	33.7
1911	22.8	23.0	25.6	28.6	31.6
1912	25.6	28.8	30.0	33.4	35.4
1913	23.3	26.1	26.0	29.0	32.6
6-year average	23.73	25.08	25.93	29.13	33.52

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

*Ohio Bulletin No. 282.

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.

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.

TABLE NO. 33

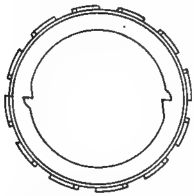
YIELD OF CORN FROM PLANTINGS OF DIFFERENT DEPTHS

(Average for three years)

Depth	Bushels per acre			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.

The Texas Station recommends about three inches as the proper depth for most sods, and three years tests in Iowa show an increased yield from the shallower planting, say 1 to 3 inches over the deeper planting 4 to 6 inches.



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.

Extensive tests in Illinois* to determine the proper distance between rows resulted in the following conclusions:

1. On all ordinary Corn Belt land of the northern part of Illinois, plant corn hills not more than 36 inches apart and plant at least three kernels per hill.

2. In central Illinois on the common brown silt loam prairie land, of a productive capacity greater than 50 bushels per acre, plant corn 39.6 inches between hills and drop three kernels per hill (with 39.6 inches between rows there are exactly five rows per rod).

3. In central Illinois on the common prairie land, of lower productive capacity than 50 bushels per acre, as for instance average Corn Belt land, plant the hills 36 inches apart and drop two kernels per hill.

TABLE NO. 34
SHOWING YIELD PER ACRE AS AFFECTED BY DISTANCE BETWEEN ROWS

State	No. of Years in Test	No. of Kernels per Hill	Distance between rows, (inches)						
			44x44	44x39.6	44x36	44x33	36x36	33x36	33x33
*Illinois (Northern)	4	2	44.1	47.1	48.7	50.9	54.2	54.3	52.0
Illinois (Northern)	4	3	54.1	55.7	56.7	57.7	58.9	59.9	61.0
Illinois (Central)	4	2	47.7	50.0	51.9	52.8	54.5	55.0	54.0
Illinois (Central)	4	3	51.6	51.9	52.3	51.4	49.1	49.1	46.8

An Ohio test covering a three-year average shows that the number of plants per acre being the same, there is a gain of 4 1-2 bushels per

*Illinois Bulletin No. 126

acre in favor of one plant every 12 inches, as compared with three plants every 36 inches. The gain in stover was 659 pounds per acre. However, the question of cultivation and harvesting of the crop is to be considered. Corn planted in hills is more easily harvested, and gives a better opportunity in cultivating or keeping the weeds in check.

Second. The custom of the locality or even the section of the Corn Belt affects thickness of planting. The Georgia Experiment Station found that better results could be obtained by having the rows four feet apart with one stalk every three feet in each row. 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 eight inches 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.

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.

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.

TABLE NO. 35

SHOWING RELATION OF THICKNESS OF PLANTING TO YIELD

State	Distance between Hills	No of Experi-ments	No. Yrs. in Test	Showing Average Yield per acre (bu.) Number of Kernels planted per hill				
				1	2	3	4	5
Iowa (Entire state)	3 ft. 6 in.	127	7	33.5	51.5	59.5	61.5	61.0
Iowa (Northern sect)	3 ft. 6 in.	38	7	31.5	48.5	58.0	60.0	59.0
Iowa (Central sect.)	3 ft. 6 in.	44	7	35.0	54.5	64.5	69.0	69.5
Iowa (Southern sect.)	3 ft. 6 in.	45	7	34.5	51.5	57.0	57.0	56.5
*Nebraska			6	48.3	67.7	75.5	76.7	76.3
**Ohio			10	31.7	50.8	60.8	64.9	63.0
***Kentucky	3 ft. 6 in.		2		51.6	58.1	60.4	

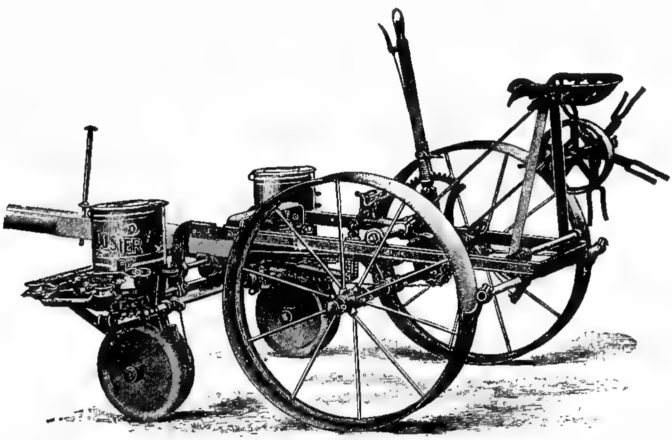
The foregoing table gives a summary of the tests conducted in various states of the Corn Belt for a period of years. The foregoing statements have been well substantiated by these tests. In the most favorable seasons and on the more fertile soil, the thicker planting has produced the higher yields, but in less favorable years and on thinner soil, the lower rate of seeding has given the better yield. Take the results from Oklahoma for instance. The year 1910 was an especially good corn season. The respective yields from 2, 3 and 4 stalks per hill were 72, 90.4 and 98.4 bushels per acre. The following year, 1911, was very dry. The respective yields were 31.1, 25.8 and

*Nebraska Bulletin No. 112
**Ohio Bulletin No. 282.
***Kentucky Bulletin No. 163.
For Nebraska, Ohio and Kentucky, the results given represent number of plants per hill. Ohio yields are figured on basis of shelled corn.

22.4 bushels per acre. The amount of corn produced decreased with the heavier rate of seeding in the dry year.

The data from Iowa shows the effect of season, climate and soil on rate of seeding. Comparing the three zones of the state, namely, northern, central and southern, it is seen that the yield varies with the same rates of seeding. In the north, the heavier seeding produced the higher yield. With a smaller ear, and lighter stalk more stalks can succeed in a hill. Going south however to the larger ears, and heavier stalks (and in some cases older soil) the number of stalks per hill must be slightly reduced. In the southern part of the state it is generally aimed to have from two to three stalks per hill, and in the northern part of the state, from three to four. The average for the entire state of Iowa shows the best results from three to four kernels planted per hill.

In these tests it should be added too that the yield of stover as a rule was heavier with the thicker planting. In Nebraska the yield of stover increased over 16 per cent between two and five stalks per hill. The Ohio test shows a corresponding increase in yield of stover amounting to 100 per cent, however, between the one stalk and 5 stalk stand. This was for an average of ten years.



CORN PLANTER
Showing disc furrow opener.

RELATION OF THICKNESS OF STAND TO PER CENT OF BARREN STALKS

It has been found that the thickness of planting affects the per cent of barren stalks. In a five year's test in Iowa, the results have been as follows:

TABLE NO. 36

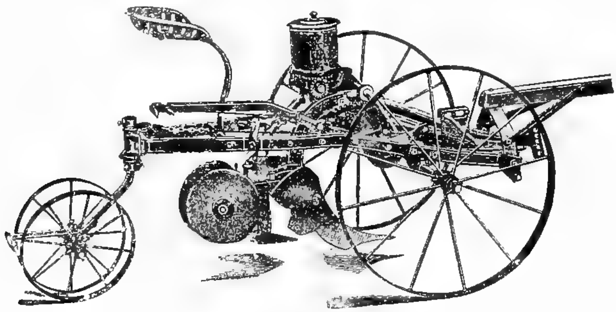
**SHOWING PER CENT OF BARREN STALKS AS AFFECTED BY THICKNESS OF PLANTING.

(This table shows the number of barren stalks per 100 plants)

State	Number of Years	No. of kernels per hill 1	2	3	4	5
Iowa ----------	5	4.2	3.4	5.6	8.8	10.7

As the rate of seeding increases the per cent of barren stalks rises. This has been found to be particularly true in dry years.

The effect of barren stalks on yield is well shown in the following table giving the results of an experiment conducted in Ohio* in 1906.



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.

TABLE NO. 37

SHOWING RELATION OF BARREN STALKS TO YIELD

Per cent of Barren Stalks	Yield per acre, bushels	Per cent of Stand
1.6	75.70	75
3.5	74.76	76
5.5	69.25	74
7.5	67.21	74
10.8	65.20	71
19.7	65.9	74

From the above table it is seen that as the per cent of barren stalks increase the average yield of corn decreases. It should be stated however, that planting too thick on a thin soil, or in a dry season, tends to increase the per cent of barren stalks.

*Ohio Bulletin No. 140.
**County Demonstration Station Reports, Iowa.

RELATION OF THICKNESS OF PLANTING TO AMOUNT OF SUCKERS.

The effect of thickness of planting on tillering or suckering is also of importance. A tiller or sucker is simply a lateral branch arising from one of the lower nodes or joints of the corn plant. Through selection and cultivation this habit of corn has been largely overcome in the effort to produce one strong stalk from each kernel planted, capable of supporting a productive sized ear. While there is some difference in the amount of tillering between different varieties of corn this habit is affected more by the thickness of stand, fertility of the soil and amount of moisture. See the following table.

TABLE NO. 38

SHOWING PER CENT OF SUCKERS AS AFFECTED BY THICKNESS OF PLANTING

(This table shows the number of suckers per 100 plants)

State	Number of Years in test	No. of kernels per hill 1	2	3	4	5
*Nebraska	2	138	60	25	10	3
Iowa	7	52.8	21.2	10.2	7.1	6.5

RELATION OF THICKNESS OF PLANTING TO SIZE AND QUALITY OF EARS.

Another thing to be considered under thickness of planting previously mentioned in the quality of corn. The per cent of nubbins and worthless ears increases with the thicker planting.

Aside from a poorer quality of corn from too thick planting it will be remembered also that a large per cent of the nubbins would be left in the field by the average corn picker, thus reducing the actual yield. See the following table.

TABLE NO. 39

SHOWING PER CENT OF NUBBINS AND POOR EARS AS AFFECTED BY THICKNESS OF PLANTING

State	Number of Years in test	No. of kernels per hill 1	2	3	4	5
**Iowa	7	11.8	17.6	23.1	31.9	41.5
Ohio	10	16.1	16.7	21.9	31.1	42.6

*Nebraska Bulletin No. 112.
**County Demonstration Reports, Iowa.

NOTES

1. The results of the foregoing tests with reference to thickness of planting shows that in the northern section of the corn belt where the ears are smaller, as well as in other sections of the corn belt where the soil is abnormally fortile, the highest yields have been secured by planting four kernels per hill. The average stand in the fall was about 3.3 stalks per hill.

In the central portion of the corn belt where a little larger eared variety can be grown, and where the soil is newer, the highest yields came from a little thicker planting, or five kernels per hill. However, the average stand from the tests where five kernels were planted was only 3.6 stalks per hill in the fall.

In the southern section, where the largest varieties are grown and where the soil is older the best results came from planting about three kernels per hill, giving an average stand of 2.5 to 3 stalks per hill.

2. The largest proportion of good ears as shown by most of the tests, come from a two to three stalk stand in the northern and central districts, while in the southern district the best results seemed to be obtained from about two kernels per hill, with reference to the proportion of good ears. Beyond that rate of planting the per cent of good ears rapidly decreased.

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.

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 ordinarily good conditions a farmer in the northern and central section of the corn belt would do well to plant so as to have three good strong stalks in every hill; that is, where the proper variety is used, which will mature under normal conditions. In the southern district the results indicate that under ordinary conditions an average of about 2.5 good stalks per hill would give better results than thicker planting.

Just what number would give the best result from any one farm must be decided by the farmer himself. In general the thickness can be increased on rich soil, or with a smaller 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 with the increase in thickness of planting from 4.2 per cent where there was only one stalk per hill, to 10.7 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. In the summary of all the experiments the proportion of nubbins and worthless ears was lowest where there was an average of one stalks per hill. The 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.

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.

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 is 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.

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.

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.

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.

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 meth-

*Address by Theo. W. Morse, before the Thirty-first Annual Meeting of the Board of Agriculture of Kansas.

ods, listing vs. check-rowed, the figures show 75 cents in favor of the former.

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 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.

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.

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.

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.

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.

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.
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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.
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Ohio Circular No. 53.
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Maryland Bulletin No. 46.
Corn Experiments,
Kansas Bulletin No. 56.
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Iowa Bulletin No. 55.
Field Experiments with Corn,
Minnesota Bulletin No. 31.
Experiments with Corn.
North Dakota Bulletin No. 76.
Nebraska Bulletin No. 112.
Ohio Bulletin No. 140.
Kentucky Bulletin No. 163.
Tennessee Bulletin No. 2.
Ohio Bulletin No. 282.
Illinois Bulletin No. 126.
County Demonstration Station Reports, Iowa.

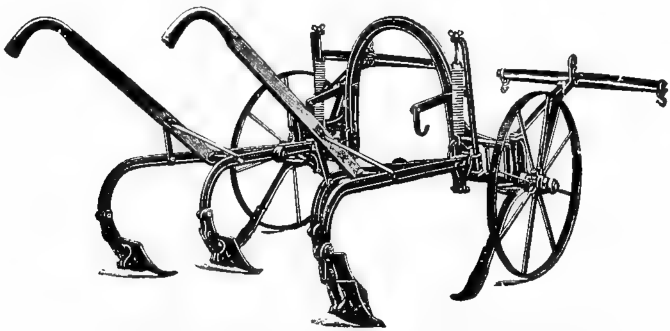
CHAPTER VIII.

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

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 gets a setback. That is, there should be no perceptible cessation of growth between the time the



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 structure 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.

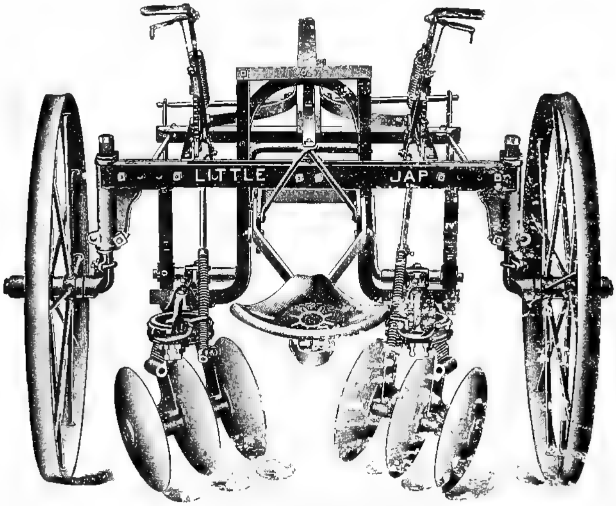
Harrowing Corn. The reasons for using a harrow or weeder before the first cultivation of corn are to kill newly germinated weed seeds; to start other weed seeds by warming the soil and admitting the air; to prevent the formation of a crust; to produce a loose surface mulch; and to get over a large area 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 structure, 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.

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.



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. 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.

WEEDER.
This is used when the weeds are small and the ground is in good condition.

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.

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.

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.

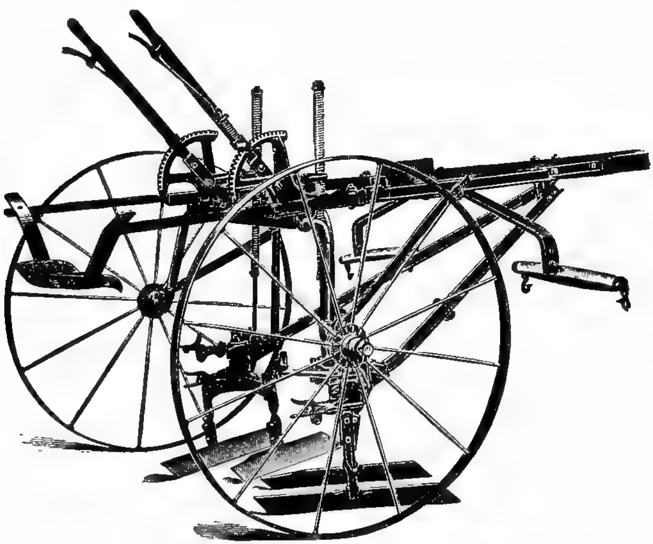
Deep cultivation cannot be done at any other time than the first time over. According to investigations in North Dakota, the roots of rows of corn three feet apart were interlaced at the end of 30 days after planting. The bulk of the roots were within the first eight inches of soil. Six inches from the hill the main roots were within 2½ to three inches of the surface.

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 structure. These may be cutivated 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.

From the results of an experiment conducted in Indiana for five years, the average yield of corn was 42.3 bushels per acre for the shallow cultivation, (1 to 3 inches) and 37.9 bushels where cultivated four inches deep.

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.

A similar experiment was conducted at the Ohio Station* and the results of a ten-year test showed an average yield of 56.4 bushels per acre and 2661 pounds of stover from deep cultivation, as compared with 60.4 bushels of grain and 2874 pounds of stover per acre from the shallow cultivation. The double shovel was used in the deep cultivation, and the spring tooth cultivator in the shallow cultivation.



SURFACE CULTIVATOR

These shovels are made to pulverize the surface rather than stir to any considerable depth

*Ohio Bulletin No. 282.

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.

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.

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.

At the Kansas Agricultural College, experiments were carried on to determine the advisability of frequent cultivation with the following results: (Note the variation in yield in different seasons, which was probably due to climatic conditions. No profitable returns resulted from excessive cultivation.)

TABLE NO. 40
FREQUENCY OF CULTIVATION

Times Cultivated During Season	Rate of Yield per Acre in Bushels		
	1891	1895	1896
Once		23.42	37.62
Twice	68.03	30.88	44.42
Three times		26.45	43.77
Four times	76.06	20.77	48.94
Five times		20.51	48.27
Six times	70.08	17.08	49.34

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.

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.

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.

The best kind of shovel with which to equip either single or double cultivators 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 beam, serve well to reach under the tobacco plant and cut weeds and loosen the soil without breaking the leaves.

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 often 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.

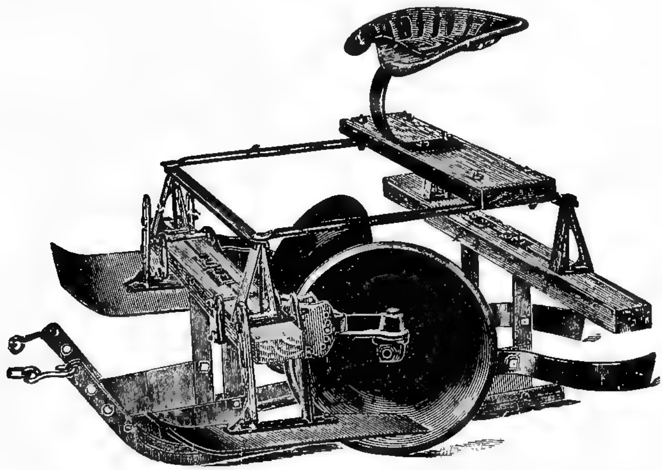
All forms of shovels should be so adjusted that the loosened soil will make a fine and even covering for the firmer soil beneath. Ridges left by the shovels make a larger surface for evaporation, and allow

"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.



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."

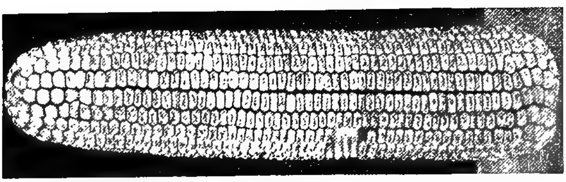
The "go-devil," as it is usually called in listed corn districts, has two heavy two-inch runners about eight inches high and 40 inches long which fit into the furrow. To the rear of these is a set of discs, two or three on each side, which may be set by a small lever placed near the seat. These discs 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.

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.



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.

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 husks well dried before being gathered.

*Bachelor's Thesis, Morris and Cohagen, 1907

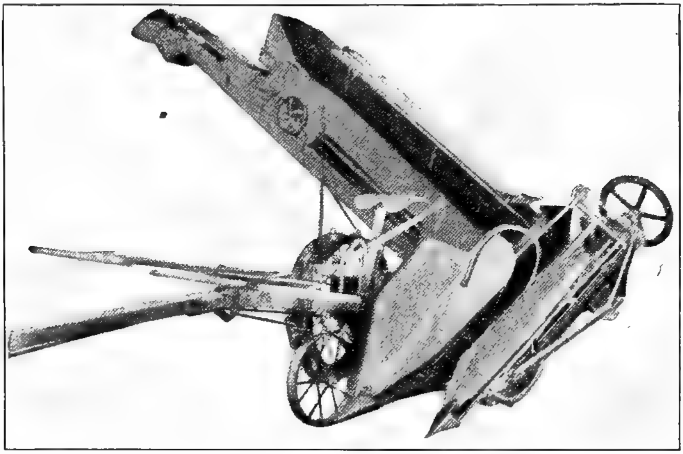
Time of Harvesting. The season has much to do in prolonging the ripening period. A damp, cold autumn keeps the foliage green and sappy. Early drought hastens the curing of the stalk and leaves, and matures the ears. The effect of frosts is marked when the freezing is severe. Early varieties which are 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.

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.

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 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.



CORN PICKER AND HUSKER.
Used in larger fields, and drawn by six horses.

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 at the present time the prevailing price ranges from four to five cents, some even paying more.

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. Forty to fifty bushels can be unloaded in four to five minutes. The fact that the

CORN PICKER AT WORK.
Used in large fields where little turning is necessary.

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.

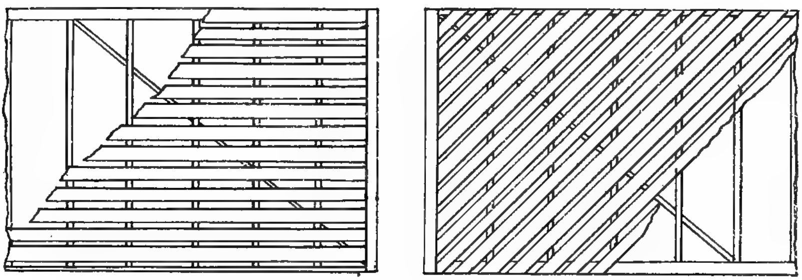
STORING CORN.—Principles Involved. The principles of storing corn are:

(1) The admittance of as much air as possible from the outside to come in contact with the corn.

(2) The escape of the heated air in the crib rapidly and without interruption.

(3) The exclusion of moisture from the crib.

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. Of late, woven wire fencing is most commonly used for temporary cribbing of corn.



HORIZONTAL AND SLANTING BOARDS ON CORN 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.

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. The crib should not be over eight feet wide for proper ventilation.

Hollow Tile Corn Crib. A crib which has been growing in favor recently is the hollow tile structure. Special tile is being manufactured, which, when laid by the mason, has the hollow channel extending downward to the outside of the crib so as to prevent rain or snow getting into the crib. The objection to the cement floor is fast disappearing, and its decided advantage in keeping out rats and mice is being recognized. The hollow tile crib as a rule is built circular, with an open core running up through the center. It represents a permanent structure at a reasonable cost.

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 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:

**Bulletin No. 50, Illinois.

***Thesis Cohagan and Morris, 1907. (Represents only laboratory tests)

TABLE NO. 41

*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	10.8	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

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.

PORTABLE GRAIN ELEVATOR.
Easily moved from one crib to another.

*Shrinkage begins the last of October each year and percentage was taken each month.

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 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.

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.

*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.

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 shrunk 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.

COLLATERAL READING

Corn Harvesting Machinery,
U. S. Department Bulletin No. 173.

The Shrinkage of Ear Corn in Cribs,
Illinois Buletin 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.

Bachelor Thesis of Morris and Cohagan,
Iowa State College, 1907.

CHAPTER X

THE COST OF GROWING CORN

In the past, corn growers as a class have not kept accurate figures regarding the cost of production. Profits have accrued because of the 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.

COST OF PRODUCTION DEFINED

According to the Farm Management investigators of the United States Department of Agriculture a farm can not properly be called successful unless:

First—It pays a fair rate of interest on the investment.

Second—It returns fair wages for the farmer's labor.

Third—It maintains at the same time the fertility of the soil.

In other words, three factors are always involved in crop production, namely, the capital, the man and the soil. These must necessarily be considered in figuring the cost of production, and in determining profit and loss.

At the suggestion of the United States Department of Agriculture "cost of production" for the corn crop may be analyzed as follows:

(1) Labor cost.

(2) Seed.

(3) Fertilizer.

(4) Equipment.

(5) Interest, taxes and upkeep on land.

(6) Overhead Expenses, etc.

LABOR COST. One of the main items in producing the corn crop is labor which may be classified as follows:

(1) Man labor.

(2) Horse labor.

(3) Power labor.

Man Labor. It is customary to get along with as little extra paid help as possible, but all labor spent on a crop should be charged in the cost of production. Usually the prevailing wage rate is used in figuring cost of man labor. This varies of course in different localities. By common custom in each community, there is a wage rate with board furnished and another where the laborer boards himself. In a report of the United States Department of Agriculture, March 20, 1915, the average wage per month without board, all of the states being included, was $29.88 during the previous year. Individual state averages ranged from $16.50 in South Carolina to $56.00 in Nevada.

Including board, the wages per month averaged $21.05 for the United States, ranging from $12.00 per month in South Carolina to $39.00 per month in Nevada.

Day labor other than harvest, without board, averaged $1.45 per day, ranging from $0.82 in South Carolina to $2.54 in Montana. The same with board furnished averaged $1.13, ranging from $0.64 in South Carolina to $1.80 in Montana.

Day labor at harvest time, without board, averaged $1.91, ranging from $1.06 in Mississippi to $3.25 in North Dakota. With board furnished, the average was $1.55, ranging from $0.82 in Mississippi to $2.68 in North Dakota. While the wage rate fluctuates between different years, there has been an increase of approximately 50 per cent in farm wages during the past fifteen years.

In case of hired labor the labor cost is easily figured. With the total amount paid out divided by the number of hours work employed, or simpler still, by dividing the daily wage by the average number of hours worked per day, the cost per "Man Hour" is given.

With a record of the time spent on a given crop it will then be easy to determine the cost of "Man Labor" for that crop.

All unpaid labor, such as work done by the farmer himself, and by members of the family to whom no regular wages are paid, should be included in figuring total labor cost.

Horse Labor. The term "Horse Labor" applies of course to the use of the farm horses. The cost per "horse hour" is determined by dividing the total cost of keeping the horses by the number of hours worked. Knowing the number of hours devoted to each field it remains easy to figure the cost of horse labor for the various crops. In determining the cost of keep for the horses, three items are involved: feed, labor in caring for the horses and interest on investment, including taxes, veterinary expenses, shoeing, etc.

In the live stock account the horses have been credited with the amount of work done, etc. The sum of all these credits subtracted from the sum of the debits, or charges, gives the cost of horse labor for the year.

Another method of determining the cost of horse labor, sometimes used, has been to charge the maintenance of all the horses used on the farm to the cultivated area, and to apportion the different crops according to the relative acreage and amount of work done.

Power Labor. This refers to tractors, engines, etc., used on the farm in place of horses, usually. The cost per hour may be figured in the same manner as for the horses. This would involve all costs in running and maintaining the power machine. By knowing the amount of time given to each crop the proper charge can be entered in the cost of production.

Amount and Character of Labor. The amount and character of the labor required to produce the corn crop varies necessarily in different sections of the corn belt, and with different corn growers. The following table taken from Farmer's Bulletin No. 661 of the United States Department of Agriculture gives the approximate number of hours needed in the production of corn, including both man and horse:

TABLE NO. 43

SHOWING NUMBER OF WORK UNITS REQUIRED FOR EACH ACRE OF CORN PRODUCED.

(A working unit is defined as a 10-hour day of man or horse labor)

	WORK UNITS PER A. (10-hr. days) Man	Horse
Corn husked from standing stalks		
Corn Belt states	2 to 3	5
Corn husked from shock	6	6
Corn for silo	4 to 6	5 to 7
Corn husked, Southern States	3 to 4	3 to 4

Treating labor more in detail the necessary operations in corn production are classified as follows:

(1) Breaking or removing stalks.
(2) Discing or dragging.
(3) Plowing.
(4) Harrowing.
(5) Listing.
(6) Applying manure or fertilizer.
(7) Planting.
(8) Cultivation.
(9) Gathering and cribbing.
(10) Cutting or binding.
(11) Shocking.
(12) Shelling and marketing.

A few years ago the American Agriculturist and the Orange Judd Farmer made an extensive investigation of the cost of growing the corn crop. The reports covered in a very complete manner 4,051 acres, located in 156 counties in 21 states. In considering the different operations necessary in corn production, data will be given from the results of this investigation. This is of value mainly in that it represents an average over a wide range of territory under a variety of conditions. In the itemized records of cost given later, as reported by extensive growers in the corn belt, the amount of work accomplished per day's labor will be seen to be considerably greater than is represented in these averages.

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.

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.

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.

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. In the schedules fertilizing was reported on some parts of 1,639 acres, requiring 634 1-4 days of labor and 483 1-4 days of team service.

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.

Cultivation. The cost of cultivation differs more than any other operation, 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.

Gathering and Cribbing. Two methods were followed; first, cutting up and shocking, then husking from the shock; second, husking from the standing stalks, 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.

SEED COST. Up to the present time we have been concerned with the labor cost. Going now to the cost of seed it is but a simple matter to compute this, especially where seed is purchased from some dealer and the cost is known. In case the seed has been home grown the cost should be figured to include actual labor in selecting, storing and preparation for planting. In the reports given this cost varies from $1.00 to $8.00 per bushel, the average being around $3.50. In most of the accounts, however, the seed is charged at only the prevailing seed corn price, not including cost of storing, preparation for planting, etc. A bushel should plant approximately seven acres.

FERTILIZER. The method of figuring the cost of fertilizer applied to the land for each crop varies, but the government charges 50 per cent of this cost to the crop for that year, apportioning the balance to the succeeding crops, that is where manure is used. According to the Indiana Experiment Station the value given to a ton of manure is approximately $2.25, which represents the amount of fertility contained in the manure at the prevailing market prices. At any rate all fertilizer used should be charged to the succeeding crops.

EQUIPMENT. This includes first of all the machinery used in the production of the crop. In considering the depreciation in the value of machinery much depends upon the care given and the extent to which it is used. The rate of depreciation will vary from 5 to 20 per cent. Probably from 7 to 12 per cent would be approximately correct for most farms. This can be figured from the inventory taken in the spring. Any new machinery purchased is charged to "Improvements" and only the interest and depreciation charged to cost of production. Adding to the depreciation, the interest on the average value of the machinery for the year gives the total cost of machinery use. In order to distribute this cost, it may be assumed that for every hour horses were worked machinery was used. Knowing then the number of hours spent in the care of each crop and the total cost of machinery use the cost per "machinery hour" may be figured. Multiplying this by the number of hours given to any crop gives the amount to be charged against that crop for machinery use. Any labor in repairing and keeping up the machinery is also charged to this account and apportioned among the various crops. This account also includes harness, etc.

INTEREST, TAXES AND UPKEEP ON LAND. This may be called the "Real Estate Account," which includes the value of land, buildings, fences and water supply. Normal farm values should be used. It includes also the upkeep of the land and improvements, interest, taxes, depreciation of buildings, etc. The proportion of this to be charged to each crop may be determined according to the acreage devoted to the same, and buildings used, as barns, cribs, etc.

In case the land is rented, the rental charge is considered instead of interest on land.

OVERHEAD EXPENSES. In addition to the interest on land the interest on the cash required to run the farm should be charged. This may be apportioned among the various crops, live stock, etc. It should represent the average amount of money the farmer is obliged to have on hand at all times during the year for the purpose of paying current expenses.

There is still left a great variety of items which plainly come under the head of expense. Taxes on personal property, current expenses, telephone, insurance, etc., must be apportioned among the different crops, live stock, etc.

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.

In the following statement is given an account of the actual cost of producing corn in 1912, by Mr. Fred McCulloch of Hartwick, Iowa. This record was taken under the direction of the United States Department of Agriculture and it represents a summary of the daily records which were made by Mr. McCulloch.

TABLE NO. 44

SHOWING ACCOUNT WITH CORN IN FIELD "D" 2

(38.91 acres valued at $5,658.70)

	TOTAL LABOR		TOTAL COST	LABOR PER ACRE		COST PER ACRE
	Man Hours	Horse Hours	(for entire field)	Man Hours	Horse Hours	
Labor costs***	918½	1888	$495.54	23.6	48.52	$12.74
Tractor 38¾ hours			46.70			1.20
Manure charge*						
20% of 1910 application			64.15			
50% of 1912 application			8.61			1.87
Seed, 6.05 bus. at $8.00...			48.40			1.24
Machinery use cost.......			85.20			2.19
Interest on 1911 costs**						
Brought forward			3.20			.08
Interest on land value....			282.94			7.27
Overhead expense			60.17			1.55
Total cost			$1,094.91			$28.14
Total yield	2,685 bus.		Cost per bushel			40.8 cents

INCOME

2,545 bu. corn at $ .40	$1,018.00	(65.4 bu. per acre)	$35.66
140 bu. (seed) corn at $2.50.............	350.00	(3.6 bu. per acre)	
Stalks at $ .50 per acre.................	19.46		
Income	$1,387.46		$35.66
Total costs	$1,094.91		$28.14
Profit	$ 292.55		$ 7.52

Without figuring the extra value of the seed corn in the total income, it will be seen in the foregoing statements that there would have been practically no profit.

Of special consequence in the foregoing table is the cost of production which amounts to $28.14 per acre or 40.8 cents per bushel.

*In the manure charge 20 per cent of the 1910 application and 50 per cent of the 1912 application was charged to the crop for 1912.

**Interest on 1911 costs refers to work and material employed on this field the fall previous.

***Mr. McCulloch found that his cost for labor was as follows: Per man hour, 14.9 cents; per horse hour, 10 cents and per tractor hour, $1.22.

An investigation conducted by the Agricultural Experiment Station of Missouri* found the cost per acre of producing corn to be $13.52. This represents accurate costs taken from 357 acres.

TABLE NO. 45

SHOWING COST OF PRODUCING CORN. (Missouri)

Items	Cost per acre	Per cent of total cost
Man labor	$3.074	22.7
Horse labor	3.596	26.9
Seed	.275	2.0
Equipment	1.021	7.6
Use of land—taxes, interest and upkeep	5.164	38.2
Manure	.392	2.9
Total	$13.522	100

Of the total cost of producing the crop ($13.52 per acre) 49.6 per cent, or practically one-half, is charged to labor; and 38 per cent of the total is taxes, and upkeep usually termed "use of land."

As a result of this same investigation, covering a large acreage, the labor requirement of the different field operations in caring for the corn crop was computed. This is given in the following table:

TABLE NO. 46

SHOWING LABOR REQUIREMENT OF FIELD OPERATIONS

Operation	Total acres	Man-hours per acre	Horse-hours per acre
Discing	1187.0	1.48	5.33
Plowing	1227.8	3.76	9.51
Harrowing	1423.4	1.12	3.12
Planting corn	1082.3	1.40	2.21
Cultivating	1750.7	2.36	4.32
Harvesting corn	412.0	5.29	7.10
Filling silo	56.0	8.78	8.43
Storing grain	173.0	2.68	3.59b

The foregoing table gives the number of hours labor for both man and horse for each operation. In the following table the labor requirement is classified and recorded in three divisions: preparation and planting, cultivating and harvesting.

*Missouri Bulletin No. 125.
b—Hauling corn from field to barn.

*TABLE NO. 47

SHOWING LABOR REQUIREMENT PER ACRE—CLASSIFIED. (Missouri)

Crops	Man-hours	Horse hours	Per ct. Total Man-hours	Per ct. Total Horse-hours
Corn (679.7 acres)				
Preparation and planting	7.67	19.72	32.07	46.60
Cultivating	7.90	13.44	33.03	31.76
Harvesting	8.35	9.16	34.90	21.64
Total	23.92	42.32	100.00	100.00

Approximately 32 per cent of the necessary man labor and 46.6 per cent of the horse labor is required for preparation of land and planting. Cultivation takes 33 per cent of the man labor and 31.7 per cent of the horse labor. For harvesting, approximately 35 per cent of the man labor and 21.6 per cent of the horse labor is required. These figures should apply to average conditions in the determination of labor cost for the corn crop.

INDIVIDUAL ESTIMATES OF COST

Several reports received from prominent corn growers and large farms are given to show cost of production in various localities of the corn belt. Of course in these following estimates some items have been omitted, which should be included in the total cost of production.

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 for the year 1914.

The following is figured on a sixty bushel yield. It will be noted that a five per cent interest charge on the land valued at $150.00 per acre has been made. This would be equivalent to a rental of $7.50 per acre.

*Missouri Bulletin No. 125.

TABLE NO. 48

COST PER BUSHEL OF RAISING CORN ON 60 ACRES

(Sibley Estate, Sibley, Illinois, 1914)

1—Fall plowing 45 acres at $1.50	$67.50
2—Breaking 15 acres corn stalks	4.00
3—Spring plowing 15 acres at $1.25	18.75
4—Discing 45 acres fall plowing 4½ days at $4.50	20.25
5—Harrowing before planting, 4 horses, 1 man, 2 days	9.00
6—Seed corn, 9 bushels at $1.00	9.00
7—Planting 60 acres, 3½ days, $4.00 per day	14.00
8—Harrowing after planting	9.00
9—Cultivating first time, 2 men, 2 teams, 4 days at $3.50	28.00
10—Cultivating second time, 2 men, 2 teams, 3½ days at $3.50	24.50
11—Cultivating third time, 2 men, 2 teams, 3 days at $3.50	21.00
12—Extra work thinning and weeding	10.00
13—Husking 2400 bushels at 3½c	84.00
14—Shelling and marketing at 3c	72.00
15—Value land, $150.00 per acre on 60 acres 5%	450.00
16—Taxes on 60 acres	20.00
17—Repairs and upkeep	15.00
	$876.00

Cost per bushel of corn to produce and deliver to market, 36 cents.

Mr. John Sundberg, a prominent corn grower of Monona County in western Iowa gives the following estimate on the cost of producing the 1914 crop.

TABLE NO. 49

COST OF PRODUCING ONE BUSHEL OF CORN ON $250.00 LAND

(Monona County, Iowa)

Interest at 5% on valuation, and $1.25 per acre taxes	200 mills
Cutting, raking and burning of stalks	12
Discing ground	16
Plowing for corn	20
Planting	6
Harrowing twice	6
Cultivating four times	18
Gathering of corn	45
Fence	5
Grease, oils and repairs, and wear on machinery	8
Total cost per bushel	336 mills

This is figured at 60 bu. per acre. 33.6c per bushel, $20.16 per acre.

"By using silos we are getting at least one-third more from our land," states Mr. Sundberg.

Mr. F. H. Klopping from the same district, Pottawattamie County, also well known to the corn breeders, made the following estimate for the 1914 crop.

TABLE NO. 50

COST OF PRODUCING AN ACRE OF CORN. (Pottawattamie County, Iowa)

Breaking and raking stalks	$ .17
Plowing	.80
Harrowing three times	.20
Discing two times	.30
Planting	.18
Cultivating four times	1.60
Husking corn	2.30
Interest on machinery and horses and deterioration of same, about	.45
Interest on land and taxes	12.20
Total cost per acre	$18.20

With a 50-bushel crop the cost per bushel would be 35 cents. A yield of 40 bushel would cost 45 cents per bushel.

Another estimate from western Iowa was submitted by Mr. George M. Allee of Buena Vista County, 1914.

TABLE NO. 51

COST OF PRODUCING AN ACRE OF CORN. (Buena Vista County, Iowa)

On basis of one acre. ($3.50 for man and 2 horses.) ($5.00 for man and more than 2 horses.)

1—Discing stalks (twice) 20 acres per day	$ .50
2 -Plowing—2½ acres per day	2.00
3—Discing (twice)	.50
4—Harrowing (once) 40 acres per day	.12
5—Planting—16 acres per day	.21
6—Harrowing (twice)	.25
7—Cultivation (4 times) 7 acres per day	2.00
8—Husking and hauling to market, at 8c per bu per 50 bu yield	4.00
9—Rent	6.00
10—Seed at $3.50 per bushel (7 acres per bu.)	.50
	$16.08

Cost per bushels (50 bushels per acre) 32.1 cents.

In the foregoing estimates note that Mr. Sundberg figured the cost on the basis of interest on land value and taxes which amounted to about $13.75 per acre, while Mr. Allee figured the cost on a rental charge of $6.00 per acre. However, these men figured the cost at about 33 cents per bushel.

Inquiries from the eastern half of Iowa revealed but slightly varying estimates.

Neal Bros., of Mt. Vernon, Iowa, have carefully prepared the following estimate, based on twenty acres.

TABLE NO. 52

COST OF PRODUCING CORN (Linn County, Iowa)

1—Plowing, 1 man and 4 horses at $5.25 per day, 4 acres per day	$27.25
2—Harrowing—1 man and 4 horses at $5.25 per day, 40 acres per day	15.75
3—Discing—1 man and 4 horses at $5.25 per day, 25 acres per day	8.40
4—Planting—1 man and 2 horses at $3.25 per day, 20 acres in 1¼ days	4.00
5—Cultivation—1 man and 2 horses at $3.25 per day, 6 acres per day, 13 1-3 days	43.33
6—Seed corn, 3 bushels tested seed	9.00
7—Rent at $6.00 per acre	120.00
8—Husking and cribbing at 4½c per bushel	45.00
9—Insurance and wear on machinery	10.00
	$282.73

Cost per acre, $14.14. Cost of 1,280 bu., $282.73 or 23.6c per bushel.

This does not include shelling and marketing, as the corn is fed on the farm to keep up the yields. Note that a rental of only $6.00 per acre has been charged.

Mr. D. L. Pascal, grower of prize winning Reids' Yellow Dent corn in Clinton County, Iowa, figures the cost of production as follows:

TABLE NO. 53

COST OF PRODUCING CORN (Clinton County, Iowa)

1—Discing the land twice before plowing	$ .75
2—Harrowing before plowing	.25
3—Plowing land	1.75
4—Harrowing twice after plowing	.40
5—Discing twice before planting	.75
6—Harrowing twice before planting	.40
7—Seed	.50
8—Planting	.30
9—Harrowing after planting	.20
10—Cultivating five times	3.50
11—Husking per bushel and men board selves, 60 bu. at 5c	3.00
12—Rent for corn land would average here	8.00
Cost of producing acre	$19.80

At 60 bushels per acre, cost 33.0 cents per bushel.

From the foregoing reports from corn growers the cost per bushel ranges from 23.6 cents to 36 cents, and the cost per acre from $14.14 to $21.60, the average for the six farms being 32.4 cents per bushel or $18.89 per acre. These accounts however do not include any charge for manure, and, many other items included in Mr. McCulloch's report are omitted.

PROFITS IN CORN GROWING.

The difference between the cost of producing an acre of corn and the value of the product is the profit. Figuring this cost on the basis of 5 per cent on the investment would naturally make considerable difference in the different localities, due to the value of the land, but on the whole, it may be very conservatively stated that, in the heart of the corn belt, it is quite impossible to raise an acre of corn for less than $15.00, figuring 5 per cent on the money invested in the land and the operating expenses.

Of course it is not necessary to double the yield in order to double the profit. Suppose it costs thirty bushels of corn to grow an acre of corn, then if you had a yield of thirty-one bushels you would have one bushel profit; if your field was thirty-two bushels, you would have twice the profit. It will be seen that the percentage of net profit received from an acre of corn increases rapidly with an increase over and above the actual number of bushels of corn it costs to produce the acre.

For example, here are some figures taken from the United States Department of Agriculture, wherein they figured the average value of a bushel of corn over a period of years, at 42.4 cents, while the growing cost per acre was figured at $14.63, with the following results:

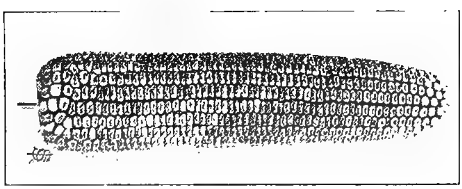
40 acres of corn yielding 75 bushels per acre makes as much net profit as 104 1-4 acres, yielding 50 bushels to the acre, or 293 acres yielding 40 bushels per acre or 3,270 acres of corn yielding 35 bushels per acre.

The increased net profits are quite alarming when you stop to consider that a forty-acre field of corn, yielding 75 bushels to the acre will produce more net profit than five sections of corn, producing 35 bushels to the acre.

This clearly shows that it is more bushels of corn to the acre and not more acres that really make most for a increased net profit.

COLLATERAL READING:

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.
Farmer's Bulletin, U. S. Dept. of Agriculture, No. 661.
Missouri Bulletin No. 125.
Farmers' Bulletin, U. S. Dept. of Agriculture, No. 584.



CHAPTER XI.

DISEASES AND INSECTS ATTACKING CORN

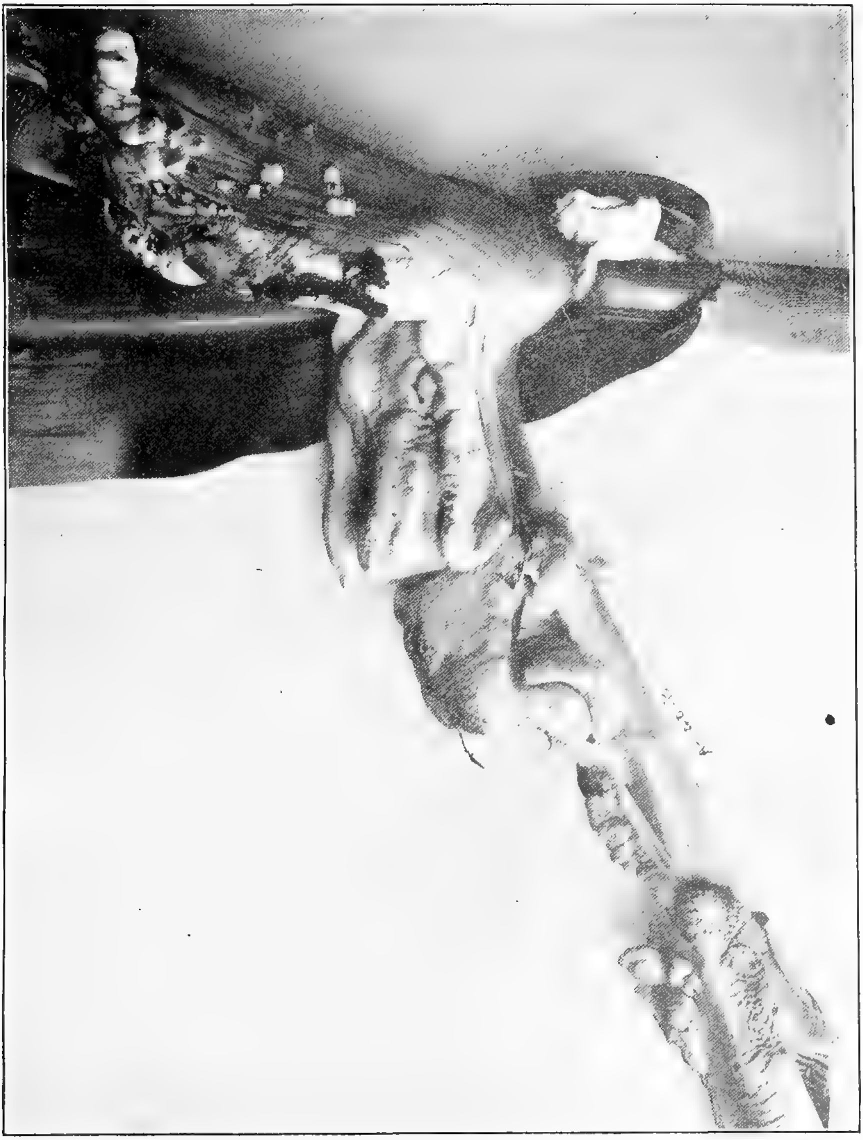
DISEASES OF THE CORN PLANT

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 is 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.

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.

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.

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



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.

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.

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.

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 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	Average	Weight of Ears Total	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. The 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.*

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.

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, Illinois 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.'"

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.

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."*

CORN STALK DISEASE.* This disease is characterized by the falling of the corn or the stalks are broken close to the joints. In many cases the corn is broken off just below the joint or just above. The pith is destroyed, brownish or in some cases reddish in color. The fibers are soft and easily broken off. The small dwarf shoots in the axis of the leaves are often decomposed. On the surface of the stalk and in the nodes there is often an abundance of the mould.**

*Iowa Circular No. 21.

**This was determined as a species of Fusarium. Other species of this genus cause wheat scab or blight, flax wilt, cucumber wilt, etc.

The disease attacks the roots, the stalks and the ears. The specific organism causing the damage has not been determined. The disease is widely distributed throughout Iowa, and in Illinois. As a rule it is unnoticed until after the wind has blown over the infected corn, and then the damage is usually charged to the wind or to insects.

Remedy. The only rational treatment is crop rotation. Corn should not follow corn where the disease exists, since the fungus remains on parts of the plants attacked. When corn is planted in the same field the next year the young stalks will be infected. The Iowa Experiment Station recommends the use of formalin in treating the seed from infected plants; one pint of formalin to forty-five gallons of water for fifteen minutes. This will destroy all of the spores adhering to the surface of the corn. This treatment would avail little or nothing if the seed were planted in an affected field.

EAR ROTS OF CORN.* In a field of matured corn it is not uncommon to find ears more or less covered with and penetrated by mold. In many cases, husks and silks are also involved and appear cemented together and to the ear by a mass of white cob-webby filaments. The parts affected have lost their substance, are light in weight and brittle in structure.

This condition is known as ear-rot. Several types of the disease are known. Some of these are so similar though that the casual observer would notice no distinction.

The first indication that ears of corn are diseased is a fading of the bright green of the husks to a pale yellowish green color. With the advance of the disease the outer husks grow darker and darker, frequently becoming dirty and sooty in appearance. The inner husks too may be more or less tinged with brown, particularly along the advancing margin of the diseased area.

The ear rots may be noticed first soon after the fertilization of corn has taken place, the number of infected ears increasing throughout the season.

The best spore producing periods seem to follow hot, rainy weather preceded by more or less continued dry spells. Since, then, under favorable conditions the spores are produced in such large numbers throughout the season, the matter of little or much infection depends in part at least on these spore producing periods coming at a time when corn is in the most susceptible condition for infection. It is when corn is in the thick milk stage and later that the large per cent of infected ears in the field begins to show.

*Illinois Bulletin No. 133.

These diseases occur with more or less severity over a wide area. In Illinois alone the State Department of Agriculture estimated the loss from ear rot at $5,620,147 for a single year.

Corn grown on the rich, black land of our corn belt, however, is more subject to the disease than on higher, thinner soils.

The greater the number of old stalks and the greater the supply of moisture, the better the opportunity for a continual and rapid propagation of the most destructive of these fungi.

The ear rots are undoubtedly more prevalent where corn is grown continuously for some time than on land where a careful system of rotation is practiced.

Causes of Ear Rots. These diseases of corn are due to definite species of mold like parasites. So far as is known these grow on nothing but the corn plant. These molds belong to the great group of plants called fungi. These fungi develop upon the growing stalks and dead stalks, as well. They are both parasitic and saphrophitic.

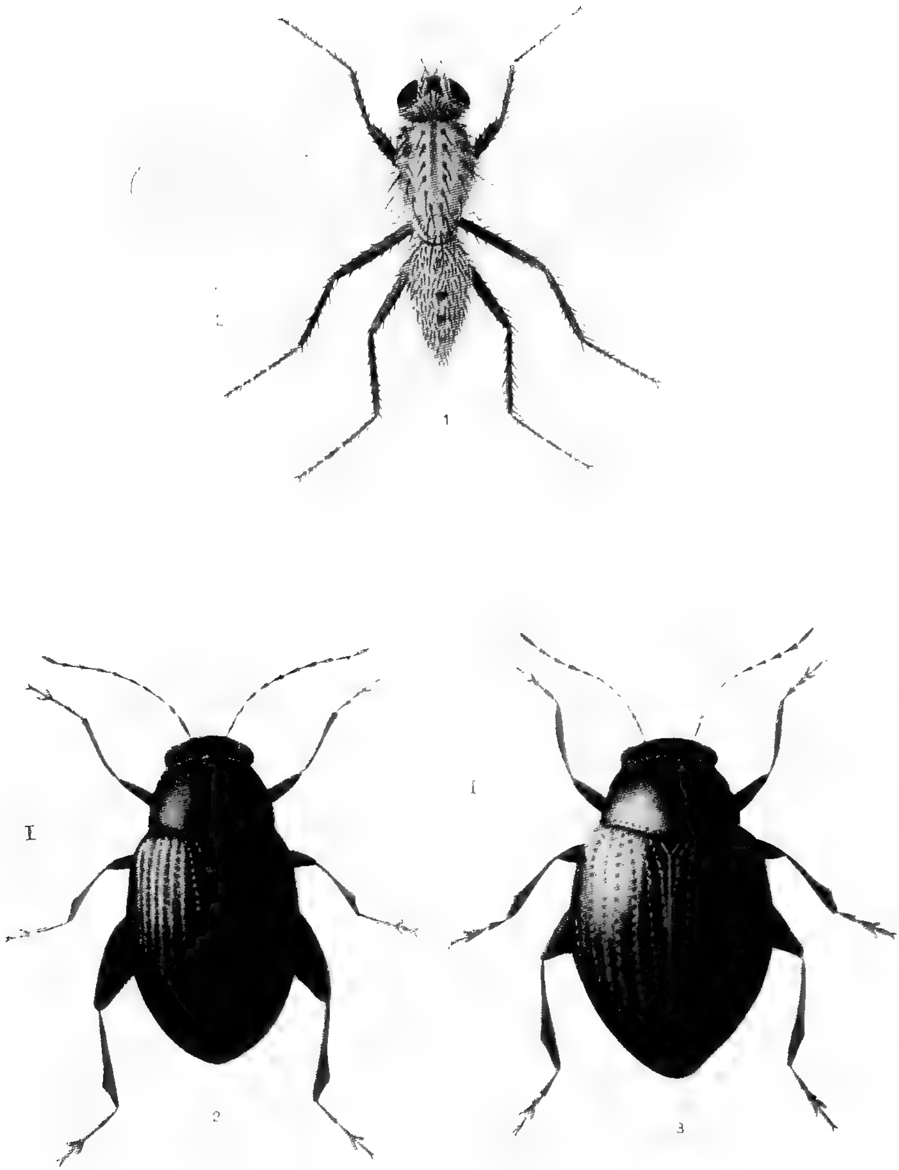
The spores are produced during the summer upon old stalks, even from those lying on the ground the second year, and these spores are readily carried by the wind. Lodging upon the developing ear, they germinate under favorable conditions of moisture and temperature. The rot does not occur without the infection of these spores.

There are several kinds of these ear rots. Careful observation is necessary however, to differentiate these. The four types commonly discussed are as follows:

(1) Diplodia.
(2) Fusarium I.
(3) Fusarium II.
(4) Fusarium III.

The greater amount of damage seems to be done by the "Diplodia Zeae." The manner of infection, character of growth and the nature of the damage does not seem to vary materially, however, between the different species.

In the Diplodia, the germinating spore sends out a slender thread-like structure called a mycelium. These slender threads penetrate the plant tissues. After the ear has become entirely involved or the growth of the parasite somewhat checked, the fungus begins to form its reproductive stage. This consists of small black bodies which develop in husks, cobs, and more rarely in grains, and which contain large numbers of purplish brown rather slender two celled spores. These spores are scattered by such natural agencies as the wind.



Lydia Moore H

PLATE I.

Fig. 1 -THE SEED-CORN MAGGOT, *Pegomyia fusciceps*, adult. Fig. 2—THE COI FLEA-BEETLE, *Chætonema Pulicaria*. Fig. 3—*C. confinis*.

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Remedy. Crop rotation seems to be the only remedy. The fungi harbor in the old corn stalks. Corn should not be planted for two years thereafter where there has been much of this disease.

THE COB ROT OF CORN. This disease is manifested in a softening and decay of the cob, rendering the grain unmerchantable. The fungus causing this disease belongs to the genus "Coniosporium." It does not seem to affect the living corn plant. The mycelium penetrates the various cob tissues and the lower portion of the kernel. It may cover as much as the lower half of the kernel. The infected corn is damaged for feeding or marketing.

BEETLE OF THE SOUTHERN CORN ROOT WORM AT WORK EARLY IN THE SPRING

The stalk borer is also shown on the upper leaf.

INSECT ENEMIES

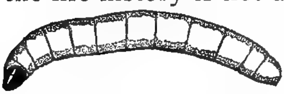
The newly planted seed, the young plant, the growing stalk, the developing ear, and the stored grain, are all subject to insect enemies. Each year pests which have heretofore been of little economic importance gain in number until they destroy whole fields. The increased acreage of corn on land which has been cropped for a number of years favors the breeding of this insect life.

The most disastrous insect enemies are here described and remedies and preventives suggested.

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 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 greatest damage from this pest usually occurs in a cold wet spring. Replanting is sometimes necessary. 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 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.



Black-headed Grass Maggot
Scaria sp.

WIREWORMS. *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.

The wire worm is of a reddish brown color, varying from yellowish 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.

The eggs which produce the wire worm are laid in grass lands in

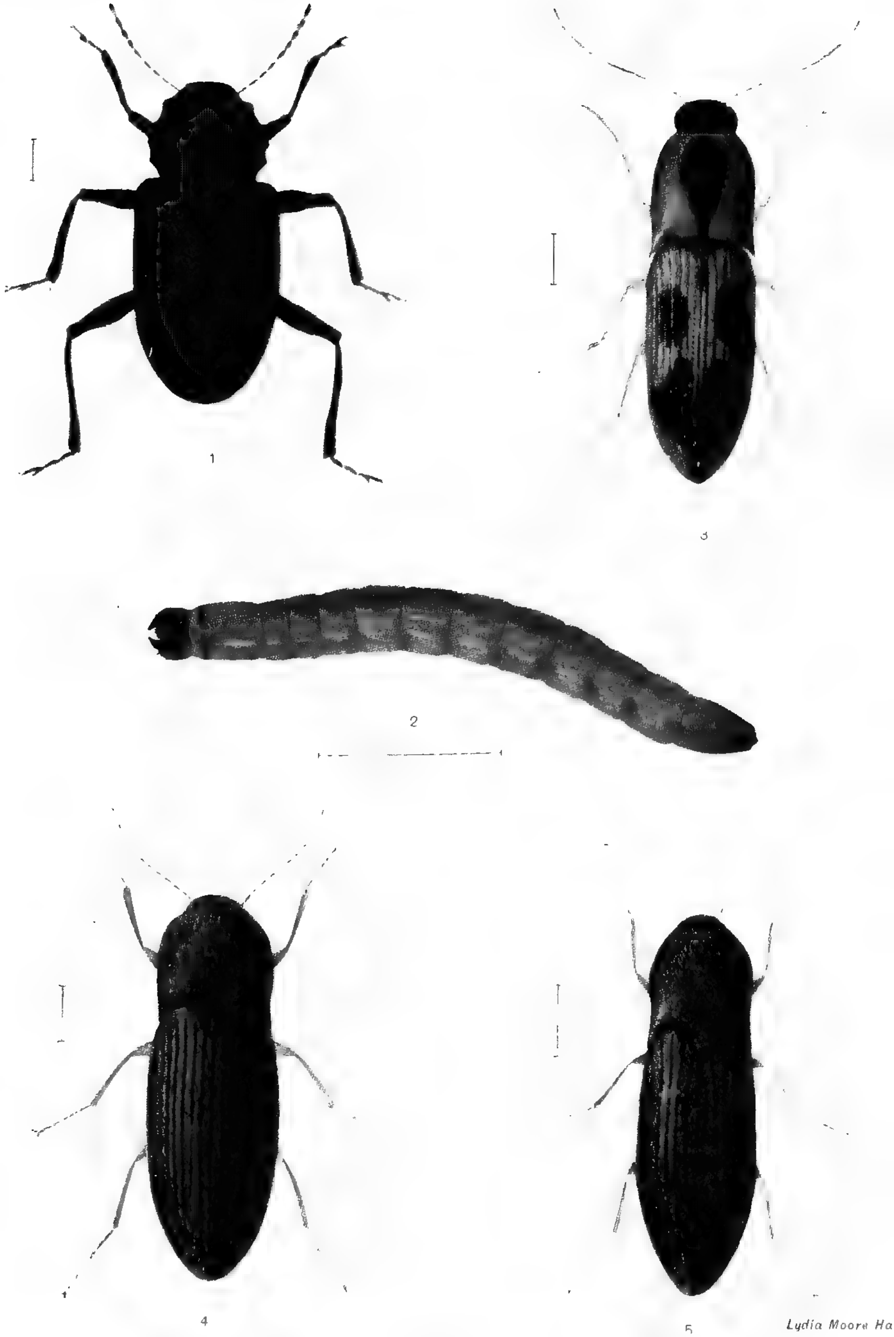


PLATE II.

Fig. 1—*Myochrous denticollis.* Fig. 2—THE CORN WIREWORM, *Melanotus cribulosu*
Figs. 3-5.—CLICK BEETLES, adults of other Corn Wireworms; *3 Drasterius elegans; 4 Agriote*
mancus; 5 A. pubescens.

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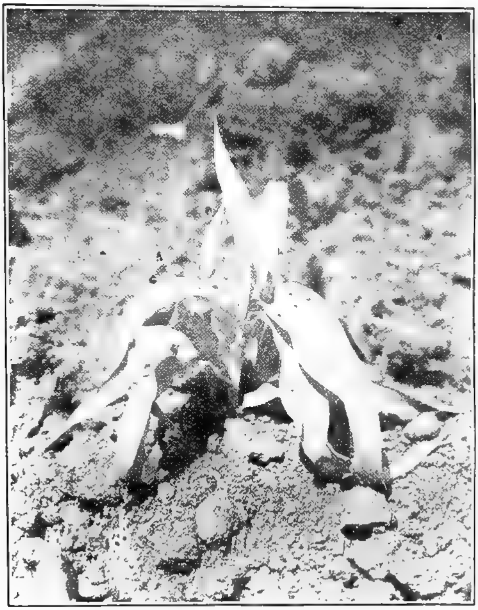
PLANT APHIDS AS SEEN ON THE TASSEL OF CORN the earth. The wire worm coming forth, feeds on the roots of grass. They may be found in any of our tame and wild grasses, but they are seldom found here in sufficient numbers to make a very great impression on the appearance of the grass lands. However, when 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 larval 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.



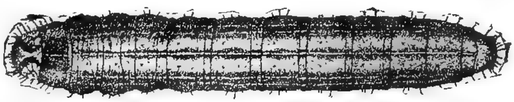
CORN PLANT SHOWING EFFECTS OF ATTACKS BY THE BILL BUG.
Note that the holes in the leaves are in rows.

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 larval 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 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.

CUT WORMS. These caterpillars are exceedingly harmful at times, their damage being of a very injurious nature. They attack the



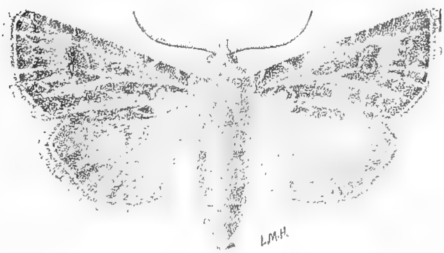
Clay-backed Cutworm. *(Feltia filadiaria)* Enlarged.

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.

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 cutworms 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 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 ot 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. A parasite is known to prey on the cutworm. A tiny larvae from the egg of a small fly proves fatal to the affected cutworm.



Clay-backed Cutworm.
(Feltia gladiara). 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

PLATE III.

The White Grub; the beetle, egg, larva and pupa; enlarged two and one-half diameters.

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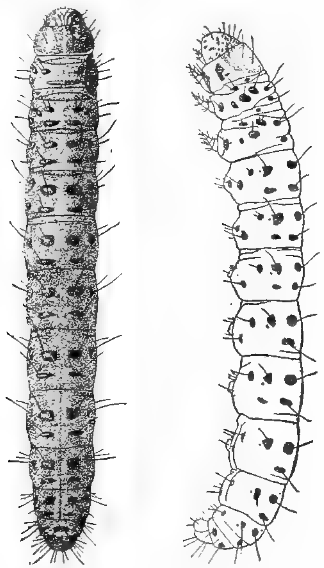
one side. The greedy larva feeds during the night and lives during the day in a little silk-lined tube about one inch below the surface. The larva does not pupate before winter, but hibernates in the silk-lined tube. In the spring its growth is completed. It then pupates and by June 10th the imago is 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.

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.

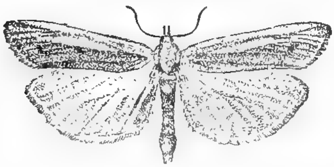


The common Sod Web-worm
(Crambus trisectus)
Back and side views, much enlarged.

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.

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.

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 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 stalk in an upright position. If 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 *Lachnosterna* besides the genera *cyclocephala,* which do damage to the corn plant.



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.

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.

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

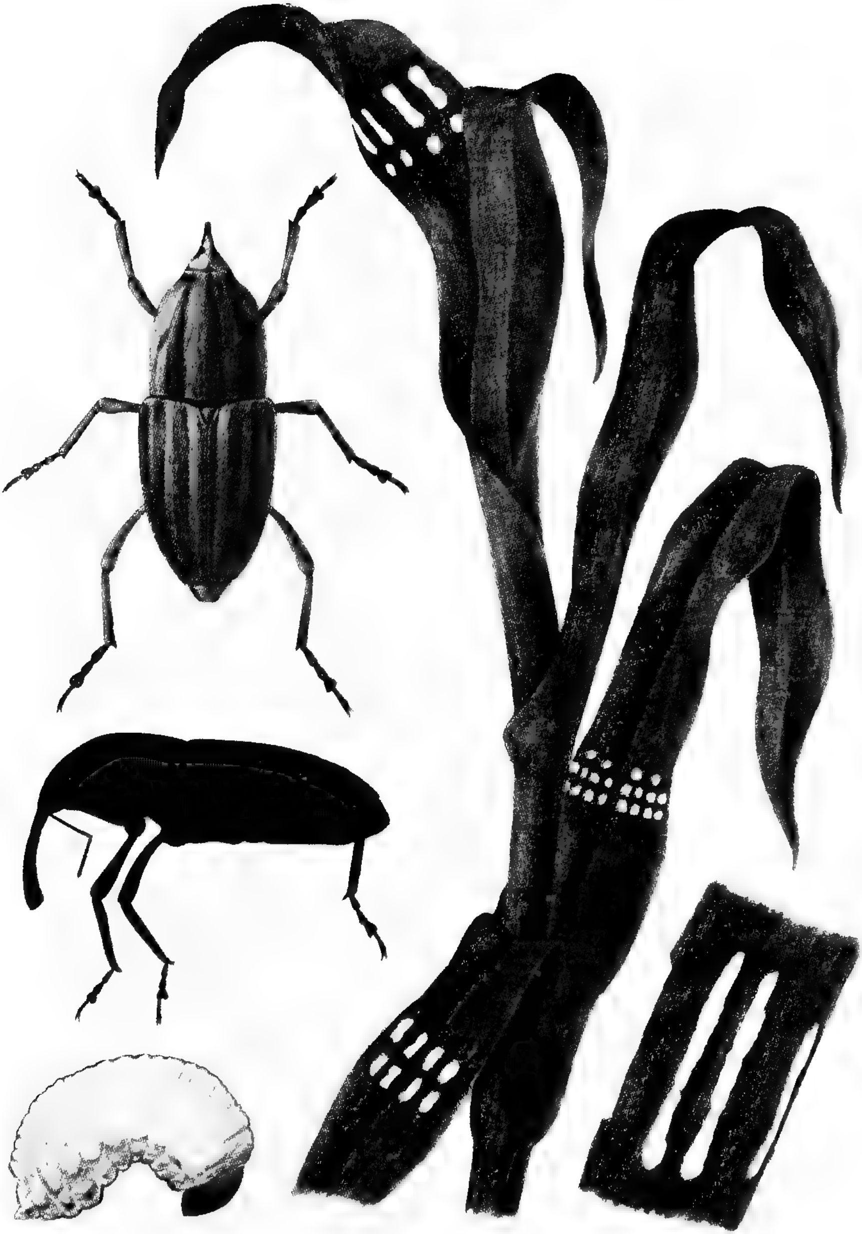


PLATE IV.

Corn Bill-Bugs and larva, with injured corn plant.

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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.

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.

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.

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 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. This and succeeding generations are asexual giving birth to the living young. 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 a field not in corn the previous year. It is generally November before those of the viviparious 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 16 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.

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 and early spring plowing disturbs the homes of the ants and destroys large quantities of eggs of the aphis. Clean cultivation, especially on low ground, prevents

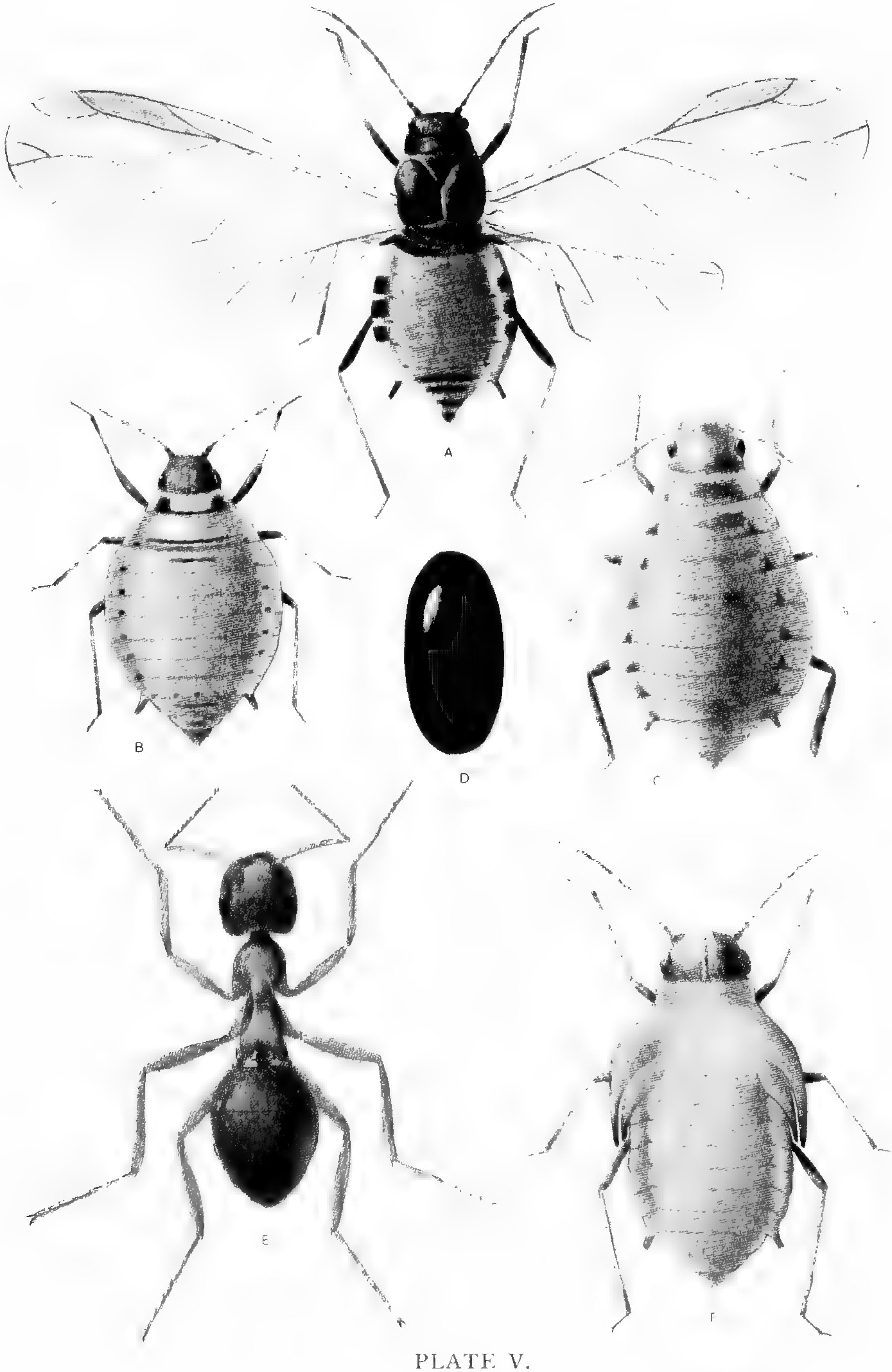


PLATE V.

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.*)

COURTESY OF PROFESSOR S. A. FORBES, ILLINOIS STATE ENTOMOLOGIST

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.

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 loss in a single year. Its ravages are worse during continued dry spells, and corn plants attacked 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.

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.

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 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:

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

*U. S. Department of Agriculture Report 1881-1882, P. 90-91.

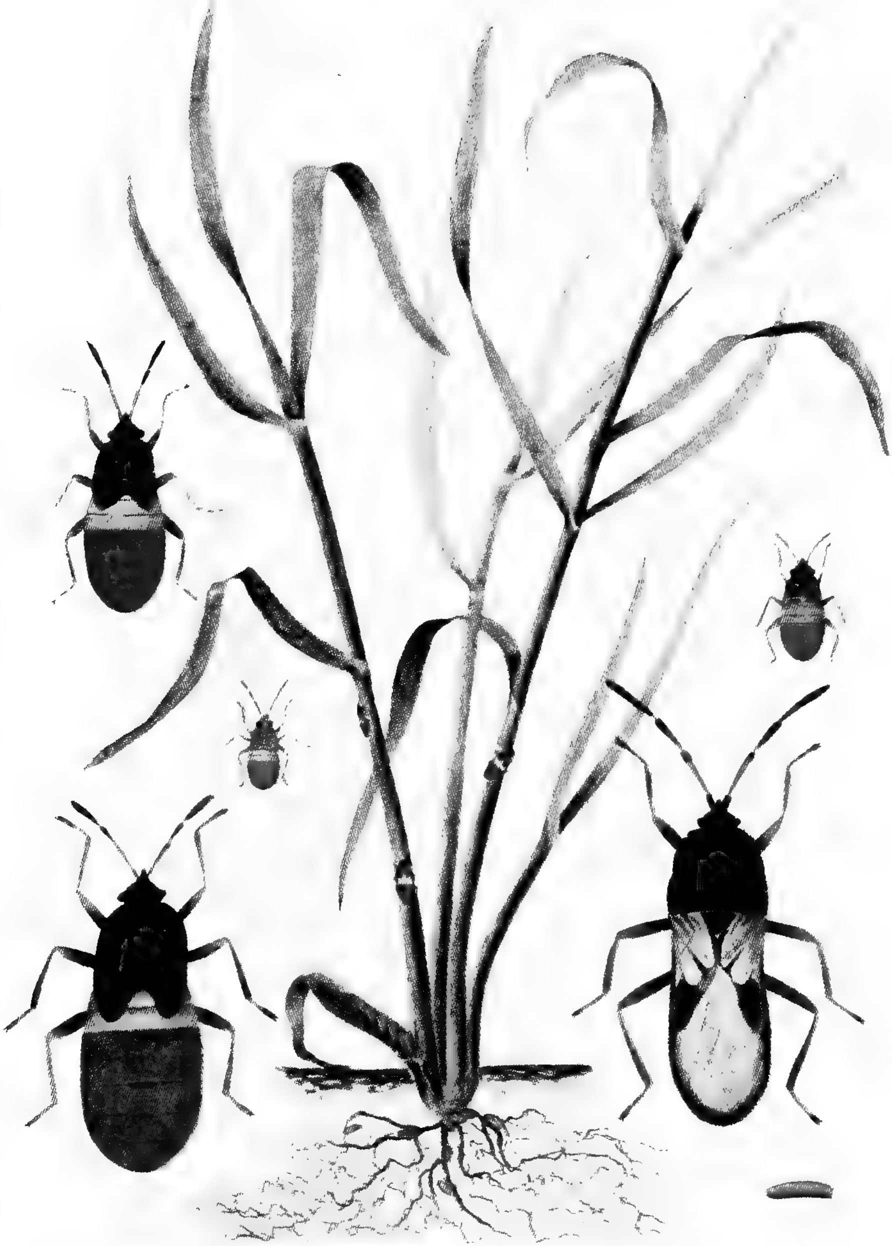


PLATE VI.

The Chinch-bug; five stages of development and the egg.

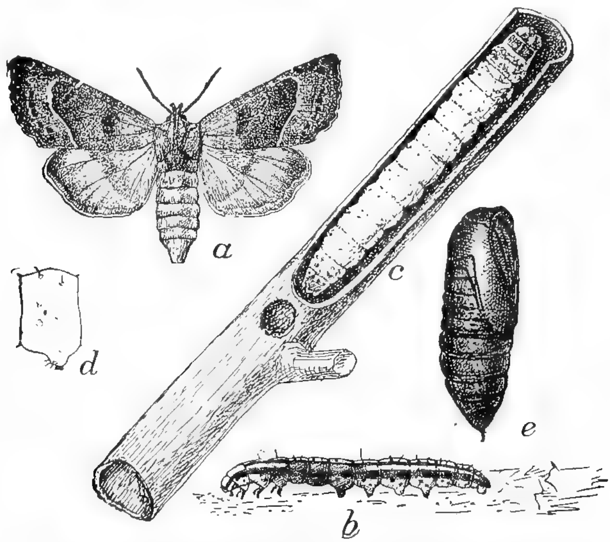
broad stripe on each side is characteristic. The pupa stage, which lasts about 2 weeks, is passed in rubbish on the ground. The imago or adult comes forth and begins to lay eggs again in 6 to 8 days. This, in all, gives 7 to 8 weeks for the life cycle in midsummer. There are usually from 2 to 3 broods each year in the northern states. The last brood hibernates either as larvae or pupae. The moths appear very early the next spring.

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.

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.

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 grassy places. Here they may be discovered by the tops of the grass attacked turning whitish in color and dying. This grass should be mowed 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.



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.

*This investigation carried on by E. P. Humbert under the personal supervision of M. L. Bowman.

PLATE VII.

The Army-worn, with pupa, moth, and egg.

COURTESY OF PROFESSOR S. A. FORBES, ILLINOIS STATE ENTOMOLOGIST.

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 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.

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.

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,

**See Eighteenth Report of Illinois State Entomologist, by Forbes.

Each bundle represents four average hills of corn from ground in corn for the first, second, third and fourth years as shown from left to right.

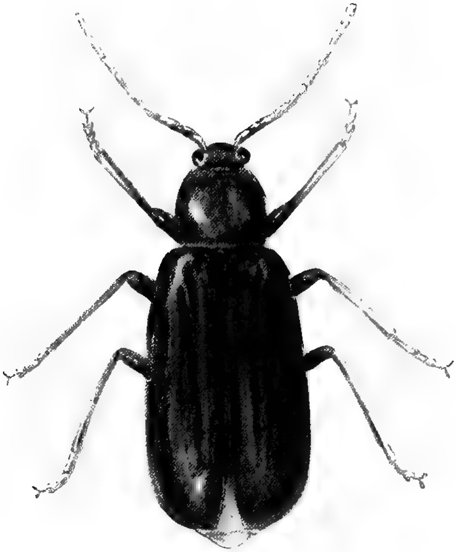


FIG. A

FIG. B

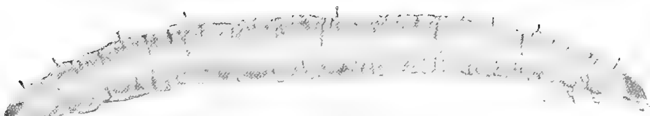


FIG. C

FIG D

CHARLOTTE M KING ARTIST

PLATE VIII.

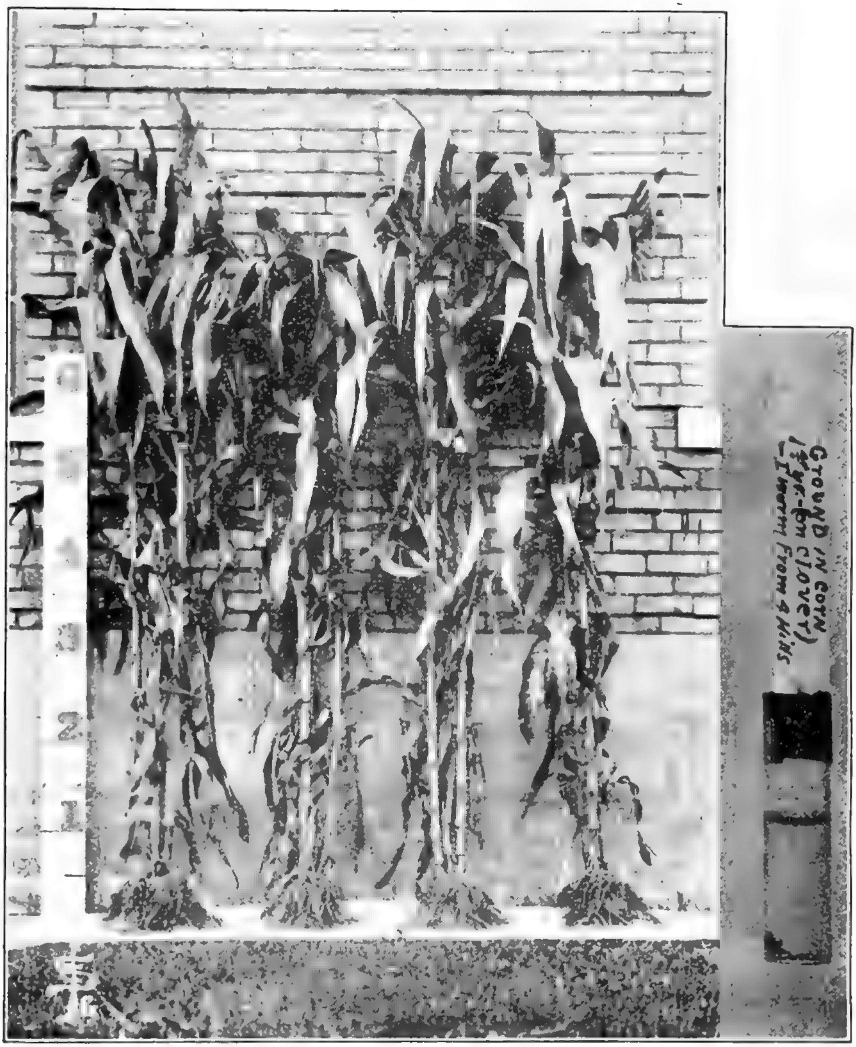
CORN ROOT WORM, (*Diabrotica longicornis.*) A, Beetle; B, Pupa; C, Larva; D, Larva in Corn Root.

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 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 page 246), when if it were not for the corn-root worms they would not have shown the effect in the least.

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 picture (page 246).

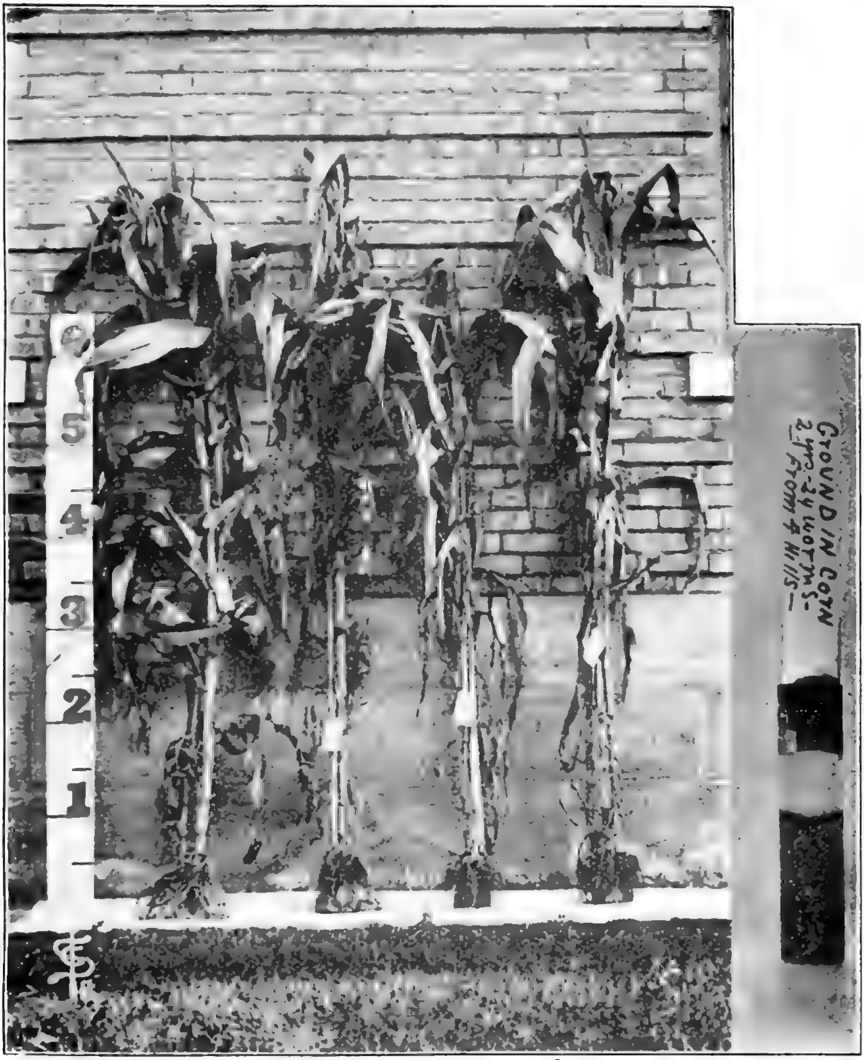
When the ground has been in corn but one year the damage will not be particularly apparent the year following. Quite frequently the presence of the corn-root worm is not suspected until the small grass-green beetles are found upon the plant. These beetles begin coming forth about the time, or a little 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 on page 238 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 following cuts. 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.



FOUR HILLS REPRESENTING GROUND IN CORN FOR THE FIRST YEAR.

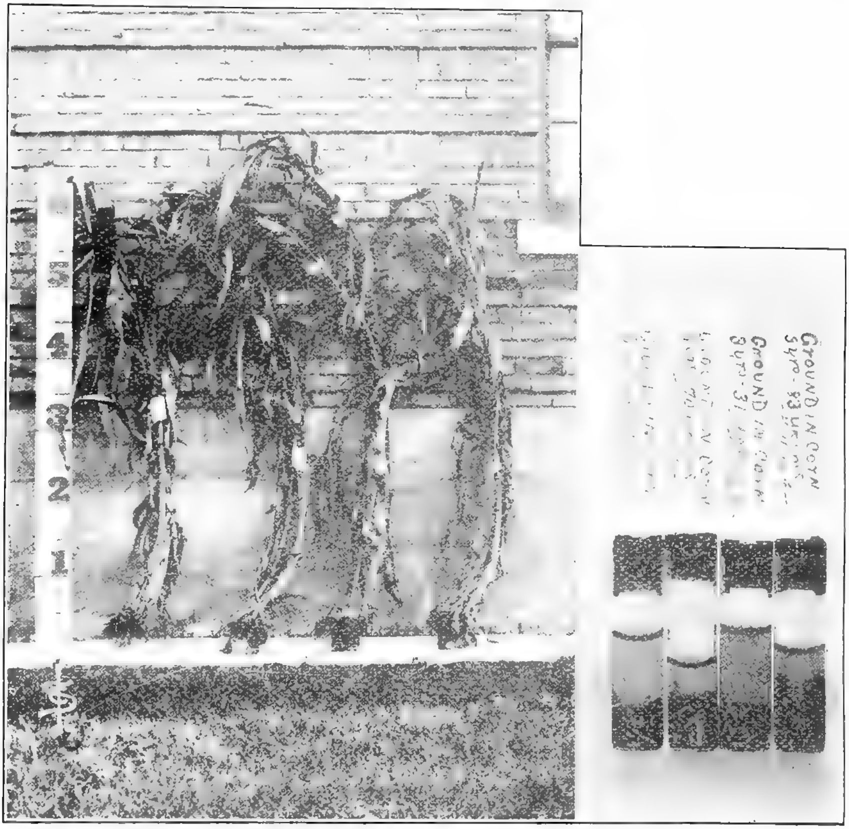
Note the extensive root development. There was one corn root worm. The ground was in clover the previous year.



FOUR HILLS FROM GROUND IN CORN FOR THE SECOND YEAR

Note a lighter root development. Twenty-four corn root worms were taken from the four hills.

The extensive development of the roots of these plants (page 240) is to be especially noted in contrast with those in the following illustrations, especially on pages 242 and 243. It is very uncommon to find

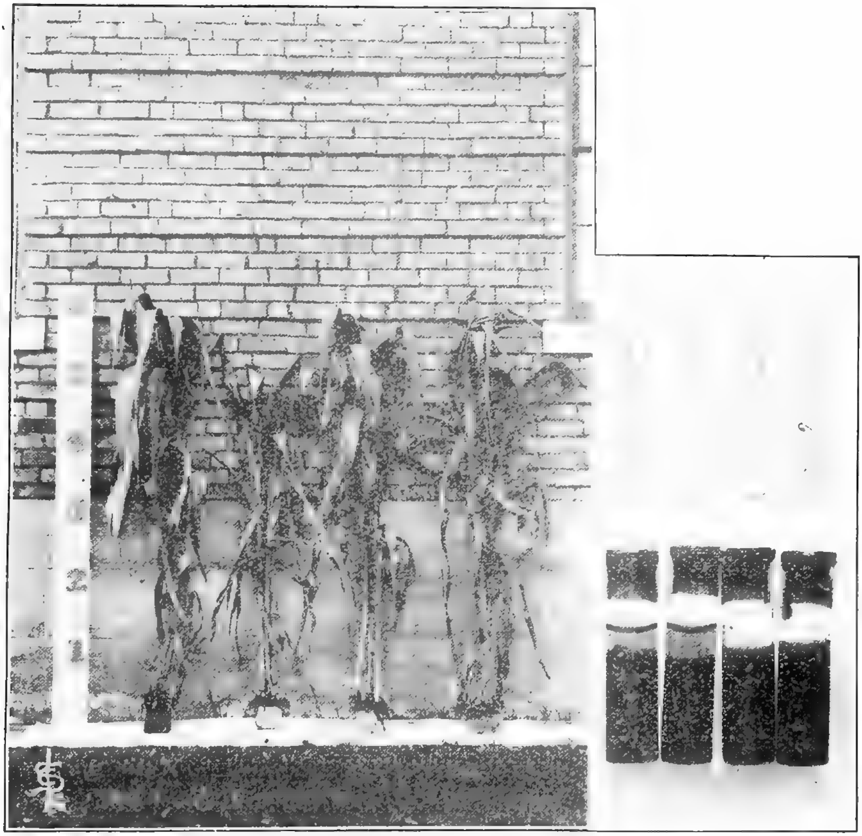


FOUR HILLS REPRESENTING GROUND IN CORN FOR THE THIRD YEAR.
Number of corn root worms in each hill, numbered from left to right, 65 70, 31 and 83 worms respectively.

corn-root worms in ground that is in corn for the first year. The one 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.

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 root system is being very noticeably and seriously reduced.

On page 246 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



FOUR HILLS REPRESENTING GROUND IN CORN 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.

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.

Cuts on pages 245 and 246 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 preceding pages.

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.

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.

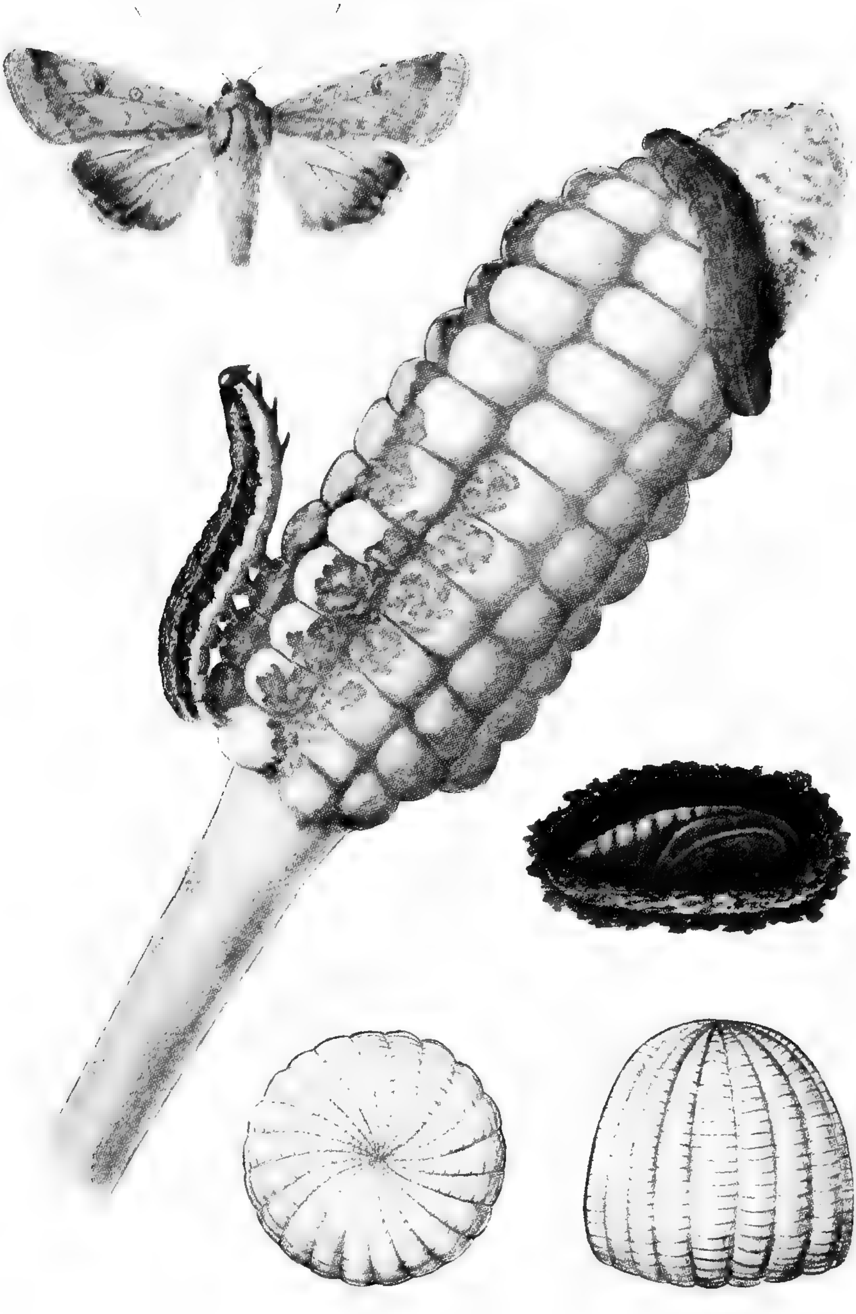
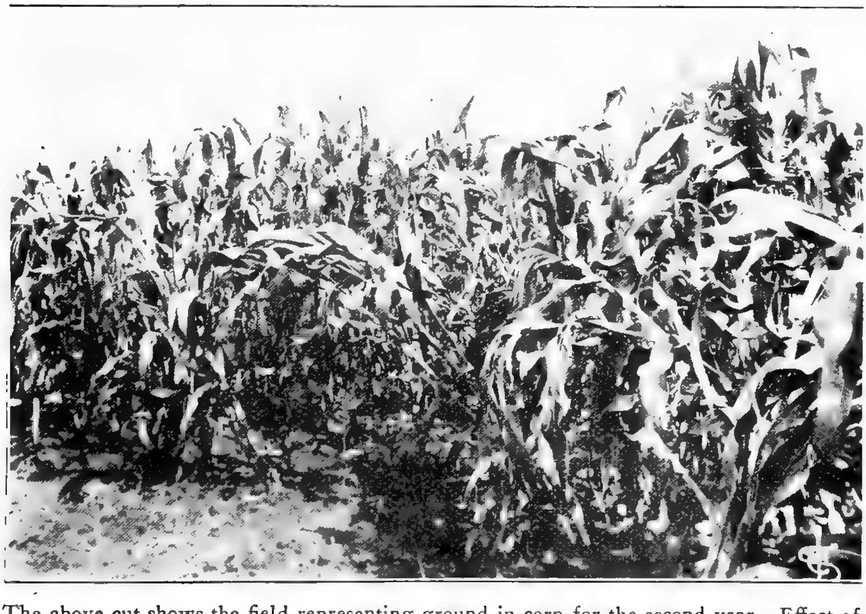


PLATE IX.

The Corn Worm: light and dark individuals, pupa, moth, and egg, with Injured ear of corn.

COURTESY OF PROFESSOR S. A. FORBES, ILLINOIS STATE ENTOMOLOGIST

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.)



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.

The above cut shows the field representing ground in corn for the third year.

The above cut shows the field representing ground in corn for the fourth year.
(Ground in alfalfa five years before.)

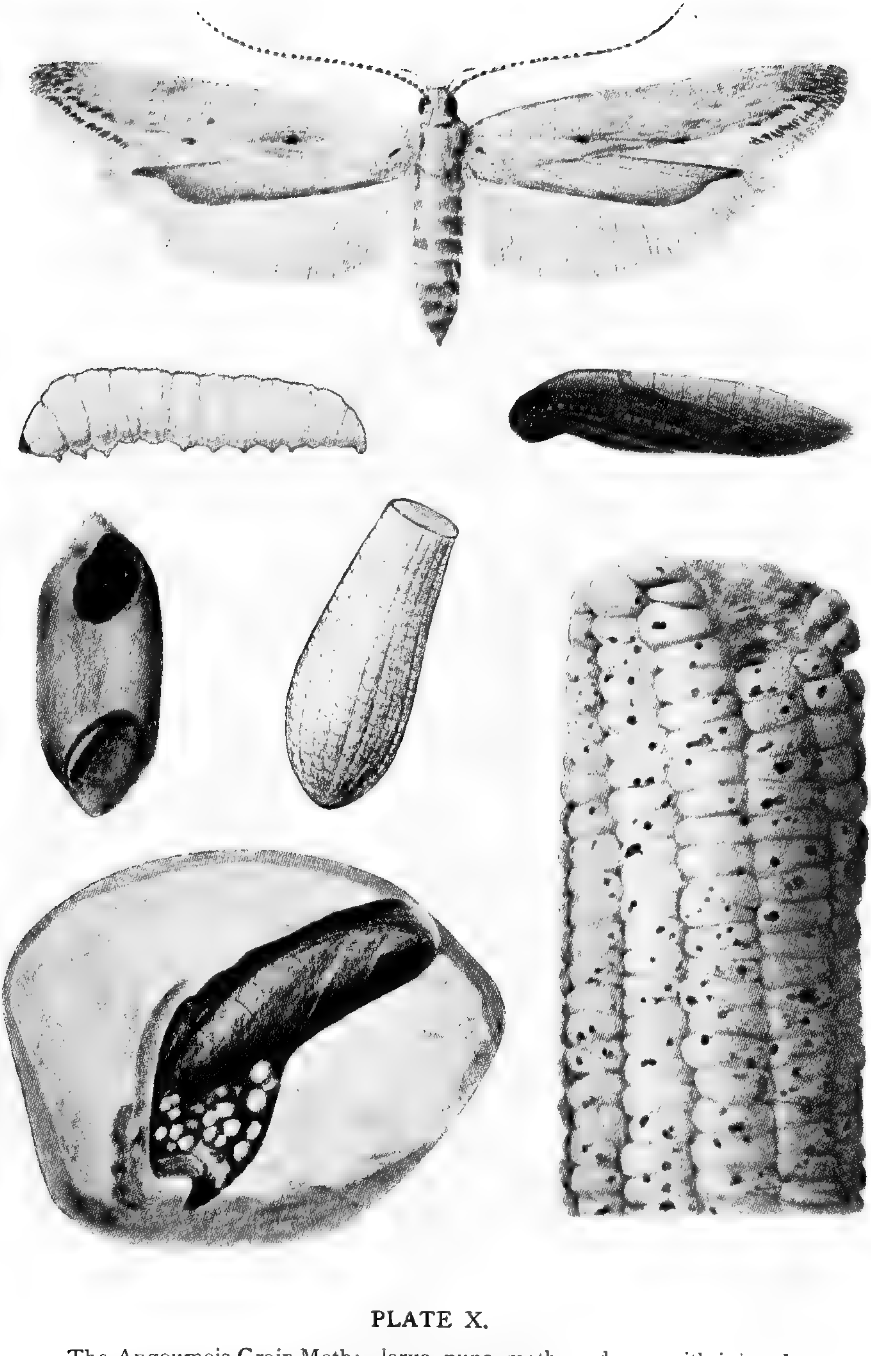


PLATE X.

The Angoumois Grain Moth: larva, pupa, moth, and egg, with injured kernel and ear of corn.

COURTESY OF PROFESSOR S. A. FORBES, ILLINOIS STATE ENTOMOLOGIST

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 *(Acrididae).* 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.

*"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."

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.

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, after passing through six moults. Then they pupate. Three generations go through this cycle in one season. The larvae of the

*Page 395 of Bulletin 95 of Illinois.

first generation live chiefly on the 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. The Kentucky Experiment Station has conducted experiments with poisons in combating the ear worm, but the result of their work does not justify the use of such a treatment.

INSECTS INJURIOUS TO STORED CORN

THE ANGUMOIS GRAIN MOTH *(Sitotroga cerealella).* 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, 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.

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

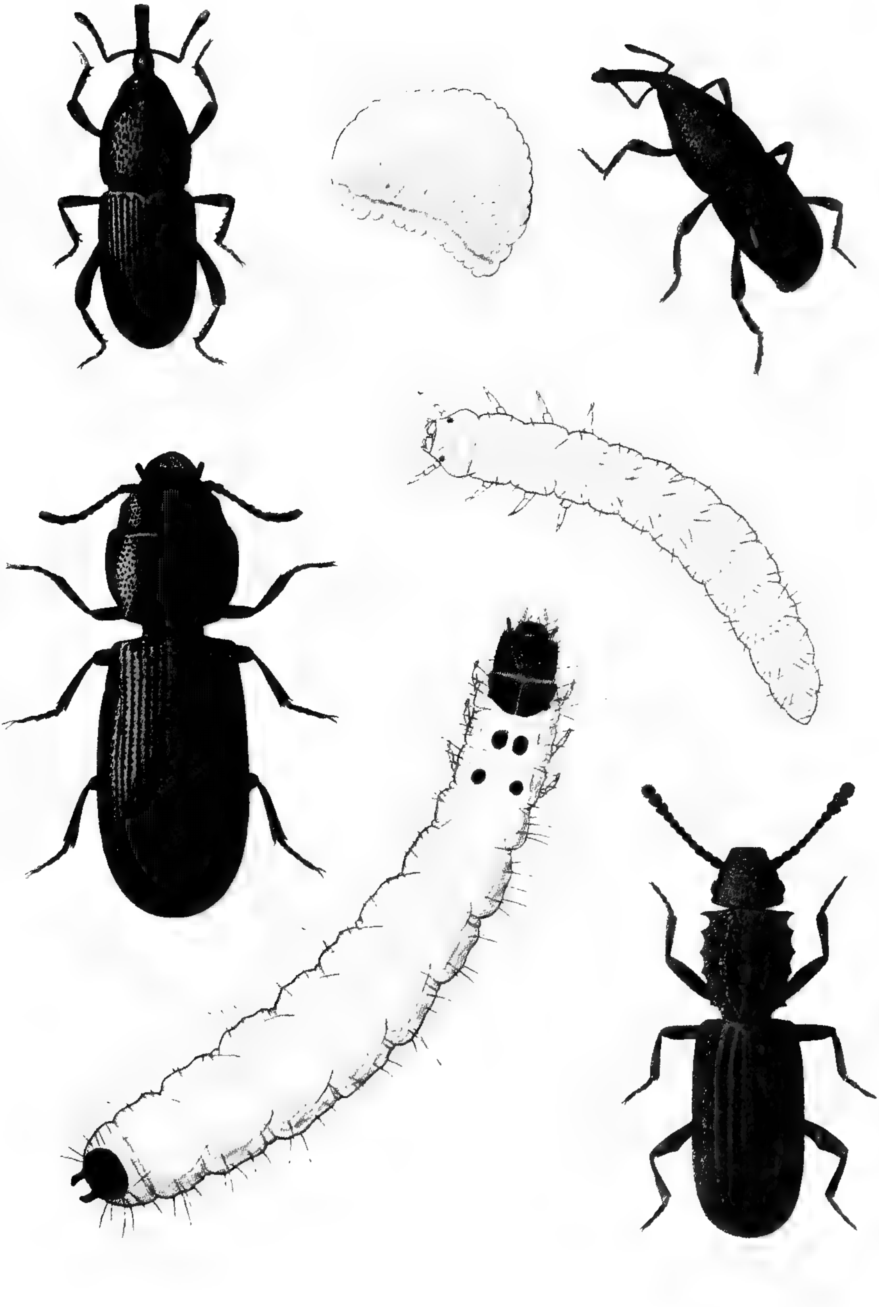


PLATE XI.

The common grain Weevils and larvæ.

from time to time. Grain which has been fumigated is not injurious for feeding or seeding purposes.

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.

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.
Iowa Circular No. 21.
Illinois Bulletin No. 133.

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 a 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.

On the other hand, the commercial market has quoted corn at such high figures for the past few 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.

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 however.

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

*18.2 per cent shrinkage 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

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 1914 (2,672,804,000 bushels), nearly 20 per cent (498,285,000 bushels) was shipped out of the county where grown. 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 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 criticized, considered from the standpoint of permanent maintenance of agricultural prosperity.

SHIPMENT OF CORN OUT OF COUNTY WHERE GROWN

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 1914, inclusive:

TABLE NO. 54

CORN SHIPPED OUT OF COUNTY WHERE GROWN—1900-1914 INCLUSIVE.

1900	22.7 per cent	1908	21.3 per cent
1901*	10.0 per cent	1909	24.9 per cent
1902	22.1 per cent	1910	22.9 per cent
1903	18.7 per cent	1911	20.4 per cent
1904	22.3 per cent	1912	21.8 per cent
1905	25.0 per cent	1913	17.2 per cent
1906	23.2 per cent	1914	18.7 per cent
1907	18.0 per cent		

*Very dry year.

The following table shows the average per cent of corn shipped out of the county where grown for a ten-year period.

TABLE NO. 55

SHOWING PER CENT OF CORN CROP SHIPPED OUT OF COUNTIES WHERE GROWN, BY STATES

State	10-year Average	State	10-year Average
Maine	0	Missouri	12
New Hampshire	0	North Dakota	2
Vermont	0	South Dakota	26
Massachusetts	1	Nebraska	37
Rhode Island	1	Kansas	22
		Kentucky	11
Connecticut	1		
New York	2	Tennessee	16
New Jersey	15	Alabama	3
Pennsylvania	6	Mississippi	3
Delaware	38	Louisiana	6
		Texas	9
Maryland	29		
Virginia	10	Oklahoma	23
West Virginia	5	Arkansas	4
North Carolina	4	Montana	2
South Carolina	3	Wyoming	0
		Colorado	9
Georgia	3		
Florida	3	New Mexico	5
Ohio	24	Arizona	5
Indiana	32	Utah	3
Illinois	45	Nevada	0
Michigan	6	Idaho	2
Wisconsin	3	Washington	4
Minnesota	14	Oregon	2
Iowa	24	California	19
United States	21.9		

TABLE NO. 56

PERCENTAGE OF CORN IN THE HANDS OF FARMERS

March 1, 1901 to 1915, inclusive

1901	36.9 per cent	1908	37.1 per cent
1902	29.1 per cent	1909	39.3 per cent
1903	41.6 per cent	1910	38.3 per cent
1904	37.4 per cent	1911	40.4 per cent
1905	38.7 per cent	1912	34.9 per cent
1906	40.9 per cent	1913	41.3 per cent
1907	44.3 per cent	1914	35.4 per cent
		1915	34.1 per cent

It is seen that in Illinois and South Dakota the greatest movement of the corn crop occurs. The average for the entire United States was 21.9 per cent.

The United States Department of Agriculture has made inquiries concerning the shipment of corn out of counties where grown for the past thirty years. They report that there has been a gradual increase in the portion of the corn crop so handled. Considering the past three decades it is stated that in the eighties 16.9 per cent of the corn crop was shipped out of the counties where grown; in the nineties 19.2 per cent; and in the last decade 21.9 per cent of the crop.

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.

A primary market is defined as the first nearby market to which grain can be shipped and which serves as the first market to which grain can come. This does not properly include the country town elevators which first receive the grain from the surrounding territory. In the annual report of the Chicago Board of Trade, the following are given as "primary markets": Chicago, Milwaukee, Minneapolis, Duluth, St. Louis, Toledo, Detroit, Kansas City, Peoria, Omaha, Cincinnati and Indianapolis. Grain is inspected at these points. Several of these markets are also terminal markets.

A terminal market is one which serves as a transfer point for grain which has been received and inspected previously in a primary market. In the Price Current Grain Reporter, a large number of the principal cities are included in the list of terminal markets. Boston is clearly a terminal market because New England shippers send no grain to Boston for inspection. However, Boston is also considered a terminal-export market, for considerable grain is exported from that point. Since very little corn from this country is exported, we are more especially concerned with the initial, primary and terminal markets.

Grain Elevators. Considering first the small shipping points it was estimated in June, 1914* that there were 16,033 regular grain elevators in the United States. Of this number 6,459 were operated by line companies, 2,033 were operated by farmers and 7,505 by independent companies.

*Grain Dealer's Journal.

Other states than those given below do not operate extensively through grain elevators. They handle grain in bags, warehouses and cribs.

TABLE NO. 57

DISTRIBUTION OF GRAIN ELEVATORS

	Line Companies Elevators	Farmers	Independents
Indiana	299	53	763
Illinois	522	269	1400
Iowa	452	337	969
Kansas	417	146	773
Ohio	206	41	842
Missouri	130	10	503
Wisconsin	273	38	499
Michigan	224	25	445
Minnesota	1040	304	326
North Dakota	1264	390	310
South Dakota	651	201	350
Montana	167	55	79
Nebraska	850	164	246
	6495	2033	7505

COST OF HANDLING GRAIN THROUGH ELEVATORS.

An accurate account of the cost of handling grain through a modern elevator is given by Mr. G. J. Railsback of Ashland, Nebraska, in the Price Current Grain Reporter, April 7, 1915. This shows the average yearly expense taken from a seven-year record.

TABLE NO. 58

SHOWING COST OF HANDLING GRAIN THROUGH ELEVATORS.

	Bushels	Average Yearly Value	Purchases Bushels	Average Shrinkage Cost
Corn	96,743	$50,949.00	619	$327.72
Oats	4,171	1,432.00	33	12.80
Wheat	36,932	31,121.00	437	380.13
Total	$137,846	$83,502.00	1,089	$720.65

Table continued next page.

TABLE NO. 58—Continued
AVERAGE YEARLY EXPENSE

Salary and incidental expense	$1,157.70
General expense	432.16
Tax	64.45
Insurance	60.00
Shrinkage, average 1,089 bushels	720.65
1-12 of average paid grain, $6,958 at 6%	417.51
Interest on investment, elevator, at 6%	480.00
Total	$3,332.47

Cost of handling 137,846 bushels of grain, $3,332.47 or 2.4c per bushel. At another elevator owned by the same people the average cost was 2.57 cents per bushel for handling the grain.

In Grain Dealers Journal dated August 25, 1914, Mr. H. C. Roberts, manager of the Farmer's Elevator Co., Illiopolis, Ill., estimates the cost of handling grain at 2.89 cents per bushel. Mr. E. B. Conover, manager of a grain company at Springfield, Ill., in an itemized statement gives the cost at 4.65 cents per bushel. The average cost of handling grain may be roughly estimated at about three cents per bushel.

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.

(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.

(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. A line elevator system consists of country elevators at various stations frequently along one railroad line. The number of elevators owned by a single company has been known to be as great as six hundred.

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.

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.

Independent Elevators. Independent elevators are individuals, partnerships or corporations owning one or at most only a few elevators. The growth of the independent or private elevator company has been marked within recent 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.

***Farmers' Co-operative Elevators.** A farmers' co-operative elevator means a corporation made up of stockholders who are chiefly farmers. 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.

*Account taken from American Co-operative Journal, on History of the Farmers' Elevator.

The origin and growth of the farmers' elevator movement represents one of the most hotly contested battles of modern grain marketing. It has withstood triumphantly and today is a great factor in the marketing of the annual corn crop.

Back in the early eighties and previous to that time a growing dissatisfaction was fomented among the grain producers on account of the apparent depression of prices, frequent "short weights" in selling and shipping, "leakage" and "shrinkage" in transportation and dishonest treatment on the part of some grain buyers. At that time the "line elevators" held practically a monopoly on the grain trade. Then it was that "scoopers" originated. A scooper was a grain buyer who went from place to place buying and shipping grain. He did not have an elevator, but had the grain scooped into the cars from the farmer's wagons.

About this same time a large syndicate arose which was headed by large exporters and commission firms with capital. Other syndicates followed. These operated along the various railroad lines. The "scoopers" were then forced out of business. In many cases it was discovered that members of these grain buying syndicates were also stockholders of the railroads, and were owners of large storage warehouses. They were able to dictate prices. Besides this they became favored shippers through their influence with the railroad companies; and by owning their warehouses in addition to doing their own buying and selling through the Exchanges, they could influence practically every department of marketing.

At this same time independent elevators were increasing in number. However these were very largely dominated by the syndicates. Those who refused to be controlled by the syndicate were soon forced out of business.

Grain Dealers' Associations represent the next step in the history of grain buying. These associations brought about many improvements in the marketing of grain but in many cases they increased the suspicion on the part of the producer that prices were being "fixed".

Out of the discontent which was growing among the farmers, attempts were made to ship grain directly to the principal markets. This proved impracticable on account of the failure to get cars from the railroads. The only escape seemed to be through organization, so late in the eighties we find records of the Farmers' Elevators.

The first Farmers' Elevator to be organized in Iowa was at Rockwell in 1899. Up to that time such organizations had not proved very successful. One of the first difficulties was to secure elevator sites from the railroad companies. Then, trouble was found in securing cars and equable shipping rates. For several years it was almost impossible to induce commission merchants in the central markets to handle their grain. The Farmers' Elevators were practically boycotted. Until the penalty clause was inserted in the by-laws of the organization, progress was very slow. The penalty clause simply provided that in case the farmers of the organization sold corn to other elevators they should pay a certain amount to their own elevator. This was for the purpose of protection against some of the methods which had been employed by other grain dealers to cripple the Farmers' Elevator. The fact that the organization has endured against all adversities is the best proof of its value to the producer.

In recent years the movement has become of such strength as to win the solicitation and support of a large number of the commission firms. State and National organizations are being formed. It might be added that a growing harmony is being felt among all grain dealers. The growth is best shown in the following table.

TABLE NO. 59

SHOWING THE NUMBER OF FARMERS' ELEVATORS IN DIFFERENT STATES—1903-1913.

State	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Illinois	15	90	125	125	150	170	170	225	300	300	300
Iowa	7	30	78	175	200	209	250	300	324	347	347
Minnesota				150	168	178	205	224	240	277	307
N. Dakota				85	85	85	85	85	300	300	350
S. Dakota				100	100	100	150	200	200	220	220
Nebraska						140	160	200	200	200	200
Kansas											32
	22	120	203	635	703	882	1020	1234	1564	1644	1756

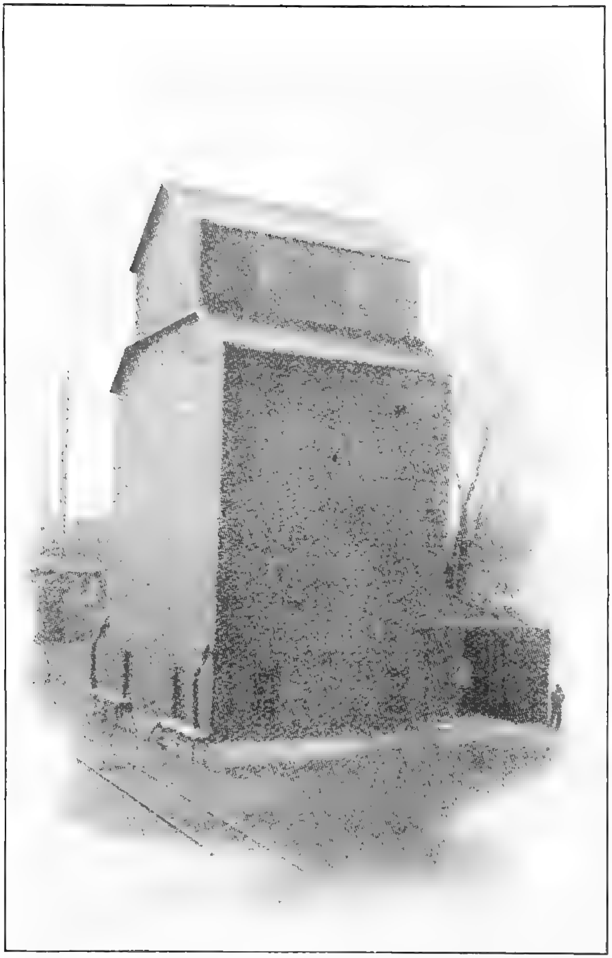
Farmers' Elevator—How Organized. Organized under the laws of their respective states the corporations elect the usual officials, namely, president, vice president, secretary, treasurer, and board of directors, varying in number but usually consisting of from five to nine men.

The capital of the company is ordinarily about $10,000. Shares of stock are issued and sold. The par value of a share is usually $25.00, or $50.00. The number of shares which may be issued to one person is frequently limited, so that the total investment of any one individual may not be more than $200 or $500, varying in different companies. Frequently each share owned by a stockholder entitles him to one vote at a meeting of stockholders, but the number of votes that may be cast by any individual is usually limited regardless of the number of shares he may possess. In some companies the transfer of stock is subject to the approval of the board of directors.

In distributing the profits several plans are followed. In some cases the profits are divided among the stockholders according to the amount of stock held. In some states the companies are permitted by law to distribute profits on the co-operative basis. A definite return is granted to each stockholder which is merely interest on the capital invested. This rate of interest is determined by law. The profits are then distributed among the stockholders according to the amount of business each has done with the company. This may be according to the number of bushels of grain each has sold to the elevator.

The penalty clause already referred to provides that any stockholder in the Farmers' Elevator Company who sells grain to another elevator shall pay a certain amount to his own elevator (usually from 1-2 to 1 cent per bushel). From eighty to ninety per cent of the companies have this clause included in their by-laws. In some cases the legality of this clause has been questioned and others feel that it is no longer necessary, although it is felt that without this provision in the past the movement would have been greatly crippled.

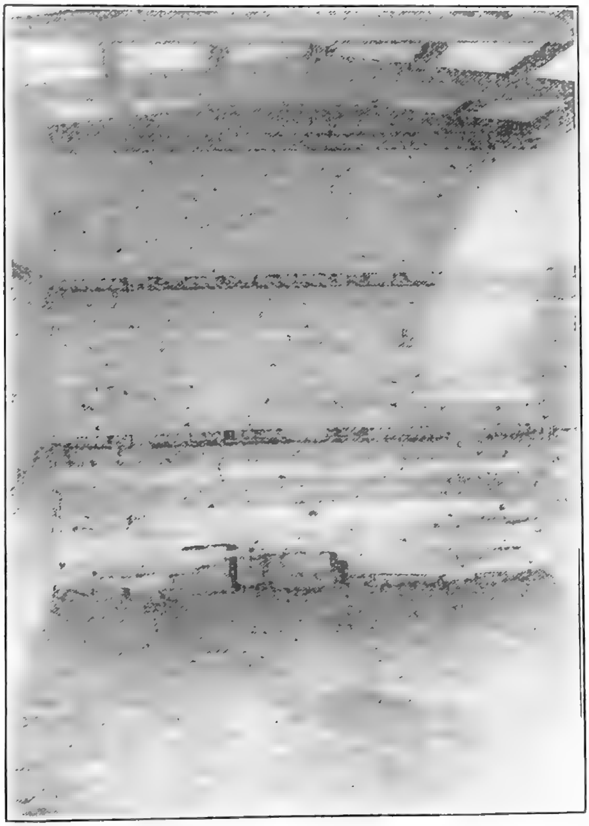
Representatives of local cooperative organizations can be as well posted each day as managers of the "line elevators." Market quotations by wire are received from all of the leading distributing and storing points. No knowledge, however, of the movement of grain enroute to market can be ascertained. 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.



SMALL COUNTRY ELEVATOR

Corn Enroute to Market. At a certain time of year, 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



CAR BEFORE IT HAS BEEN PROPERLY LINED FOR GRAIN provided, the farmers would be compelled to pay high storage charges, 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.

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.

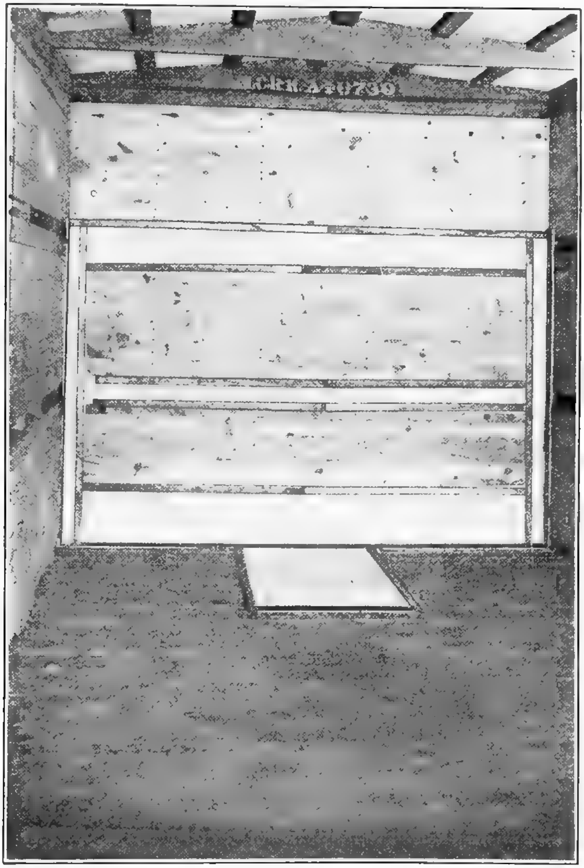
The points to be inspected in a car, arranged in order of their greatest important, as determined by leakage statistics, are as follows: lows:

(1) The grain doors;
(2) The sheathings;
(3) Door posts and end posts;
(4) End doors and windows;
(5) Linings;
(6) Floors.

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, 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.



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 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.

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.

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."

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.

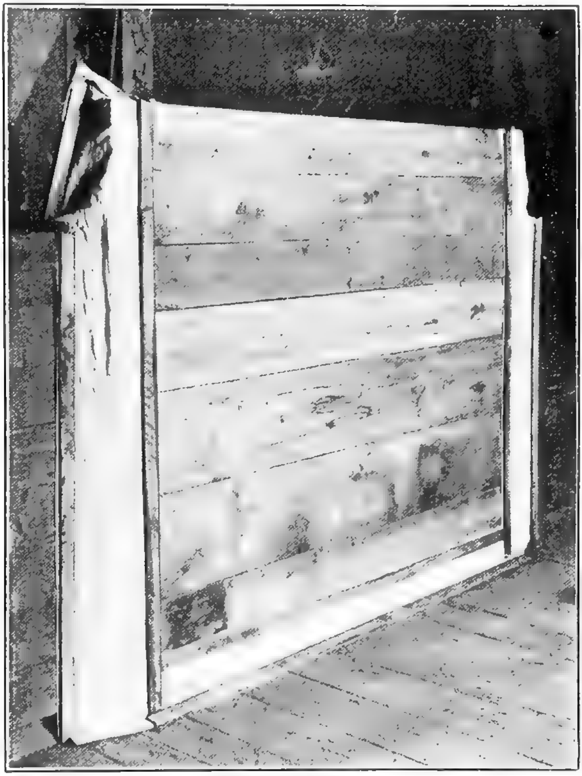
In addition to the above, special attention is directed to the floors, more particularly when small grains such as flaxseed, rye and wheat are to be loaded.

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.

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.



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.

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.

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

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.

"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.

"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.

"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."

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.

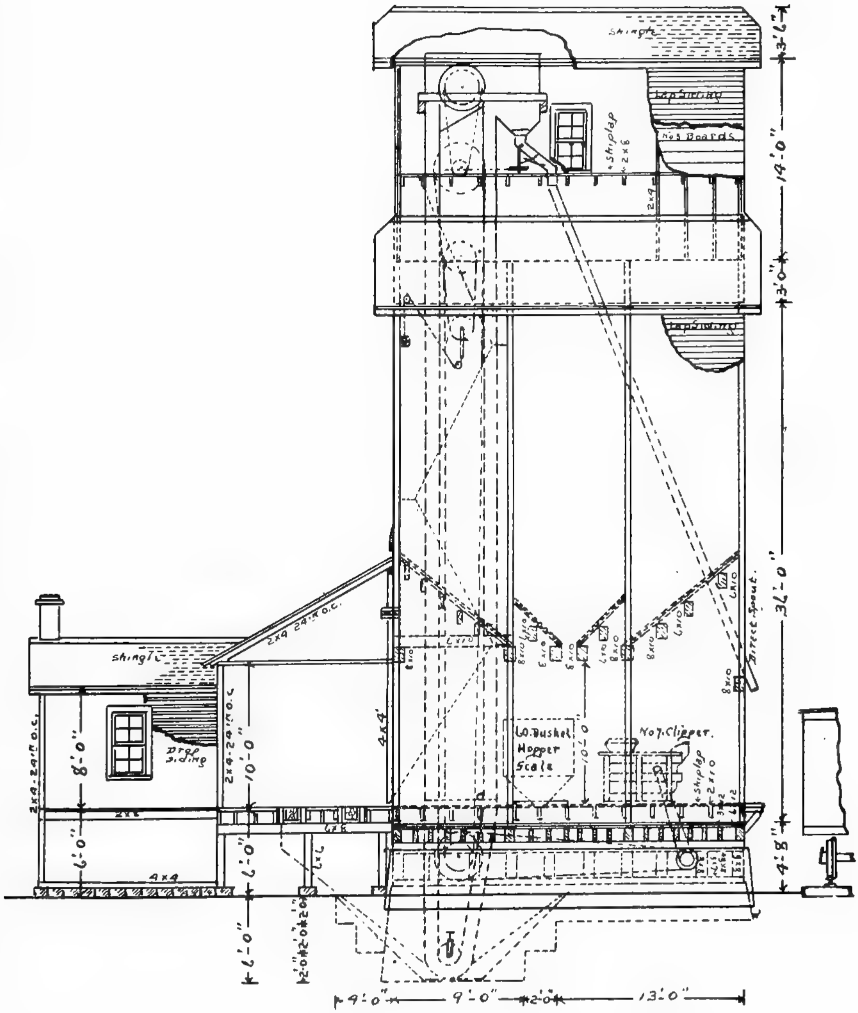
"The mere statement of 'leaky roof' by some one at a destination is not sufficient, by any means," writes Mr. A. Kirkland, Claim Agent for the Illinois Central Railroad. "We should have more than this, and furthermore, inspectors or others should call the attention of the railroad company at destination 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."

STOPPING LEAKAGE ON THE SIDE OF A GRAIN CAR

TERMINAL MARKETS.

Strictly terminal markets are points of 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. Many of the so-called terminal markets are also primary markets where grain is inspected.



DESIGN OF RIGHT ELEVATION OF SMALL COUNTRY ELEVATOR.

Follow the course of the grain from its delivery from the wagon until loaded into car.

Approximately one-half billion bushels of corn was shipped out of the county where grown in the United States in 1914. Of this amount one-half was handled through the principal markets, and it will be of interest to note that Chicago alone received nearly as much as all of the other markets combined. The greatest daily receipt of corn recorded for the Chicago market was 2,055,000 bushels, February 13, 1913.

TABLE NO. 60*

SHOWING RECEIPT OF CORN AT PRINCIPAL MARKETS—1914

Chicago	106,600,000	bushels
Minneapolis	12,260,999	bushels
Duluth	1,377,000	bushels
St. Louis	17,106,000	bushels
Milwaukee	18,338,000	bushels
Kansas City	23,173,000	bushels
Omaha	30,005,000	bushels
Peoria	14,520,000	bushels
Toledo	4,310,000	bushels
Detroit	3,349,000	bushels
Total	231,038,000	bushels

The following table will give some idea of the movement of the corn crop by months, in 1914. This shows the receipts and shipments of corn for the Chicago market alone.

TABLE NO. 61*

SHOWING RECEIPT AND SHIPMENT OF CORN BY MONTHS FOR THE CHICAGO MARKET—1914

	Received—Bushels	Shipped—Bushels
January	8,774,000	4,773,000
February	8,401,000	3,327,000
March	7,644,000	4,249,000
April	2,139,000	6,705,000
May	2,492,000	4,423,000
June	9,741,000	6,727,000
July	5,131,000	4,188,000
August	9,925,000	6,132,000
September	8,146,000	5,794,000
October	5,914,000	3,706,000
November	12,458,000	6,001,000
December	25,835,000	9,234,000
Totals	106,600,000	65,259,000

*Annual Report of Chicago Board of Trade.

During the year 1914, over sixty per cent of the corn received in Chicago was shipped out again. Mr. J. C. F. Merrill of the Chicago Board of Trade states that the Corn Products Refining Company alone uses approximately 100,000 bushels of corn daily, besides other large milling concerns use enormous quantities.

In 1914 the principal markets including Chicago, Milwaukee, Minneapolis, Duluth, St. Louis, Toledo, Detroit, Kansas City, Peoria, Omaha, Cincinnati and Indianapolis, received 244,383,000 bushels of corn and shipped out 161,450,000 bushels. Most of the corn reshipped from the above markets was of course used in other cities, and the balance exported.

Corn Values. The following table exhibits the highest and lowest prices for Contract Corn (Spot) at Chicago during each month.

TABLE NO. 62*
SHOWING HIGHEST AND LOWEST PRICES FOR CORN
1905 to 1914 inclusive. (Ten-year average.)

	Price per bushel Lowest	Highest
January	51.9	55.3
February	52.4	55.3
March	53.5	58.2
April	56.0	61.1
May	59.2	66.2
June	60.2	64.9
July	61.0	67.1
August	63.7	69.9
September	62.8	69.0
October	58.9	65.4
November	56.9	63.0
December	54.0	60.5
Entire Year	57.5	63.0

Between the highest and lowest average annual prices for the past decade there was a range of 5.5 cents per bushel. From May until October inclusive we find prices above the average, and November to April shows the prices below the average. During the ten years the August prices were the highest.

Taking an average of the thirty-five years previous to the past decade we find practically the same range between the highest and lowest average prices. (5.8 cents.) For the same period the market of August, September and October was the highest.

*Annual Report of Chicago Board of Trade.

In the ten year record given above the lowest average price (51.9 cents) was recorded in January, and the highest average price (69.9 cents) was reached in August. The average range then between the highest and lowest prices for the year was 18 cents per bushel.

A study of the markets for the past fifty years shows that during the months of December, January and February the lowest market price for corn was recorded forty-two times, and the highest market price was recorded only eight times. For the months of March, April and May the lowest market price was recorded three times and the highest price fifteen times. For the months of June, July and August the lowest market price was recorded once and the highest market price thirteen times. For September, October and November the lowest market price was recorded four times and the highest market price fourteen times. See following table.

TABLE NO. 63

SHOWING TIME OF HIGH AND LOW PRICES FOR CORN (Fifty-year average)

Month	Number of times recorded Lowest price	Highest Price
January	16	4
February	8	0
March	2	1
April	1	2
May	0	12
June	1	2
July	0	4
August	0	7
September	1	2
October	3	4
Nevember	0	8
December	18	4

It is of more than passing interest to note that during the average year approximately forty-five per cent of the corn received at the large markets arrives there during the months of December, January and February.

GRAIN INSPECTION

History of Grain Inspection.* Illinois was the first state in the union to provide by law, rules and regulations for the inspection of grain and for registration of warehouse receipts for grain under state supervision.

*Taken from "The Book of The Board of Trade," 1910.

The earliest record of any attempt at the inspection of grain in the west, if not in the entire country, was in Chicago, in 1848. Previous to that time all transactions were made from samples shown or grain as offered from farmers' wagons. In 1854 the volume of grain having very largely increased, the old manner of measuring by the half bushel became too slow and uncertain, and agitation resulted in a change to the present system of weighing grain, by which a stated number of pounds represents a bushel of each of the different kinds.

The foundation of the present system of inspection was laid by the Chicago Board of Trade in 1858, and this system has since been adopted, substantially in the same form, throughout the country where grain is inspected at all, and its influence is now felt in the grain trade all over the world.

In 1871 the state, through its General Assembly, enacted a law creating a Board of Railroad and Warehouse Commissioners and provided further for the classification and supervision of elevators and warehouses; and for the appointment of a chief grain inspector and a registrar of grain for the City of Chicago, together with the necessary corps of assistants to each. In compliance with this law, the inspection of grain in Illinois has since been under the jurisdiction of the state.

All grain was first inspected in the cars. A large force of men was necessarily employed for this work in such a market as Chicago. Each man stood alone. Dissatisfaction grew out of this method on account of a lack of uniformity in grading.

The change of inspection was initiated by Mr. J. C. F. Merrill, Secretary of the Chicago Board of Trade. A committee of three competent judges was first provided to pass on all grain on which the inspector's grade was doubtful.

Room inspection originated in Minneapolis and Duluth. During the cold winter months, when a large per cent of the corn crop reached the primary and terminal markets, and during stormy weather, conditions were not very favorable for accurate grading in the cars on track. None of the official grading is now done at the car.

All grading and inspection is now done by government officials, or by those appointed by the Board of Trade, Chamber of Commerce, or Railroad and Warehouse Commissioners. In many states, federal inspection is already effective.

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.

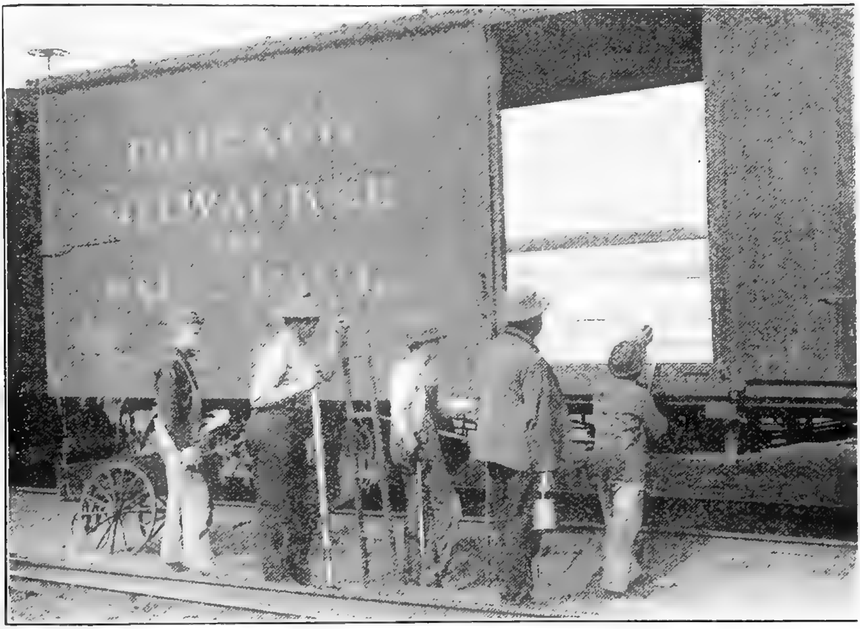
In Chicago a deputy inspector with from two to four helpers is required for each of fourteen principal railroads. They begin work early each morning. During the months of heaviest shipments of grain, these men must be at work by daylight. The deputy inspector gets the shipping bills first from the freight office, giving number and description of the cars to be inspected.

BREAKING THE SEAL

A deputy grain inspector is standing in the foreground; 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 State Inspection Headquarters.

One man goes ahead and first examines each car to be inspected for leakage or stealage due to damaged car or broken seal. This record with a complete description of the car is preserved for evidence in case of recovering damages. Then after getting the seal record of a car, he opens it and tacks on the door what is known as an "Inspector's Ticket."

This ticket is tacked on the car for the inspector to make his record. It is perforated across the middle so the inspector can tear off the bottom half for his own record, giving initials of consignee, contents of car and car number. The part of the ticket left on the car gives the name of the railroad on whose tracks the car stands, and date of inspection. This remains on the car until it is loaded and is the authority of the elevator superintendent for unloading the car.



THE INSPECTOR'S TAG IS NOW PUT ON THE CAR

With the inspector there are probably two helpers who get the samples of grain from the cars. They go ahead and carefully sample each car with a "tryer." (A "Tryer" is a hollow steel or brass tube about two inches in diameter and four feet long, with spaces four inches long and an inch and a half wide, the full length of the tryer, with a closed space between these open spaces of two and three quarter inches. This tube is fitted with a wooden plunger that fits closely inside the tube.) The tryer is pushed down to the bottom of the car and then plunger taken out. The tube readily fills, thus getting a sample of all of the grain from the bottom to the top of the load.

THE EXTRA BOARDS ARE BEING REMOVED

Several "tryerfuls" are taken in this way to ascertain the uniformity of the grain in the car. If there is any variation between the different parts of the car more than one sample may be taken and the extent of the mixture will be recorded. Each sample contains about two quarts and is placed in a heavy cloth bag. If the car is of uniform grade throughout only one sample is required. This sample, however, is made up from a part of each "tryerful" of grain taken. It is hung on the car door fastener for the inspector who follows closely. In case a car is too full to use the tryer, it is reported "subject to inspection" and sold as such. The inspector fills out the inspection ticket, giving car number, initials, kind of grain, railroad, consignee, date and his own name with any remarks which he wishes to make. This ticket is quickly filled out and placed in the sample bag.

One man follows the inspector and gathers up the samples to be taken into the inspection office. Another man re-seals the car and again records the seal. The purpose of this is to furnish evidence in case a seal is broken or changed before the car is unloaded.

A SAMPLE OF GRAIN IS COLLECTED

The car number and the grade is marked on the tags to be placed in the sack. These are to be representative samples. They are taken to the State Inspection Headquarters and used in selling the grain on the cash market.

As soon as all of the cars have been inspected the men return with the samples, packed in wheel baskets, to the Illinois State Grain Inspection Department. First they go to the room where the moisture test is made. During the busy season, a large force of testers are required. They have already installed over one hundred moisture testing outfits. After the test is completed the moisture percentage is recorded on the inspector's ticket, which is placed back in the sack and taken with the sample into the grading room.

AFTER THE CAR HAS BEEN SAMPLED
IT IS AGAIN SEALED

In the grading room the official graders inspect the samples for color, condition, per cent of damaged grain and per cent of dirt and foreign material. The sack is first emptied into a special pan. Color and condition can be quickly determined by expert judgment. A special set of sieves are at hand for use in determining the amount of cracked corn, dirt and foreign material. The data is recorded on the inspector's ticket in the sack.

The sample is then "split". This is done at a special table. A part of each sample is taken out of the cloth bag and placed in a paper sack on the outside of which is recorded a complete description of the grain, including car number, kind of grain, grade, initials of consignee, railroad, date inspected and moisture content. This sample is then ready to be sent across the street to the Board of Trade Building for the day's trade. The remainder of the sample in the original cloth bag with the inspector's ticket still enclosed is hung in an adjoining room

MAKING MOISTURE TEST. (Brown-Duvel Method)

Samples from cars on table in foreground. These men are seen weighing out sample, placing sample in flask, reading and recording tests. (Picture taken by Robert H. Moulton.)

on a numbered hook. This hook number is recorded in order that the sample may be relocated promptly if wanted. Occasionally a second inspection is ordered. This must be done within twenty-four hours however, for after that time the sample is emptied and only the inspector's ticket preserved.

In case of reinspection, if no error is found in the first inspection, the original grade is maintained. In case of error the grade is altered and the change reported to the consignee. Should the consignee still be dissatisfied, under the rules governing the inspection department, he has a right to appeal to what is known as the "Appeals Committee." Their decision is final and cannot be appealed further. The Committee of Appeals consists of three discreet and competent persons to hold office one year and must be appointed by the Board of Railroad and Warehouse Commissioners.

THE MAIN INSPECTION ROOM. (Illinois Inspection Department)

Grading grain. Samples have been received from the moisture-test room adjoining. They are being examined for damaged grain, color, condition, dirt and foreign matter, etc. Note sample pans, scales, etc. The man at the desk to the left is making a record of each car of grain, giving its full history from which certificate will be made by the Registrar. The record is copied from the inspector's ticket. (Picture taken by Robert H. Moulton.)

During the busy season approximately fifteen hundred cars of grain arrive at the Chicago yards daily. Indeed as many as 2,520 cars of grain have been recorded for a single day. These must be inspected, sampled, tested, graded and made ready for the day's market by 11:00 o'clock each morning. The samples in the paper sacks are assembled for each man to whom the cars of grain were consigned. These sacks are then taken across to the Board of Trade Building and placed on tables arranged on the floor close to the "pit" where buying and selling is done. Each commission firm rents a table, or part of one, usually a quarter or half, upon which to do business.

THE HOOK ROOM WHERE SAMPLES ARE HUNG AFTER BEING GRADED
(Illinois Inspection Department)
The samples are hung on numbered hooks and left here twenty-four hours, or until after the time has expired in which shipper or buyer may ask re-inspection. The sample is then dumped. (Picture taken by Robert H. Moulton.)

Grain Grades and Inspection.* The work of grain inspection in Chicago now requires more than a hundred men in the State Grain Inspection Department alone. Besides this the Board of Trade has a special inspection department.

The Chief Inspector of the State Department is appointed by the governor with the approval of the State Senate. It is required that he shall not be a member of the Board of Trade, or interested either directly or indirectly in any warehouse in the state. He must take oath and furnish bond in the penal sum of fifty thousand dollars. His term of office is two years.

The Chief Inspector, with the approval of the Board of Commissioners of Railroads and Warehouses, has authority to appoint deputy inspectors and assistants. All deputy inspectors are required to furnish bond, pass Civil Service examination, and be neither directly nor indirectly interested in any warehouse in the state, nor connected with the Board of Trade.

*Annual Report of Illinois Grain Inspection Department.

All persons employed in the inspection of grain are required to report promptly, in writing, to the Chief Inspector any attempt to defraud the system of grain inspection established by law, and all instances where warehouse owners shall deliver or attempt to deliver grain of a lower grade than that called for by the warehouse receipt.

GRADES FOR COMMERCIAL CORN.*

(By J. W. T. Duvel)

By virtue of the authority vested in the Secretary of Agriculture by the acts of Congress of June 30, 1906 (34 Stat., 669), and of March 4, 1913 (37 Stat., 828), to fix definite grades of grain, the grades for corn shown in Table 64 were fixed and promulgated on January 3, 1914, to take effect July 1, 1914.

TABLE NO. 64

GRADE CLASSIFICATION OF WHITE, YELLOW AND MIXED CORN, SHOWING MAXIMUM ALLOWANCES OF MOISTURE AND OTHER FACTORS.

	MAXIMUM ALLOWANCES OF			
Grade Classification	Moisture	Damaged corn	Foreign material, including dirt, cob, other grains, finely broken corn, etc.	"Cracked" corn, not including finely broken corn. (See general Rule No. 9.
	Per cent		Per cent.	Per cent.
No. 1	14.0	2 per cent (exclusive of heat damaged or mahogany kernels)	1	2
No. 2	15.5	4 per cent (exclusive of heat damaged or mahogany kernels)	1	3
No. 3	17.5	6 per cent (exclusive of heat damaged or mahogany kernels)	2	4
No. 4	19.5	8 per cent (may include heat damaged or mahogany kernels not to exceed one-half of one per cent)	2	4
No. 5	21.5	10 per cent (may include heat damaged or mahogany kernels not to exceed one per cent)	3	5
No. 6	23.0	15 per cent (may include heat damaged or mahogany kernels not to exceed three per cent)	5	7

Sample—See general rules No. 6 for sample grade.

*Farmers Bulletin No. 168

GENERAL RULES.

(1) The corn in grades No. 1 to No. 5, inclusive, must be sweet.

(2) White corn, all grades, shall be at least 98 per cent white.

(3) Yellow corn, all grades, shall be at least 95 per cent yellow.

(4) Mixed corn, all grades, shall include corn of various colors not coming within the limits for color as provided for under white and yellow corn.

(5) In addition to the various limits indicated, No. 6 corn may be musty, sour, and may also include that of inferior quality, such as immature and badly blistered corn.

(6) All corn that does not meet the requirements of either of the six numerical grades by reason of an excessive percentage of moisture, damaged kernels, foreign matter, or "cracked" corn, or corn that is hot, heat damaged, fire burnt, infested with live weevils, or otherwise of distinctly low quality shall be classed as sample grade.

(7) In No. 6 and sample grades, the reasons for so grading shall be stated on the inspector's certificate.

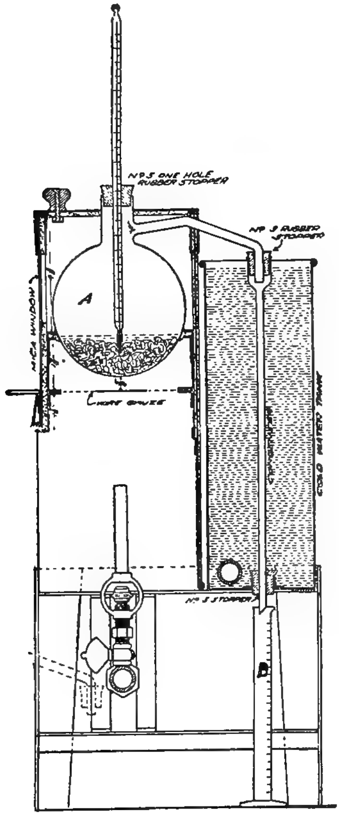
(8) Finely broken corn shall include all broken particles of corn that will pass through a metal sieve perforated with round holes nine sixty-fourths of an inch in diameter.

(9) "Cracked" corn shall include all coarsely broken pieces of kernels that will pass through a metal sieve perforated with round holes one-quarter of an inch in diameter, except that the finely broken corn, as provided for under rule No. 8, shall not be considered as "cracked" corn.

(10) It is understood that the damaged corn, the foreign material (including dirt, pieces of cob, finely broken corn, other grains, etc.) and the coarsely broken or "cracked" corn, as provided for under the various grades, shall be such as occur naturally in corn when handled under good commercial conditions.

(11) Moisture percentages, as provided for in these grade specifications, shall conform to results obtained by the standard method and tester.

Duvel Moisture Test. The moisture test is very simple, but requires painstaking accuracy. The apparatus consists essentially of a one-liter glass flask arranged above a gas burner; a thermometer which extends through the rubber stopper in the mouth of the flask (A), a glass tube also fitted through the rubber stopper into the flask and running through a metal condensing tank filled with cold water into a 25 c. c. glass graduate (B). As a rule this apparatus consists of a series of such flasks, burners, thermometers and graduates, so that a number of samples may be tested at the same time.



BROWN-DUVEL MOISTURE TESTER

Sectional view showing the various parts properly connected for use. Heating chamber and condensing tank in position.

Into each distillation flask place first 150 c. c. (cubic centimeters) of engine oil, which must have a high flash point. Weigh accurately 100 grams of thoroughly mixed grain and place in the flask, submerging it in the oil, insert the thermometer through the rubber stopper so that only the mercury bulb is immersed in the oil, then connect the flask with the condenser and 25 c. c. graduate by means of the glass tube which fits into the rubber stopper. Be sure that the graduate is dry inside.

When the flasks are filled apply the heat until a temperature of 190 degrees centigrade is reached (for corn). Heat gradually so that the required temperature is reached in approximately 20 minutes. Then remove the flame and allow the temperature to recede 15 degrees (or to 175 degrees). This will require about ten minutes more.

Since 100 grams of grain is used in the test and one cubic centimeter is equivalent to one gram, the percentage of moisture in the grain is read directly from the graduate (B). Thus if it reads 16 c. c. it is equivalent to 16 per cent moisture.

STANDARD GRADES OF CORN FOR THE FARMER.

One of the stock arguments against the standard grades of corn established is that the producer does not get full benefit. He must sell to the country elevator and accept the grade offered him. The country elevator superintendent on the other hand is not equipped to handle the multiplicity of grades now in operation. In a sense this is true. One man in a community with extra choice grain, but not having enough to warrant separate shipment or separate storage is at a disadvantage. He always has been. He always will be until his neighbors begin taking the same interest in producing and marketing a choice grade of grain. A much higher percentage of the farmers are producing a better quality of grain than formerly. These farmers naturally feel that the elevator buying their grain should be equipped both for determining the grade and with storage capacity for handling it separately. Thus the grain would be bought on its merit and the farmers having the best quality would receive the best price. No stronger argument could be used in impressing upon the minds of the producers the value of quality. The purpose of establishing these grades was to encourage growers and shippers in general to improve the bulk of the product. It is not uncommon to walk into an elevator and see grain, however, that should have graded No. 2 carrying so much dirt and foreign matter that is largely lost to the elevator that the product actually graded around No. 4 or even lower. Not until the grower has grasped the necessity of properly cribbing, storing, shelling and cleaning his grain can the producers at large hope to receive the maximum benefit. One of the first essentials, however, is the growing of varieties that mature well in the locality grown.

MIXING OF GRADES. In connection with the standard grades established for corn, perhaps no controversy has been as much hashed over as the mixing of grades. It has already been stated that different grades of corn cannot be mixed in the same bins in public warehouses. Now the question arises can different grades be mixed in shipping out from the warehouse or elevator? This is best answered in a clipping taken from the testimony of Dr. Duvel before a special commission.

"We have not attempted in any way in these grades to prohibit mixing, providing the mixing is legitimate and on the grade. In fact, we have made these grades intentionally so that mixing can be done. That is the reason why we fixed the limit on damage in these rules—No. 2 corn at 4 per cent, No. 3 corn at 6 per cent, and No. 4 corn, 8 per cent. Now, if you have two cars or, we will say, one car of No. 2 and one car of No. 4, with a maximum percentage of damage, you can mix these two cars and get two cars of No. 3. Of course, the chances are that you would have two cars that would have the maximum that you would want to mix. But we don't admit, and we don't believe, that you should be allowed to mix these two cars, and get two cars of No. 2, although I admit that in some cases under these grades it can be done and done legitimately, if you have a high No. 2 and a high No. 4 car, or especially if you have a high No. 2 and a high No. 3. But I don't believe you ought to be allowed to mix any damaged or sour corn and expect to have the thing graded as No. 2 corn. When a man buys No. 2 corn, he expects No. 2 corn, and he ought to get it."

RECEIPT OF CORN IN CHICAGO BY GRADES.

The following shows the number of carloads of corn of the different grades shipped to Chicago from the crop of 1914, and the percentage of each grade received. It will be well to remember that this crop was unusually well matured.

TABLE NO. 65

RECEIPT OF CORN BY GRADES—CHICAGO, 1914

Per cent No. 1 corn received	1.2
Per cent No. 2 corn received	26.0
Per cent No. 3 corn received	40.0
Per cent No. 4 corn received	24.0
Per cent No. 5 corn received	2.5
Per cent No. 6 corn received	2.8
Per cent S. G. (Sample Grade) corn received	3.5

Approximately seventy-five per cent of the corn received in Chicago was of Number 3 grade or poorer. Forty-eight per cent of the corn so received was yellow, fourteen per cent was white and thirty-eight per cent was mixed.

TABLE NO. 65—Continued

SHOWING NUMBER OF CARS OF EACH GRADE OF CORN RECEIVED IN CHICAGO, 1914

Grade	No. of cars received
No. 1 Yellow	6
No. 2 Yellow	10,970
No. 3 Yellow	13,897
No. 4 Yellow	7,612
No. 5 Yellow	942
No. 6 Yellow	870
Sample Grade Yellow	835
No. 1 White	5
No. 2 White	2,361
No. 3 White	4,147
No. 4 White	2,976
No. 5 White	281
No. 6 White	231
Sample Grade White	410
No. 1 Mixed	6
No. 2 Mixed	5,789
No. 3 Mixed	11,567
No. 4 Mixed	6,978
No. 5 Mixed	752
No. 6 Mixed	1,026
Sample Grade Mixed	1,464
Total	73.125

THE REGISTRATION DEPARTMENT

In connection with the Illinois State Grain Inspection Department, is the office which attends to the registration of every shipment of corn and the issuing of certificates. In the grading room a clerk is kept busy recording the complete data taken from the inspector's ticket placed in each sample of corn. There is one of these tickets for each lot of grain. This tabulated record is then transferred to the registrar's office where a certificate is made in duplicate, showing a complete record of the shipment. This certificate is made out to the person or firm to whom the grain was consigned. If he or they sell the grain they surrender the certificate to the buyer. It is with this office that the warehouse superintendent then must register grain taken in and secure certificate for grain to be shipped out.

SELLING CORN ON THE CASH FLOOR

Cash Grain.* "This is the technical term for immediate delivery. There are numerous terms and phrases common to the cash grain business, although the future and cash grain markets are so closely associated that the trade expressions are used almost as much for one as for the other.

"Immediate Shipment" means that shipment must be made within three business days. "Quick Shipment" is a term of five days, and "Prompt Shipment" is a term of ten days. Contract Grain calls for grain that grades No. 2 or better, but there are variations as to the season of the year and in grain from different sections of the country.

"Grain that has been loaded on vessels, either lying idle or moving, but which has not yet reached destination, is called "Afloat." The term "Boat Load" refers to 8,000 bushels of grain. When "Cargo" is referred to it means the loading of a steamer or vessel. An ocean cargo is usually around 200,000 bushels of corn.

"When a vessel has been engaged to carry grain to a given destination at a fixed rate of freight per bushel or per hundred pounds, it is termed a "Charter." Grain "On Passage" is grain on the ocean en-route from one port to another. "Worked for Export" is an expression used when a quantity of grain has been sold for export.

"At one end of the trading hall in the Board of Trade Building is placed a large blackboard on which are posted bids on grain "to arrive." These are prices offered to country points for grain. The date of shipment is specified in the bid, sometimes within five days after date of sale, sometimes not for several months after. When grain is not thus bought "to arrive" it is consigned by the country shipper to a Board of Trade house and sold on commission.

"After this grain (to arrive) has left the shipping point it is the duty of the seller to notify the buyer of the number of the car or cars shipped in and of the date of shipment. If after grain arrives it fails to meet the grade called for in the contract, settlement is made at the then prevailing market price for what the property is worth. If it grades better than specified, the shipper is at liberty to keep this grain and furnish the buyer with another carload that meets the grade required."

*From article by R. A. Meinke in "Farming Business," May 8, 1915.

When this grain arrives in the central market, the cars are switched to the grain yards as already designated. Promptly each car is examined and samples taken for inspection. A part of each sample, after it has been graded by the Inspection Department, is placed in a paper sack on which is recorded a complete description of the car and contents, and then taken to the "cash floor" in the Board of Trade Building.

ON THE CASH FLOOR (Chicago Board of Trade)

Note samples in sacks on the table, from the Inspection Department. Commission merchants, agents, messenger boys, brokers and buyers around the table examining samples, buying and selling. (Picture taken by Robert H. Moulton, Chicago.)

What must the commission merchant do now? Just as soon as samples from the cars consigned to him for that day reach his table, and the gong sounds to announce the time for trading he searches for his customers providing they are not already waiting for him. In this big room everything is hurry and hustle. Long rows of tables are heaped with paper bags containing samples of grain. Buyers and sellers are rushing here and there. It is noisy and crowded. Hundreds of cars of grain must be disposed of within a couple of hours.

The buyers represent exporters, shippers, millers, cereal manufacturers, maltsters and feed dealers, who buy in very large quantities. There is no formality about this buying and selling. The buyers are striving to secure the lowest possible price on what they want, and the commission merchant is fighting every inch for every fraction of a cent he can possibly get for the grain he has to sell. He must know how to get his price for his client, he must be a good judge of grain, he must know where to find the best market, and he must be honest in order to hold his shippers and buyers. If he thinks the grade given the grain which he has to sell is too low, he orders to have it reinspected. This he very frequently does. He is constantly meeting the stiffest competition known to marketing. Perhaps his client has sent another car of grain to some other commission firm in order to find out which concern gets him the best deal. He has his reputation at stake and on that he must depend for his living. If the grain is full of moisture, he knows at once he cannot sell it to the exporter or to the man who contemplates storing it any length of time. Then he must sell this to someone for immediate consumption. All these things and many more have to be quickly considered.

Trading ceases promptly at 1:30. It is left for the clerks in the office to figure up the returns for the day's business done by the firm. The following morning, perhaps, someone from the firm calls at the main office of the weighing department to get the certified weight for each car of grain sold, and this is sent to the shipper with a letter giving the grade, the price per bushel, freight charges, dockage or leakage, if any, cost of inspection, commission and a draft for the net proceeds of the sale.

In addition to this the commission merchant collects claims from railroads for loss in transit for the shipper, and often loans money to shippers where conditions require it. They must work on close margins.

COMMISSIONS AND OTHER FEES FOR SELLING.

Cost of Inspection. The chief inspector of grains at Chicago is authorized to collect on all grain inspected, the following:

For In Inspection: 50 cents per carload; 10 cents per wagon or cartload; 50 cents per 1,000 bushels from canal boats, 1-4 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 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 carload 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 carload lots in any position:

On corn or oats, per car, $1.00; 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, or other points, 1-8 cent per bushel in lots of 5,000 bushels or more, 1-4 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, seven dollars and fifty cents per five thousand bushels.

Commissions, Buying or Selling and Accounting. 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 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, 3-4 cent per bushel; on ear corn, 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 oats, 1-4 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 and weighing. Cost of sampling shall not be considered a charge against the property.

Weighing Charges at Chicago. Grain, by cargo, from elevator to vessels, per M bushels, 15c. Grain, by cargo, from vessels to elevator, per M bushels, 15c. Grain from canal boats per M bushels, 15c. Grain, in bulk, per carload, 60c. Grain, in bags, per bag, 2c.

Grain Storage Rates. Storage rates on all grain received in bulk and in good condition, shall not be in excess of one cent per bushel for the first ten days or part thereof, and one-thirtieth (1-30) of one cent per bushel for each additional day thereafter so long as such grain remains in good condition.

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.

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.

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.

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."

GRAIN STORAGE.

Handling millions of bushels of grain annually, the central market must have some provision for storage. This need has given rise to a great elevator and warehouse system. It has also made necessary an iron-clad system of supervision and management.

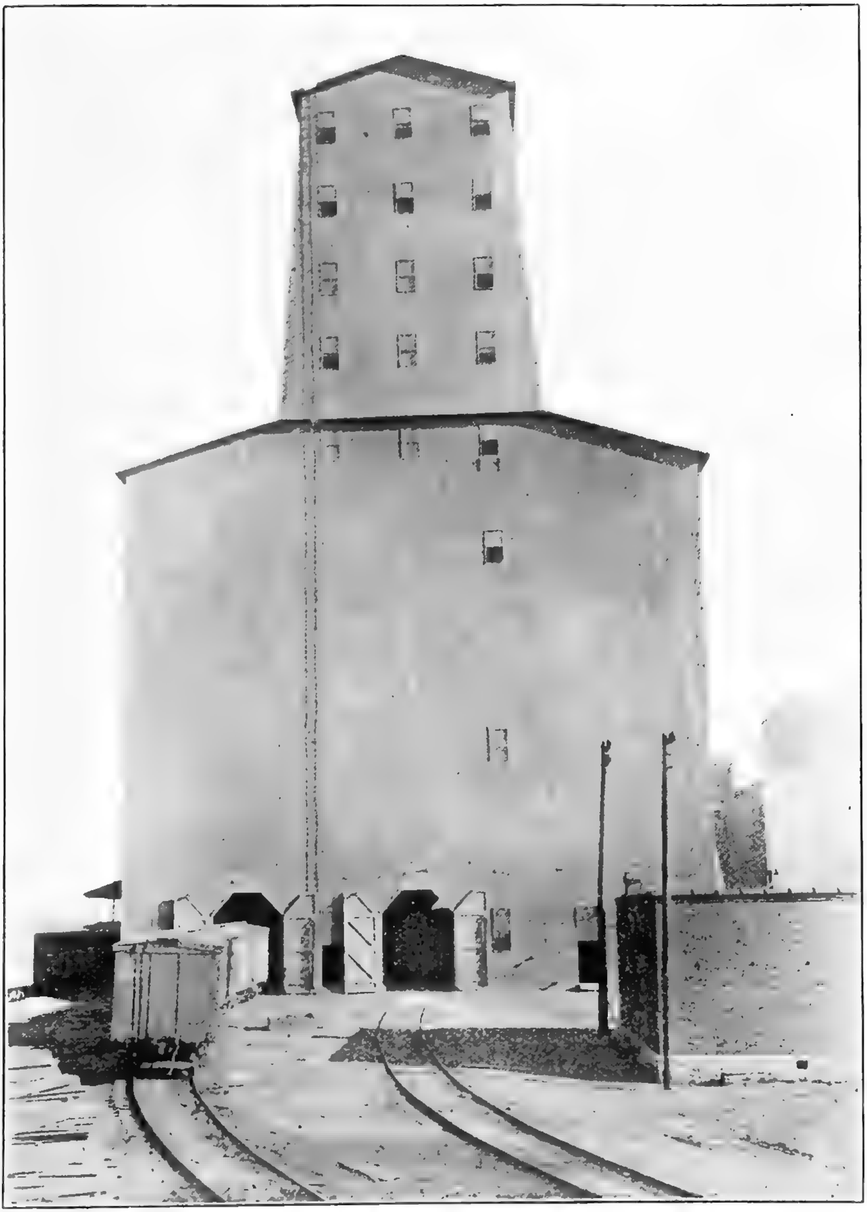
When the commission merchant has disposed of a car of grain he delivers to the purchaser the certificate which he received from the Inspection Department with the sample. The buyer then armed with the number and description of the car issues orders to the transportation company stating where he wants the car delivered. The switching engine is soon busy making the transfer and the car is promptly placed for unloading.

In many cases this means at some warehouse. The car has been carefully traced by a special police force provided by the Board of Trade to prevent pilfering and stealing. Before it is unloaded it is inspected by a deputy track man who again records the seals and reports any damage or leakage.

When the car is placed for unloading over the "sink" or "dump" the deputy trackman is present to see to the opening of the car and to see further that the dump is clean and the deputy weighmaster above ready to receive the grain. The car is quickly unloaded with special machinery. Again the trackman sees that the car is thoroughly cleaned and the dump empty before signalling to the deputy weighmaster to record the weight.

The grain is elevated to a large hopper in the top of the warehouse. This hopper will hold the contents of an average sized car. The scale, which has been inspected, automatically records the weight, but a weighman from the elevator and the deputy weighmaster from the Board of Trade, with probably an inspector also from the State Inspection Department, are present to see that no error is made in recording the weight.

From the scale hopper the grain is conveyed to a huge bin which is allowed to contain but one grade of grain. The spout from the conveyor is set by the State Official and locked and sealed to avoid any possibility of the grain being deposited elsewhere. When grain is taken from one of these bins the same precaution is taken to see that only the grade specified in the order is drawn. It is a serious criminal offense to either unload or load grain from the warehouse without permission and without the supervision of the Inspection Department.



MODERN TERMINAL ELEVATOR.

The man who stored grain in the warehouse is furnished with a storage receipt which is negotiable. In case he sells the grain he simply transfers this receipt. When this receipt is surrendered to the warehouse officials the grain may be removed according to the regular method. In removing grain from the warehouse, the superintendent must secure a certificate from the registrar's office of the State Inspection Department, stating the grade and amount to be taken. This serves a two-fold purpose. It makes it impossible for the superintendent or employee of any public elevator or warehouse to ship out any grain without the proper state official being present to inspect the grain, and further secures the banks which have perhaps loaned money on the grain stored.

PUBLIC WAREHOUSES.

There are three classes of public warehouses for storing grain. Class "A" includes all warehouses, elevators and granaries in which grain is stored in bulk in such manner that the identity of different lots can not be accurately preserved, such warehouses, elevators or granaries being located in cities having not less than 100,000 inhabitants.

Class "B" includes all other warehouses, granaries or elevators in which grain is stored in bulk, and in which the grain of different owners is mixed together.

Class "C" includes all other warehouses or places where property of any kind is stored for a consideration.

Chicago alone has storage capacity for approximately 50,000,000 bushels of grain. 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 WAREHOUSES—CHICAGO. (July 1, 1915.)

Name of warehouse	Operated by	Capacity bushels
Armour Elevator, comprising houses A, B and B Annex	Armour Grain Co.	5,000,000
Armour Elevator Co.	Armour Grain Co.	1,000,000
Calumet Elevator Co.	Central Elevator Co.	1,200,000
Chicago & St. Louis Elev. & Annex	J. Rosenbaum	2,000,000
National Elevator	Central Elevator Co.	830,000
J. Rosenbaum, Elevator A	J. Rosenbaum	400,000
J. Rosenbaum, Elevator B	J. Rosenbaum	1,550,000
Rock Island Elevator A	J. Rosenbaum	1,250,000
South Chicago Elevator Co. & Annex	Chicago Elevator Co.	3,000,000
Wabash Elevator	E. R. Bacon	1,500,000
Total Capacity		17,730,000
Total Capacity Irregular Warehouses (54)		32,645,000

Grain storage has not expanded with the increased production. The total storage capacity of the fourteen principal markets is approximately 200,000,000 bushels. Of this more than 150,000,000 bushels capacity is the old wooden style construction with high rates of interest and insurance. This leaves only about 50,000,000 capacity being of steel or iron. Seaboard capacities are very limited and decreasing.

EXPORTS OF CORN.

It is not necessary to say much concerning our corn exports from the United States. We export annually less than one per cent of our crop, while Argentina exports approximately fifty per cent of her crop. In 1914 this country exported 7,296,000 bushels. Table No. 68 shows the destination of this grain. In the same year, we imported 903,062 bushels. Our corn exports represented only little more than one per cent of the amount of corn shipped outside of the county where grown in 1914. Most of the export corn from all countries goes to the European markets. The principal distributing points are Liverpool, London, Glasgow, Hull, Manchester, Hamburg, Bremen, Christiana, Copenhagen, Rotterdam, Antwerp, Havre, Marseilles, Genoa and Naples.

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. About fifty per cent of the corn exported goes through New York, New Orleans and Galveston.

The exportation from 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; corn stored and shipped from these ports enters the vessel in condition favorable to heating. The inspection of corn at present before loading is doing much to insure against shipment of grain that is damaged. The following tables show the amount of corn exported and imported by different countries for a term of years.

TABLE NO. 66

EXPORTS OF CORN FROM THE UNITED STATES, 1867 TO 1914 INCLUSIVE

Year	Bushels	Year	Bushels
1867	16,026,947	1891	32,041,529
1868	12,493,522	1892	76,602,285
1869	8,286,665	1893	47,121,894
1870	2,140,487	1894	66,489,529
1871	10,676,873	1895	28,585,405
1872	35,727,010	1896	101,100,375
1873	40,154,374	1897	178,817,417
1874	35,985,834	1898	212,055,543
1875	30,025,036	1899	177,255,046
1876	50,910,532	1900	213,123,412
1877	72,652,611	1901	181,405,473
1878	87,192,110	1902	28,028,688
1879	87,884,892	1903	76,639,261
1880	99,572,329	1904	58,222,061
1881	93,648,147	1905	90,293,483
1882	44,340,683	1906	119,893,833
1883	41,655,653	1907	86,368,228
1884	46,258,606	1908	39,013,000
1885	52,876,456	1909	38,114,100
1886	64,829,456	1910	44,072,200
1887	41,368,584	1911	63,533,000
1888	25,360,869	1912	32,627,000
1889	70,841,673	1913	46,923,000
1890	103,418,709	1914	7,296,000

TABLE NO. 67

*EXPORTS AND IMPORTS OF CORN BY COUNTRIES. (1913)
(Including Corn Meal)

EXPORTS	Bushels	IMPORTS	Bushels
Argentina	189,240,000	Canada	9,041,000
Austria-Hungary	30,000	Austria-Hungary	25,844,000
Belgium	6,134,000	Belgium	25,036,000
British S. Africa	741,000	British S. Africa	818,000
Bulgaria	11,362,000	Cuba	3,198,000
Netherlands	11,846,000	Netherlands	39,467,000
Roumania	36,617,000	Denmark	15,938,000
Russia	22,898,000	Russia	609,000
Servia	4,627,000	Egypt	1,184,000
United States**	46,923,000	France	23,276,000
Uruguay	14,000	Germany	36,165,000
Other Countries	6,191,000	Italy	13,849,000
		Mexico	1,548,000
		Norway	1,130,000
		Portugal	952,000
		Spain	22,400,000
		Sweden	3,975,000
		Switzerland	4,785,000
		United Kingdom	97,721,000
		Other Countries	8,866,000
Total	336,623,000	Total	335,802,000

TABLE NO. 68

*DESTINATION OF CORN EXPORTS FROM UNITED STATES (1914)

	Bushels
Belgium	60,227
Canada	4,641,737
Cuba	2,410,156
Denmark	118
Germany	303,303
Mexico	467,424
Netherlands	373,770
United Kingdom	540,515

*United States Year Book, 1914.

**In 1914 only 7,296,000 bushels.

TABLE NO. 69

*PER CENT OF CORN CROP OF UNITED STATES EXPORTED
1900-1914 INCLUSIVE

Year	Per cent	Year	Per cent
1900	10.3	1908	1.5
1901	8.6	1909	1.4
1902	1.8	1910	1.6
1903	3.0	1911	2.5
1904	2.6	1912	1.0
1905	3.6	1913	1.9
1906	4.4	1914	.27
1907	2.9		

Prices of Export Corn. From 1896 to 1900 the average price of export corn was 36.9 cents per bushel. During the same time the average price of corn sold on the domestic markets was 28.5 cents per bushel. Taking a twenty-six year average, from 1881 to 1907, the average price was 52.9 cents per bushel on corn for export, and 40.1 cents per bushel for domestic markets. The current price of corn at the export terminal markets, however, would naturally be greater than the average domestic price, owing to added shipping charges, etc.

American grain destined for foreign markets is sold C. I. F. (cost, insurance, freight), the marine insurance and ocean freight being included in the cost.

Drying Export Corn. *"For several years, complaints were made as to the conditions in which our export grain, especially corn, arrives in European ports. 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 per cent of our corn received in 1904 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.

*Year Book United States Department of Agriculture.

"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.

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:

"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 competition, 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.

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.

"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 sufficient 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.

"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."

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.
Board of Trade Book, 1910.
Annual Reports of Chicago Board of Trade.
Farmer's Bulletin No. 168.
Farmer's Bulletin No. 584.
American Co-operative Journal.
Grain Dealer's Journal.
Annual Report of Illinois Inspection Department.
Farming Business, May 1 and May 8, 1915.
Price Current Grain Reporter.

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.

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:

"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.

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, 2,500,000; of Illinois, 6,500,000; of the United States approximately 100,000,000. 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.

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.

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.

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.

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.

*Today, with a membership of 1,625, 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.

*ORGANIZATION OF BOARD OF TRADE. The Board of Trade Organization consists of president, first vice-president, second vice-president, secretary, treasurer, board of directors, and twenty-four standing committees besides the special committees.

We have been prone to consider the Board of Trade simply as an organization for speculating in grain. As a matter of fact, the Board deals in practically all marketable products and securities. A closer acquaintance with such an organization should reveal some vital relationships with the gigantic machinery of marketing, which not only are interested in the buying and selling of products for profit, but which are giving assistance toward solving the great problems of marketing.

*Annual Report of Chicago Board of Trade and "Board of Trade Book," 1910.

In the organization of the Chicago Board of Trade, we find at least four agencies or departments which are of invaluable consequence to the growers and shippers of grain as well as to the buyers and sellers in the speculative market.

Legal Department. The first of these agencies is the legal department. While such a department is necessary in the interpretation and enforcement of the rules of the Board of Trade among its members, and between members of the Board of Trade and parties with whom they are constantly dealing, its functions would not be fulfilled in the broader sense unless it went further than that. This department has done more than that. Among the legal problems which it has sought to solve during the last decade, none stands out so prominently, or has redounded more to the benefit of all concerned, than the fight against the bucket shops. When this contest began, this nefarious and parasitical business was fast sucking the very life-blood out of the legitimate produce exchanges of the country. Alone and at first unaided, the Chicago Board of Trade began its fight, and now the once defiant and flourishing business has been swept away.

The Transportation Department. The work of the Transportation Department is under the general administration of the Transportation Committee of the Board of Trade. The purpose of this department is:

First—To secure the removal of discriminative rates, or unjust rules or regulations against the Chicago market.

Second—To prevent, in the making of new rates, rules and regulations, the adoption of any that place the Chicago market at a disadvantage with other markets.

The transportation rates of any community are of such tremendous importance that some organized and efficient method of protecting its interests are absolutely necessary. It is important to every shipper to have such rates as will enable him to place his products into the central market in competition with all shippers. The Transportation Department of the Board of Trade devote their energies in the investigation and regulation of these shipping rates.

The Weighing Department. One of the chief complaints of the average producer and shipper is unjust weights. The Weighing Department of the Board of Trade sends out scale inspectors to shipping points over the country with complete outfit for testing scales. All public scales in Chicago are tested at least twice a year, and oftener if conditions require.

Besides serving as a disinterested party in settling disputes in weighing and in testing scales, this department employs a force of deputy weighmen, deputy trackmen, supervisors, a policing or detective force and car tracers and office clerks, whose services are contributed to the grain trade.

The deputy weighmen conduct the weighing at the various elevators, industries and transfer points.

The deputy trackmen are stationed on the track floors of the large grain elevators to record the seals and condition of cars, and to supervise the unloading and loading of grain.

These weighmen and trackmen are under the direction of the supervisors, who are constantly visiting the elevators, and other points where weighing is done with a view to maintaining the best of conditions and service at all times.

The policing and detective force looks after conditions existing in the various railroad and storage yards. This branch of the service also attends to the prosecution of those caught stealing grain from cars, or buying the stolen grain. The protection of this department is of immense value to the shippers for the railroad yards are situated in remote parts of the city where pilferers are naturally attracted.

The car tracers follow the movements of cars when shortages transpire. This department is of invaluable service in securing evidence for the collection of claims, etc.

The office clerks issue the certificates of weight, attend to the indexing of each car in the ledgers, and perform the general office work. A complete history of the treatment accorded each car of grain is kept in systematic files in the main office. This office is opened at 6:30 each morning in order that the consignees may secure the certificates of weight for their cars promptly.

The weighing department is constantly sending out material to aid the producers and shippers in eliminating all conditions conducive to carelessness, waste and error.

During the past year (1914) this department has supervised the weighing of 361,735 cars of produce, 108,623,667 bushels of grain to and from boats, 602,771,764 bushels of seed at freight and warehouses, and has attended to the investigation of weights, especially requested, for 1,289 cars.

This department found and reported in the same year 26,011 cars, or 11.5 per cent of the total in-bound cars weighed, with leakage. Besides this their deputies went over each shipped car at the time of loading to see that it did not show any evidence of leakage before it left the loading elevator.

The number of people detected and arrested for pilfering cars in the railroad yards was 254.

At interior or country loading stations, this department tested 74 scales of which 46, or 62.2 per cent, were weighing incorrectly. In the Chicago district, 716 scales were tested of which 105, or 14.7 per cent, were in need of adjustment.

Department of Grain Sampling and Seed Inspection. This department works in conjunction with the Illinois State Grain Inspection Department. A staff of about thirty men is maintained. These men sample and inspect shipments of grain and seed coming into the central market. Often they send their men to other points to give help in settling disputes or other difficulties. They have men in the railroad yards and at all of the public warehouses to inspect grain, coming in and being shipped out. Much that has been accomplished in establishing uniform grades for grain might be credited either directly or indirectly to this department.

During the year 1914, the inspection department sampled 123,537 cars of grain, and sampled 29,000,543 bushels for lake shipment.

OBJECTS OF THE BOARD OF TRADE ANALYZED.* The purpose of the Board of Trade has already been stated. Whatever objections have existed with reference to the Board of Trade in the past, or may exist at present time, it remains to be seen whether or not it is living up to the objects set forth. They are considered briefly in the following:

First—To promote uniformity in customs and usages of merchants. The value of some uniform means of marketing all products is at once grasped. The buyer wishes at all times to have the advantage of the most favorable market, and the producer is constantly on the lookout for the highest price for his product. It would not be possible for either to keep posted in regard to the various markets if there were not some uniformity in customs and usages. The average person could not interpret intelligently the market quotations. The Boards of

Trade, especially the Exchange at Chicago, has probably done more than any other agency in establishing the customs now prevailing throughout the world in marketing. The rules and regulations originated and enforced by the large grain exchanges today perhaps have more influence on marketing than any other factor.

Second—To inculcate the principles of justice and equity in trade. In the accomplishment of this purpose a code of rules and regulations has been established to govern all selling and buying through the exchange. The Board of Trade through its legal department devotes much time to legislation affecting marketing. This department was most active in combating the "bucket shop" evil. Through its transportation department unjust and discriminatory freight rates are investigated and adjusted. Through its weighing department the question of weights and measures is given constant attention. Through its inspection department the proper grading of grain is watched to prevent unscrupulous practices. Thus are inculcated the principles of justice and equity.

Third—To facilitate speedy adjustment of business disputes. Within the Board of Trade a special committee is provided to settle disputes between members. The decision of this Board of Arbitration must be respected. Matters of great consequence are settled quickly. Questions of proper sampling and grading of grain, accurate weighing, leakage and stealage in shipping, impartial transportation charges and the like are constantly arising, and the Board of Trade through its various departments contributes the best of expert service in settling such disputes.

Fourth—To acquire and disseminate valuable and economic information. Statistical information secured by the Board of Trade relates not only to the trade of Chicago or other local markets in grain, provisions, live stock, hay, flour, lumber, cured meats, dressed beef, butter, cheese, hides, grass seeds, etc., but also has reference to such commodities in other principal markets both domestic and foreign. This information, daily, hourly, and in many instances, instantaneously, is at the service of the Board, which in turn transmit it to producers to aid them in marketing their produce intelligently, and to give instructions to their commission merchants as to the conduct of their consignment.

Telegraphic facilities are provided for the unhindered and prompt communication with shippers, customers, purchasers and consumers. Representatives of the press have constant and ready access to this information. All prices are posted in the Exchange on the bulletin board and this information is sent broadcast. Besides all this an annual report is published, giving in the greatest possible completeness all information relating to the production and distribution of the various crops and other marketable products of the world. This great service bureau has become a necessity to the business world.

Fifth. To secure for its members the benefits of co-operation in the furtherance of legitimate pursuits. Modern marketing has become as much of a specialized business as the question of production. Men who have devoted their time and energy in acquainting themselves with the problems of marketing are today a necessity in the disposal of most of our farm products. Any advantage to be found in co-operation then should be available when these men, including commission merchants, brokers, etc., are working together. This does not necessarily affect competition. It has already been pointed out that the success and profit of these men is determined by the degree of their ability to give satisfaction to the producer and shipper. They are all working for the business and competition between them is very keen.

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 or 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. or 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.* "There are many terms of the Board of Trade of which the public has little understanding. Probably the ones most frequently used with the grain markets are 'Bulls' and 'Bears'. A 'Bull' is one who believes in higher prices and who buys for an advance. A 'Bear' is one who looks for lower prices and who sells property which he does not possess but which he hopes to buy at a lower figure than he previously sold at.

"This is called short selling and the party making the sale is termed a 'Short'. In other words the short seller is one who contracts to supply another with a certain amount of grain at a specified price at a future date and who believes that before the date of delivery has arrived he will be able to purchase this grain at a lower figure than he contracted to sell it for. When a 'Long' sells his property for more than he paid for it, the operation is called 'Realizing' or 'Profit Taking.' When he is forced to sell at a loss, it is termed 'Liquidation', 'Stop Loss Selling', or 'Unloading'. When a 'Short' buys at a lower price than he previously sold his property at, it is said that he is taking profits. When he is obliged to pay more than he sold for, or buy in at a loss, it is generally termed 'Covering'.

"A 'Scalper' is a person, who, after he has made a profit on the grain he has bought or sold, closes out the trade and pockets his gains, repeating the operation several times.

" 'Hedging' is an expression frequently used in the grain trade and refers to the operation whereby a 'cash grain' dealer lessens his risk by buying or selling 'futures'. For example, if a man or concern buys a certain amount of 'cash grain' that he or they have not an immediate market for, an equal quantity will be sold in the speculative market, thus protecting the holder of the grain from a decline in prices. After a buyer for the 'cash grain' is found the speculative sale is disposed of by buying in the pit and the trade balanced up. This is called removing 'hedges'.

"On the other hand, if a dealer in 'cash grain' makes a sale before he has the grain in his possession he buys an equal amount in the future market. Thus, if he is forced to pay more for his 'cash grain' than he contracted to sell it for, his loss is offset by his purchases in the pit. Naturally there are times when even these methods fail to protect 'cash grain' dealers from losses, but it eliminates the possibility of heavy loss and enables the 'cash grain' man to work on a much smaller margin of profit than he could under other circumstances.

*Taken from article by Mr. R. A. Meinke in "Farming Business", May 1, 1915.

"A 'Margin' is a certain amount of money deposited with a broker or commission house to protect trades made or to be made. Thus a man trading on a margin need advance only a small part of the value of the property he is buying or selling. For instance you may in normal times buy or sell 5,000 bushels of wheat on a 5-cent margin for $250 when perhaps the actual value of 5,000 bushels of wheat at that time is $5,000. However, if the market goes against you to the extent of your margin you must deposit additional money with the broker or commission concern to protect them, or close out your trade.

"A 'Stop Order' is an order to close a trade at a specified price in order to limit losses. Such an order is automatically acted upon when the price stated thereon is reached, but in wild markets, such as have at times been witnessed, it is impossible to close the trade at a certain price and perhaps the 'Stop Order' will be executed at a price 2 or 3 cents away from the desired figure.

"Among members of the Board of Trade and in market reports you hear much of the 'cables'. This refers to the foreign markets, particularly that at Liverpool.

"Another expression much used on the Board of Trade is 'Visible Supply' and by this is meant the stocks of grain in public elevators in large cities and afloat on the canals, lakes and rivers.

"There are many more expressions identified only with the grain trade, but we have dealt with the more important ones here, particularly as used in connection with the speculative branch of the business.

"We often hear of the market being 'cornered'. By this is meant that a party or combination of parties have purchased more grain than the sellers or 'Shorts' will be able to deliver. They have created an artificial scarcity. The 'Shorts' finding themselves unable to get sufficient grain from the public elevators or from the country are forced to buy in the pit and pay what the 'Longs' demand. In the days of 'Old Dutch', Pardridge and Leiter there was much of this done and it was then that the Board of Trade earned the notorious reputation that the general public is disposed to give it. However, in recent years there has been a determined effort to 'clean house' and under the present rules of the association it is impossible to 'corner' a market.

Now if a 'Short' believes that the market has been manipulated and the price has been forced unnaturally high he may default on his contract and a committee is appointed to determine the market value of the grain or product in question, and settlement is made between the seller and his buyer on that basis.

"Another rule making it difficult to artificially raise prices is a recent amendment to the rules of the association whereby it is impossible to deliver grain in cars on the last few days of the contract month. Under the old rules the grain had to be in regular elevators to apply on contracts. Members of the Board of Trade recognize the fact that they have faults the same as in any other business and an element will always be found that will take advantage of and abuse liberties, but they are active in trying to correct evils and members whose acts have proved dishonorable and uncommercial have been expelled."

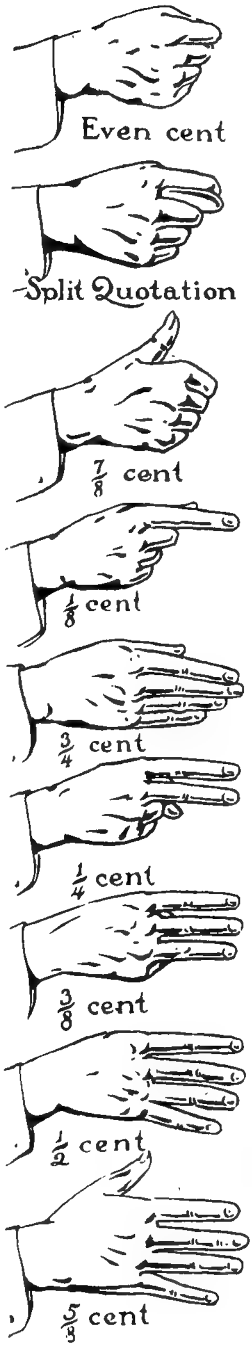
"Futures" are commodities bought on contract for delivery, which may or may not actually be made at a later date.

"Settlement" price is 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 is 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.

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.

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 corn" at 48. The seller, in reply, holds up his right hand with the index finger extended horizontally, indicating that he wants 48$\frac{1}{8}$ cents. The buyer motions acceptance and signals back $\frac{1}{8}$. The two traders note on their cards "Sold 50 at $\frac{1}{8}$, Jones" and "Bot 50 at $\frac{1}{8}$, 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-eigths; 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 party 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.

OTHER EXCHANGES. Aside from the Exchange at Chicago, there are others of prominence located at Minneapolis, Duluth, Winnipeg, St. Louis, Kansas City, Omaha and Toledo. Almost every city of any size has a grain exchange, but they are chiefly of local importance. These markets named are termed "Outside Markets" by the Chicago trade and their price movements are received by telegraph throughout the session and posted on blackboards.

SPECULATION.* "The German Economist Cohn, defines speculation as 'the struggle of well equipped intelligence with the blind power of chance.' Or, as Justice Holmes puts it, 'It is the self-adjustment of society to the probable.' In simpler English, it is an act or series of acts based upon calculation, whereas gambling is simply an act based upon blind chance."

It is a fundamental economic principle that all productive industry at the present time involves a certain amount of risk. By the leaders of the modern system of marketing, speculation is declared to be a necessity for the following reasons:

(1) Production imposes ownership and ownership is inseparable from risk. This is true of live stock, grain, real estate or articles of almost any kind. Risks are innumerable and ever present.

(2) No one knows the future. With all merchantable products the thought of possession is usually the increase in value. In dealing with the future needs of mankind one cannot foretell with absolute certainty all conditions affecting demand and supply.

(3) In the case of grain crops, harvesting is confined within rather narrow limits with respect to time, while the demand for these products is continuous. One can not harvest the crops simply as needed. At the time of harvesting there must be a surplus to meet the demand until the next harvest. This surplus must then be adapted to the future demand. In addition to this a large per cent of the farmers, including tenants and those who have heavy obligations coming due at a certain time are forced to sell promptly after harvest.

(4) Shippers cannot ship grain at once. For instance the country grain buyer pays cash for grain. He is not able to ship this at once so he must depend upon a future market. Without a definite future

*Board of Trade Book, 1910.

market he could afford to handle grain only by allowing a wide margin for profit.

(5) At certain times of the year the farmer has food supplies in excess of the needs of his local community, while in districts where farming is replaced by other industries as manufacturing, etc., not enough food is produced to meet the demand. The problem of getting this surplus to the places where needed involves time and risk.

(6) Through the central markets grain is bought and sold in large quantities. Without our present system of marketing it would be necessary to secure this grain from a considerable number of individual farmers or producers. In either case the element of time in getting such quantities of grain together must be considered.

The Benefits of Speculation. This has reference especially to the practice of dealing in futures.

(1) It creates a continuous and open market and gives a daily cash sale for grain. As long as there are men who in their study of supply and demand think they can make a profit in buying grain and disposing of it later we have a steady sale for the grain. The value of this continuous market can hardly be overestimated.

(2) More stable prices are created. Under present conditions the entire surplus crops are not immediately upon harvest thrown upon the market, thereby depressing prices, nor just preceding harvest are prices raised to exorbitant level on account of vanishing supply.

(3) Discounts changes in supply and demand. If the price of grain for the future market is high it can indicate but one thing, under normal conditions, that the supply will be small. It therefore serves to adjust the demand to the probable supply. Wastefulness and extravagance in the face of such a shortage is averted, and one is not led to horde grain in the face of a large supply when it would have to be sold on a declining market. The future prices are an indication of existing supply.

(4) Grain can be handled with a minimum of expense to the producer. The margin of profit in handling grain is lower than is exacted in the handling of any other business. Under the conditions of the past it was necessary to allow a margin of about ten cents on the bushel in handling grain, but at present it is handled on an average probably not to exceed one per cent of present values.

IN THE PIT
(Picture taken by Robert H. Moulton)

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.

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 adopting 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.

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 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 "futures" and he will tell you it is done to avoid speculating in his business.

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.

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.

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.

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.

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 or 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.

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 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:

Brown has bought of Jones.
Jones has bought of Smith.
Smith has bought of Brown.

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:

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.

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.

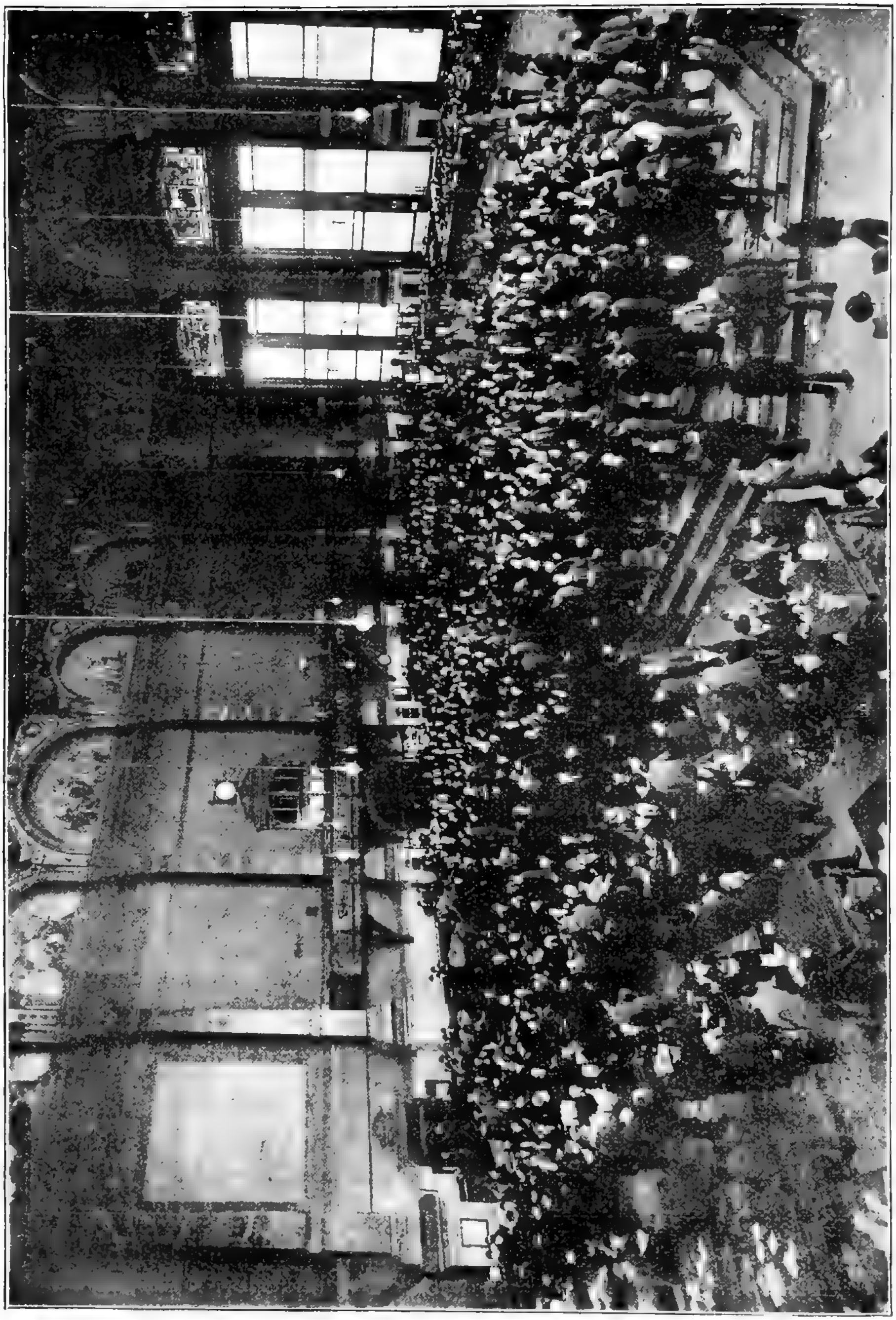
How Deliveries are Made. Deliveries on contracts for future delivery of grain, flaxseed and provisions entered into on the Chicago Board of Trade, are made by warehouse receipts for the commodities in warehouses declared "regular" by the Board. Deliveries of grain and flaxseed are made in lots of 5,000 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.

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.

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



EXCHANGE HALL 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.

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 had been 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.

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.

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 cents		Smith 3 cents per bushel
to Day	at 47 cents	Day 4 cents per bushel	
to Lee	at 43 cents		Lee 5 cents per bushel
to Brown	at 48 cents	Brown 2 cents 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.

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 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 effected 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.

COLLATERAL READING:

Speculation Not a Fine Art, By E. W. Wagner.
Reports of the Boards of Trade of the several principal markets.
"Board of Trade Book", 1910.
The Farming Business, May 8, 1915.
"Gold Bricks of Speculation," by John Hill, Jr.

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*

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.

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

*Corn Products Company of Chicago.

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:

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 analysis 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 seventeen years from 1898 to and including 1914, the following amounts with values appended, were shipped to foreign markets:

Year	Barrels of Meal	Value
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
1908	654,515	2,053,447
1909	452,907	1,549,010
1910	331,531	1,147,568
1911	463.266	1,456,683
1912	439,624	1,519,792
1913	428,794	1,444,539
1914	336,241	1,185,891

The following countries have been the chief importers of corn meal manufactured in the United States according to the Government Statistical Report on Commerce and Navigation.

The total number of barrels exported to all foreign countries for 1914 was 336,241. British Africa, West Indies, Porto Rico, the United Kingdom and the Dominion of Canada, including Labrador and New Foundland have been the principal importers.

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 Kafirs 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 1914, 59,030,623 pounds of corn-oil cake in the form of large pressed slabs were exported to European markets, the total value of which amounted to $909,407. Of the total amount exported, Belgium, France, Germany, Netherlands, Sweden and Norway, United Kingdom and the Dominion of Canada (British Columbia) are the chief importers.

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 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.

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.

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.

*Van Camp Packing Co., Indianapolis.

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.

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.

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.

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 poorer classes of our country and the hordes of Europe to adapt themselves to the use of this cheaper and simpler form of food stuff.

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.

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.

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.

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.

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.

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.

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

*Corn Products Mfg. Co.

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 1914, 18,281,576 pounds of corn oil, valued at $1,307,204, was exported from the United States.

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 1914 amounted to 59,030,623 pounds, valued at $909,407. 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	"

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.

"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 is 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. 36,850,496 pounds of grape sugar and 162,680,378 pounds of glucose, valued at $4,565,919, were exported from the United States in 1914. This product even enters Europe and the territory where the sugar beet is extensively grown.

Corn starch has long been a well known product in the American home. In one form or another 76,713,779 pounds of starch valued at $1,825,230 were exported from the United States in 1914. Laundry starch is now made largely from corn, potato starch being seldom used for such purposes.

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.

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 fifty 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.

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 gallon of 95 per cent alcohol is nearly 7 pounds. Hence, 1 bushel of corn would produce 2.7 gallons.

"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**

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 (K_2O).

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 Hirschel 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.
**Hirschel and Bendheim of St. Louis.

"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.

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.

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.

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 average 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.

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.

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.

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:

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.

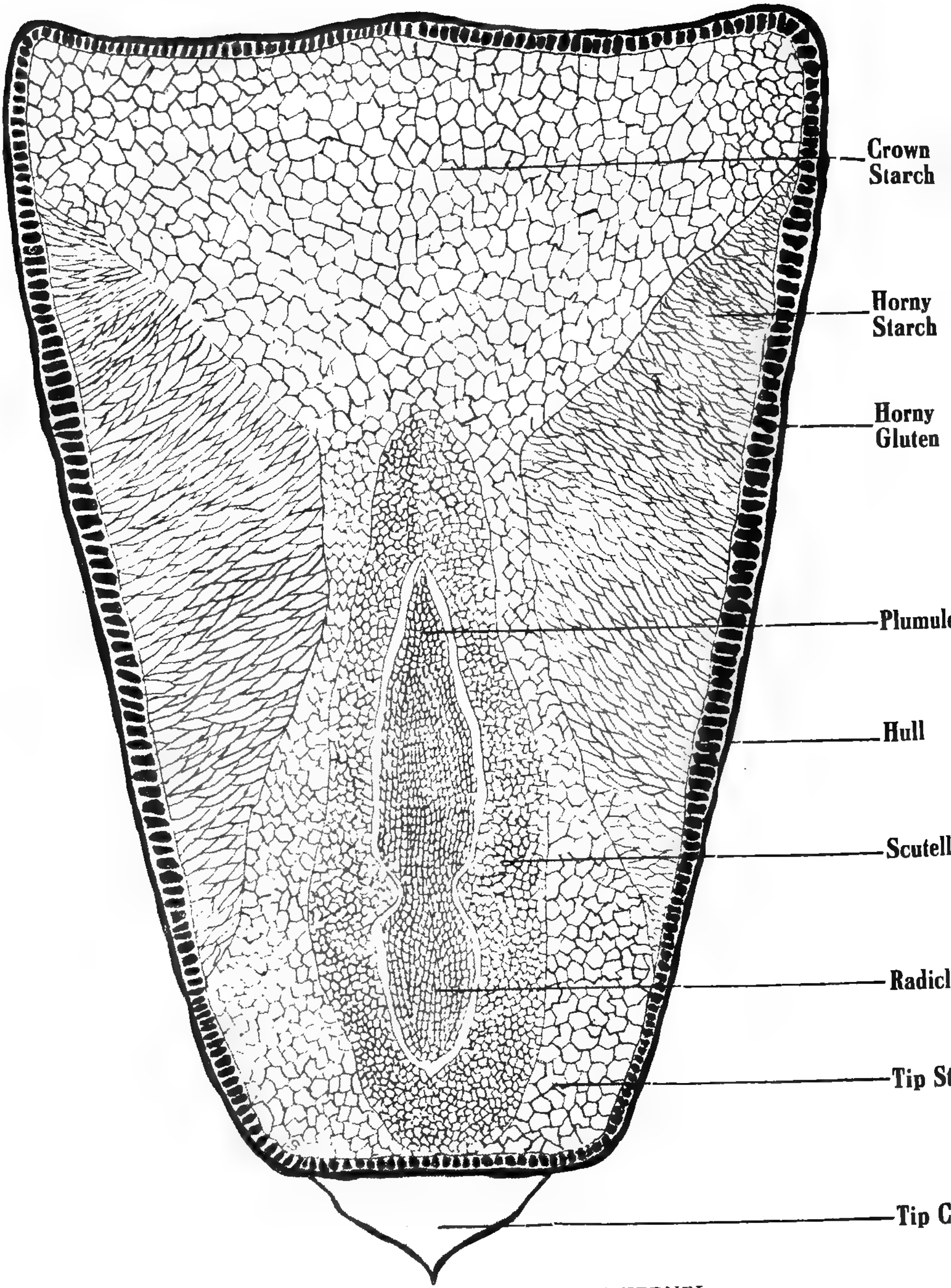
2. **Hull.** This is a very thin outer covering of the kernel. It consists largely of carbohydrates, especially fiber or cellulose, although it also contains a small percentage of other constituents.

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.



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.

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 as 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.

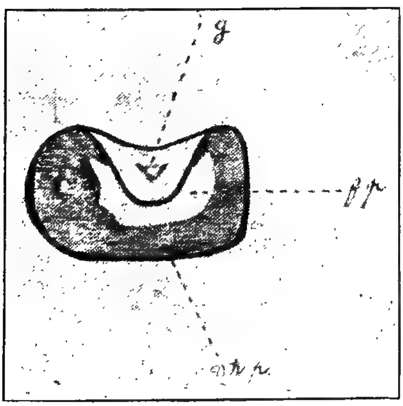
COMPOSITION OF PARTS.

Names of Parts	Protein Per cent	Oil Per cent	Ash Per cent	Carbo-hydrates Per cent
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
Horny 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.

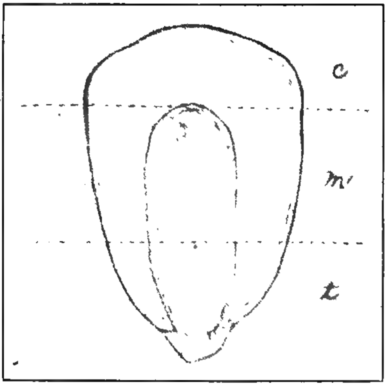
The most significant table is here presented, which shows the percentage distribution of the chemical constituents among the physical parts for an ear of medium protein content.

Names of Parts	Per cent of Total Protein	Per cent of Total Oil	Per cent of Total Ash	Per cent 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	42.36	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



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.



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.

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	Per cent Protein	Per cent Oil	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 are 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 chemical 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 first 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.

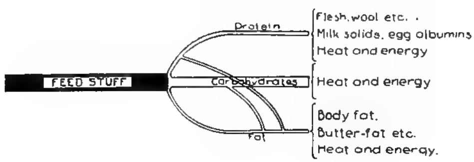
**Thus lean meat freed of fat and connective tissue is protein. The white albumen of egg is protein; so is the gluten of wheat flour. The protein of corn is found principally in the germ and horny gluten, as well as in smaller amounts in the stalk and other portions of the plant. It supplies the flesh 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.

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 carbohydrates, 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:



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.

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.

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.

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.

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 constantly taking up and giving off water according to atmospheric changes."*

Pasture grasses contain from 62 to 80 per cent of water; while roots, like mangels, 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.

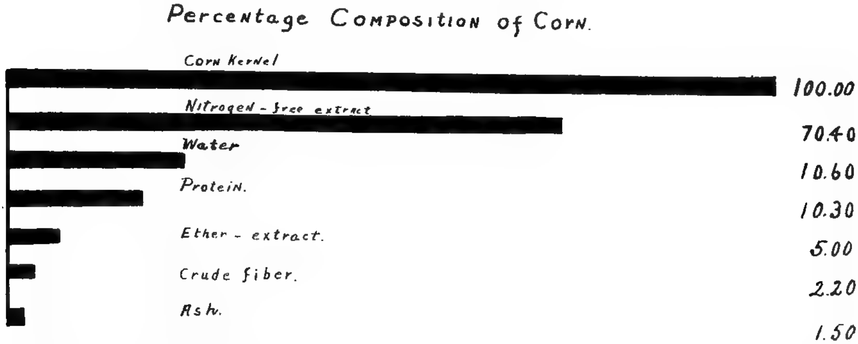
TABLE SHOWING IN PER CENT THE CHEMICAL COMPOSITION OF CORN IN DIFFERENT FORMS

	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 hygroscopic moisture.



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	Extract Ether
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 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.

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.

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.

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 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.

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 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.

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.

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.

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.

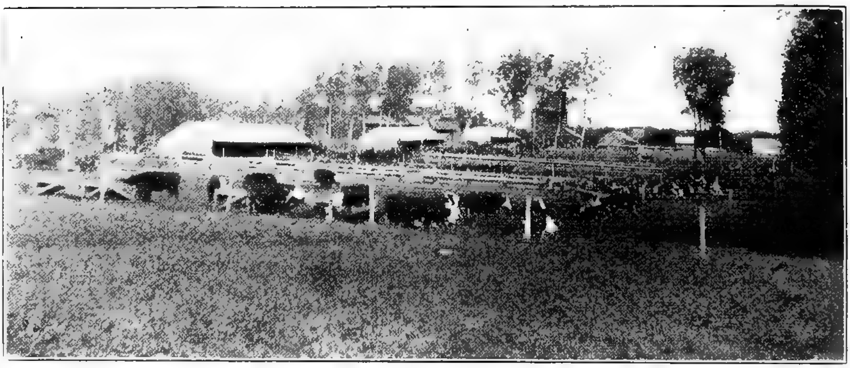
	Dry Matter	Protein	Carbo-hydrates	Fat	Nutritive Ratio
Red clover, 12 pounds...	10.1	.82	4.29	.20	
Corn, 3 pounds..........	2.6	.24	2.00	.13	
Total	12.7	1.06	6.29	.33	1:6.6
Alfalfa, 7 pounds	6.4	.77	2.77	.09	
Corn stover, 6 pounds....	3.6	.10	1.94	.04	
Corn, 3 pounds	2.6	.24	2.00	.13	
Total	12.6	1.11	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.

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."



CATTLE IN AN IOWA FEED LOT

A steer requires something like 6 pounds of digestible carbonaceous food to 1 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.

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.

VALUE OF CORN MEAL AS A FOOD AS COMPARED WITH OTHER FOODS**

Each of these foods contains the same amount of nutritive material as one pound of corn meal valued at 3 cents per pound.

Kind of Food	Cost	App. No. or Measure	Approximate Weight		Total Cost Cents
			Lbs.	Ozs.	
Corn Meal	3c per lb.		1		3
Dried Beans	6.5c per lb.		1	1	7
Bread, White	10c loaf		1	6	10
Potatoes	$1.00 per bu.	17	5	7	10
Prunes	15c per lb.			14	15
Cheese	22c per lb.			14	19
Milk	8c per qt.	2½ qt.	5	5	20
Walnuts	25c per lb.		1	5	33
Codfish	7c per lb.		5		35
Cabbage	2.5c per lb	2½	13	14	35
Meat, round steak	20c per lb.		1	14	37
Eggs	35c per doz.	25	1	8	56
Oranges	40c per doz.	20	10	15	66

NOTE—The value of corn meal as a food has not been fully appreciated. It is bound to come into more common use.

*Profitable Cattle Feeding, H. R. Smith, Page 188.
**Compiled from data taken from estimate prepared by the Iowa Dairy and Food Commission.

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.

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	Protei	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.

*All taken from Appendix of Henry's Feeds and Feeding except the last, which is from No. 43 Maryland Bulletin.

**New Hampshire Bulletin 66.

The following table taken from Bulletin No. 156 of Virginia, shows the comparative value of gluten meal and cottonseed meal for milk production:

	Feed	
	Gluten 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.

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.

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 ratio.

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
**Profitable Stock Feeding by H. R. Smith, Page 299.

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.

Distiller's 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 Sub-stance	Ash	Pro-tein	Crude Fiber	Nitrogen Free Extract	Fat	Nutri-tive Ratio
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

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.

Iowa planted 10,248,000 acres to corn in 1914. The average yield was 38 bushels. If each acre produced three tons of corn fodder, 3,340 pounds of stover per acre were left by husking the 38 bushels and leaving the stalks, leaves and husks in the field. However some of this is saved by pasturing.

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...	44.21	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.

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.

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.

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.

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.

	July 30th In Tassel	August 9th In Silk	August 21st Milk Stage	Sept. 7th Kernels Glazed	Sept. 23d Fully Ripe
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
Total Green Crop	18,045	25,745	32,600	32,295	28,460
Water	61,426	22,666	27,957	25,093	20,542

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 the 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, 1906	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.

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.

Corn fodder harvested in Iowa and the corn states today is cared for by means of improved machinery—the corn binder and the corn

*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.

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.

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, $2.00 per day for each team, and about 50 cents per acre for twine, the approximate cost of 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.

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.

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.

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."

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 in hills 3 inches apart yielded 3.6 tons of stover to 1 of grain, while that planted 12 inches apart yielded 1.3 tons of stover to 1 ton of grain. The former yielded 59 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 59 produced in the corn 3 inches apart were poor in quality, is an important consideration.

CORN IN THE SHOCK.

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.

Shredding.

Fodder cutters which clip the stalks 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.

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 satisfactory results in feeding shredded fodder. He states that there was a saving of 24 per cent by feeding in the shredded form.

Not only does shredding 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.

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.

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.

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.

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.

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.

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:"

"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."

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.

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 fodder. Also 1 ton of clover hay was equal to a little more than 3 tons of fodder. The hay was of excellent quality. The fodder 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.

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.

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					
	Per cent Water	Per cent Ash	Per cent Protein	Per cent Fiber	Per cent Nitrogen-Free Extract	Per ct. 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.

	Per cent Dry Matter	Per cent Organic Matter	Per cent Protein	Per cent Fiber	Per cent Nitrogen-Free Extract	Per cent 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.

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.

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.

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.

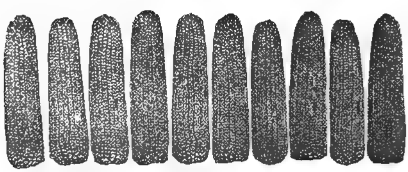
Why Pull Your Fodder,
North Carolina Bulletin No. 104.

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.

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 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.

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.

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.

Because grass land has been so cheap and the farm land so productive, the farmers of different sections of the corn belt 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 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 farmer grows.

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." 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.

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.

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.

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 trans-

*A temperature of 145 degrees Fahrenheit has been reported.

formations 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 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."

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.

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.

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 usually 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 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.

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 more smoothly because the stalks are cut one at a time.

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 percentage of grain is seriously reduced, thus lessening the feeding value.

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, the yield may be materially reduced.

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 16 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 apart.

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 harvested on the Experiment grounds of the Iowa State College on September 27th, immature and 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.

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."

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.

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 3½ feet apart will produce more fodder and of better quality than when planted thinner.

*The best variety of corn to plant is that which will mature and yield the largest amount of grain to the acre, since the grain is the most valuable part of the corn plant. The variety commonly grown in any particular locality for grain will also be the most satisfactory to grow for silage. As will be seen from the table below, taken from the First Annual Report of the Pennsylvania State College, 63 per cent of the digestible food materials present in the corn plant are found in the ears and 37 per cent in the stover.

YIELD OF DIGESTIBLE MATTER IN CORN.

CONSTITUENT	Yield per Acre		
	Ears Pounds	Stover Pounds	Total Crop Pounds
Protein	244	83	327
Carbohydrates	2,301	1,473	3,774
Fat	125	22	147
Total	2,670	1,578	4,248

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.

The following table from Professor Ladd of the Geneva Station, New York, substantiates the above statement:

*Farmer's Bulletin No. 556, United States Department of Agriculture.

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.

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 matures. 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.

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.

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.

FILLING THE SILO.

In the consideration of silage, nothing is more important than the question of proper filling of the silo. A large percentage of the losses which have been found in the wide range of experience with silos of all kinds has been due to improper filling. The recommendations of the United States Department of Agriculture in Farmers' Bulletin No. 556 are given as follows:*

"**Length of Cut.** The usual length of cutting varies from one-half to one inch. The latter is considered a little too long, since pieces of this length will neither pack so closely in the silo nor be so completely consumed when fed as will the shorter lengths. On the other hand, the longer the pieces the more rapidly can the corn be run through the cutter.

"**Packing the Silage.** Ordinarily the blower or carrier empties the cut corn into the top of the silo and there are one or more men in the

*By Professor T. E. Woodward.

silo to distribute and tramp the material. Unless there is some one to do this the cut material will be thrown too much in one place and the leaves, stalks and grain will not be uniformly distributed throughout the silo. The sides should be kept higher than the center and much of the tramping done close to the wall.

"Various contrivances have been used for distributing the silage. The one most to be recommended for this purpose, however, is a metal pipe similar to the one in which the cut corn is elevated, but put together loosely in sections. The corn from the blower passes down this pipe into the silo, and being loosely put together it can be swung so that the material can be placed anywhere in the silo. With this contrivance no work with a fork is necessary and one man can do the work of two or three and do it easier. There is very little loose material flying about in the silo and the work is much cleaner. Another advantage is a lessening of the danger of being struck by some foreign object which has passed up the blower pipe. Heavy knives of the cutter have been known to pass through the blower and into the silo. As has been mentioned, this pipe is put together in sections, so that as the silage rises in the silo the sections can be readily detached as required.

"**Adding Water.** In case the material has become too dry before it is put into the silo, water should be added to supply the deficiency of moisture and so make the silage pack better. Unless it is well packed the silage will 'firefang 'or deteriorate through the growth of mold. Enough water should be added to restore the moisture content of the corn to what it would be if cut at the proper stage. The water may be added by running directly into the silo by means of a hose or by running through the blower. It is claimed that by running it into the blower the water is more thoroughly mixed with the cut corn.

"It seems to be good practice, no matter what the condition of the corn, to thoroughly wet down the material at the top of the silo when through filling. This will help to pack the top layer and lessen the amount of spoiled silage on top.

"**Covering the Silage.** Several years ago it was a common practice to cover the silage with some material, such as dirt or cut straw, in order to prevent the top layer from spoiling. At present when any provision at all is made for this purpose it consists usually in merely running in on top corn stalks from which the ears have been removed. By this method some of the corn grain is saved. The heavy green corn stalks pack much better than straw does and so exclude the air more effectually. The top is thoroughly tramped and then wet down. Sometimes oats are sown on the top before wetting. The heat generated by the fermenting mass will cause the oats to sprout quickly and form a dense sod which serves to shut off the air from the silage beneath, and in consequence only a very shallow layer spoils.

"**Cutting Corn Fodder for Silage.** A practice used by some at the present time and one to be well recommended, is that of cutting up shock fodder and putting it into the silo after the silo has been emptied. Very often the feeder finds himself short of the amount of silage that he needs and by cutting up his corn fodder he is provided with a good quality of silage to carry him through. The main requirement in cutting up fodder to be put into the silo is to add an abundance of water. This practice results in a considerable saving of food material and adds greatly to the digestibility of the fodder.

"**Harvesting the Corn.** The corn is cut for the silo either by hand or by machine. Hand cutting is practiced on farms where the amount of corn to be harvested is so small as to make the expense of purchasing a corn harvester too great to justify its use. Hand cutting is also resorted to through necessity when the corn is down or lodged in such a manner as to prevent the use of the machine. This method of cutting, however, is slow and laborious and there are probably few localities now where the purchase of a harvester would not be a profitable investment.

"In using the harvester it will be found a great advantage to make the bundles rather small. This will take more time, but the extra expense will be more than offset by the ease in handling the bundles and in feeding them into the silage cutter. The harvester should not get so far ahead of the haulers that the corn will dry out to any considerable extent."

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

AMOUNT OF SILAGE NEEDED

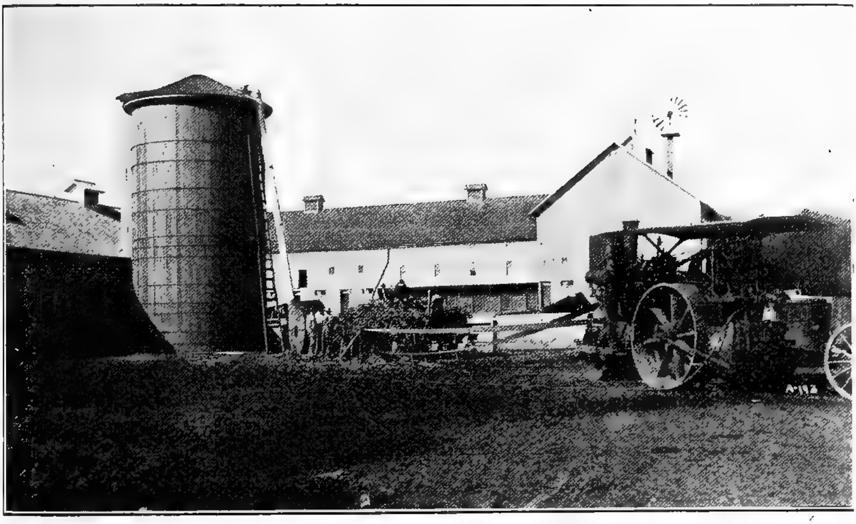
With good corn from 12 to 15 tons of silage may be secured per acre. 35 to 40 pounds of silage per day is sufficient when feeding cows.

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.

COST OF SILAGE.* As with the cost of filling the silo, no definite figure can be set as to the cost of silage. This will depend upon the yield per acre, the cost of growing an acre, and the cost of filling. Several years ago the cost was variously estimated at from $1.00 to $1.50 per ton. At present this is much too low. The before-mentioned data collected by the Dairy Division on the filling of 87 silos in various parts of the country show the cost of growing the silage crop to average $1.58 per ton. This added to the 87 cents, which represents the cost of filling, makes the total cost of the silage $2.45 per ton. The cost of the silage for the individual farms varied from $1.10 to $5.42 per ton. In general, it may be stated that $1.50 to $3.50 per ton represents the limits between which most of the silage is produced.



FILLING SILO AT THE IOWA EXPERIMENT STATION.

F. D. Coburn of Kansas estimates the cost per ton of filling the silo 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' Bulletin No. 292 shows the cost of a ton of silage as estimated on 31 farms:

*Farmer's Bulletin No. 556.

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

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	Per cent 1881		Per cent 1882		Per cent 1883		Av. Per cent	
	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
Nitrogen x 6.25........	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 Per cent	Protein Per cent	Dry Matter Per cent	Protein Per cent
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

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.

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.

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-

*Large shocks. 15.1 per cent for small shocks.

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.

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.

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

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.

"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."

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.

The following data gives the production of milk and fat:

	Number of Days	Total Yield of Milk Pounds	Average Yield per Day per Cow Pounds	Average Per cent of Fat	Total Yield of Fat Pounds	Average Fat per Day per Cow 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	—08
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 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.

Some Points in Favor of Silage.* Professor T. E. Woodward of the United States Department of Agriculture gives the following advantages for silage:

"1. More feed can be stored in a given space in the form of silage than in the form of fodder or hay.

"2. There is a smaller loss of food material when a crop is made into silage than when cured as fodder or hay.

"3. Corn silage is a more efficient feed than corn fodder.

"4. An acre of corn can be placed in the silo at less cost than the same area can be husked and shredded.

"5. Crops can be put in the silo during weather that could not be utilized in making hay or curing fodder.

"6. More stock can be kept on a given area of land when silage is the basis of the ration.

"7. There is less waste in feeding silage than in feeding fodder. Good silage properly fed is all consumed.

"8. Silage is very palatable.

"9. Silage, like other succulent feeds, has a beneficial effect upon the digestive organs.

"10. Silage is the cheapest and best form in which a succulent feed can be provided for winter use.

"11. Silage can be used for supplementing pastures more economically than can soiling crops, because it requires less labor, and silage is more palatable.

"12. Converting the corn crop into silage clears the land and leaves it ready for another crop."

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.

Farmer's Bulletin No. 556.

*Farmer's Bulletin No. 556.

CHAPTER XVIII.

JUDGING CORN

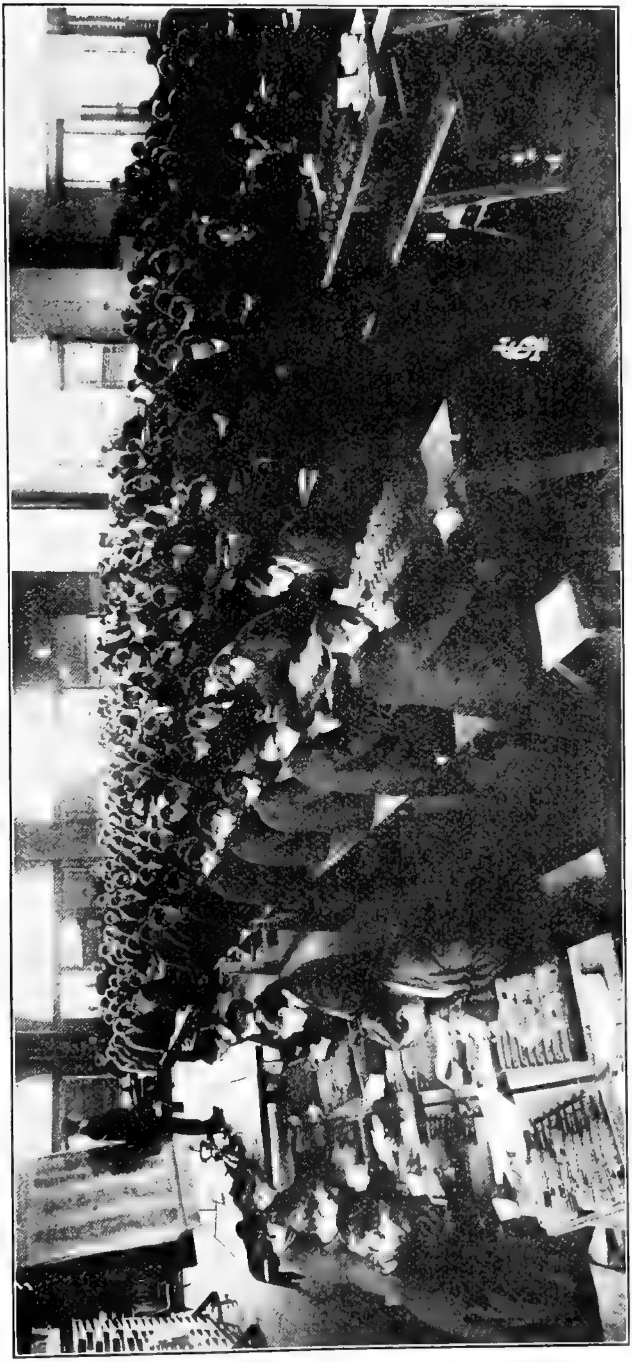
WHY JUDGE CORN? The highest and only purpose of the judge is to give first ranking to that sample which in his estimation will, if planted the next spring, produce more corn of better quality than any other sample on exhibition. Furthermore, it should show breeding, that its good qualities may be more 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 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.

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

*Indian Corn Culture, Plumb, Page 56.



SHORT COURSE STUDENTS JUDGING CORN AT THE IOWA STATE COLLEGE.

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 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 few 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 changed 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.

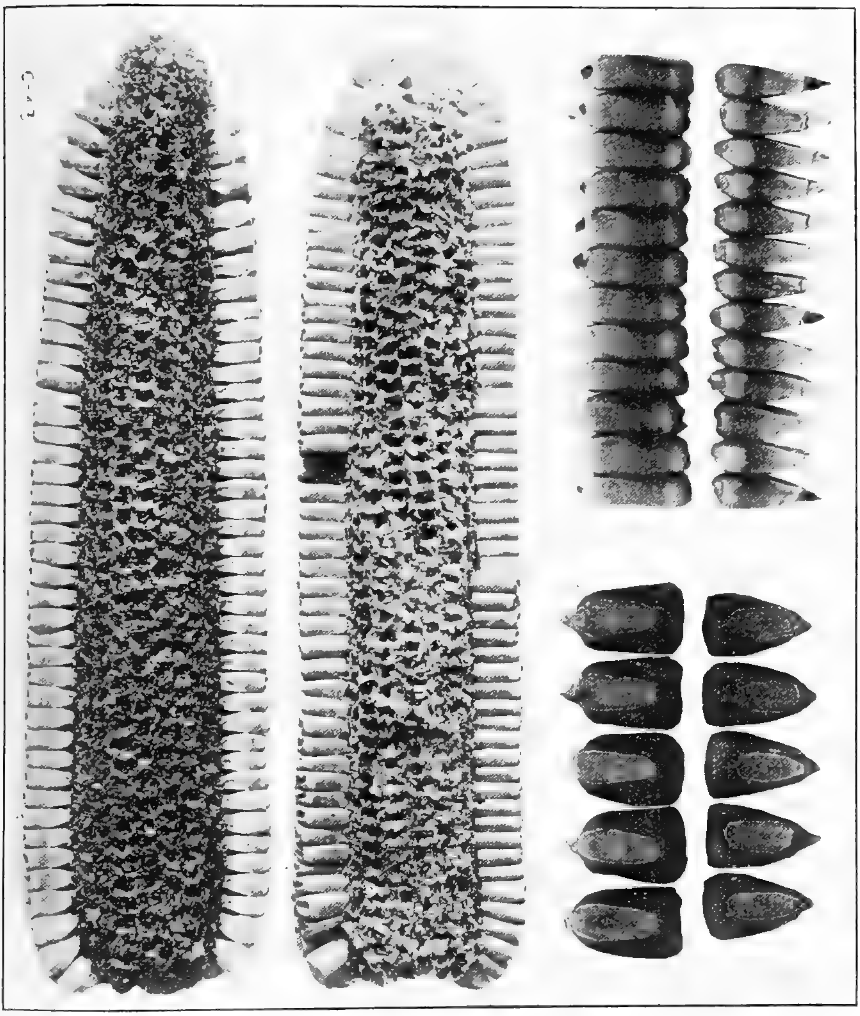
SCORE CARD USED BY THE FARM CROPS DEPARTMENT OF THE IOWA STATE COLLEGE.

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



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.

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 butt 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.

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.

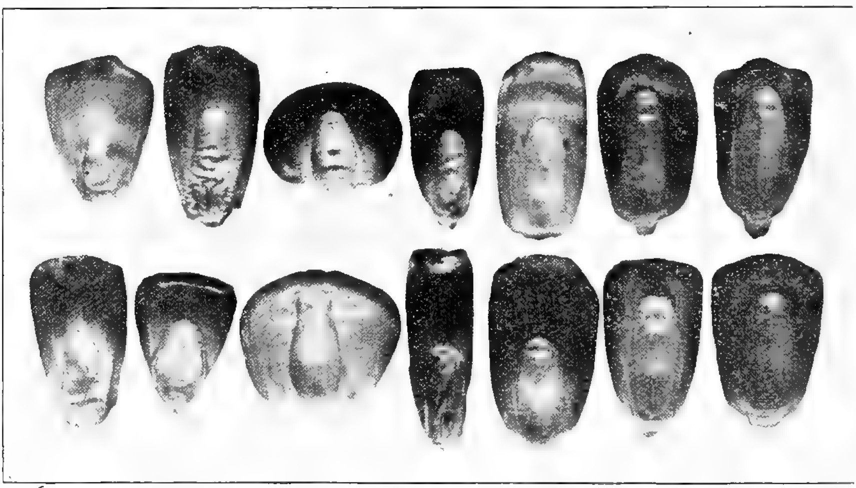
5. **Purity of Color of Grain.** In color, the kernels should be free from mixture and also true to the variety which they represent.

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.



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.

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 central sections, 8¾ to 9¾; in the southern sections, 9 to 10 inches. The circumference should generally be 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.

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).

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.

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.
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.

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.

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.

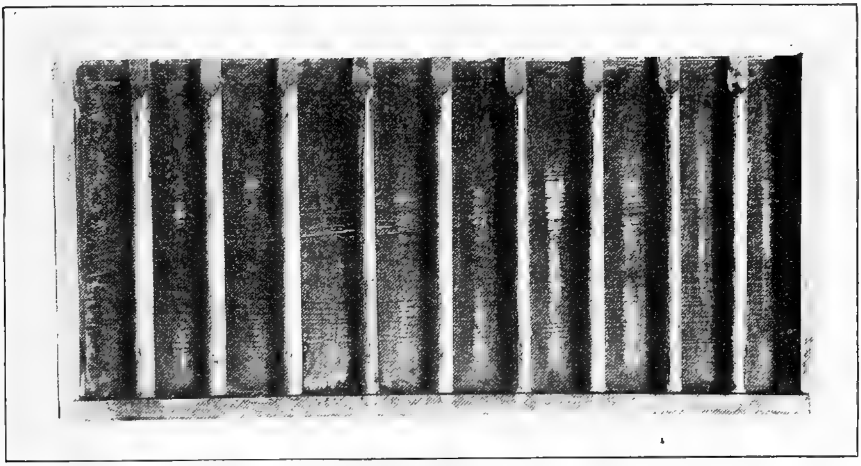
Beginning at one end, take two kernels out of each ear, near its middle, place the kernels, germ side up with tips of kernels pointing toward the ear, at its tip. An experienced judge can now pass upon each sample with his eye as he slowly walks by and immediately eliminate some samples from the competition. 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.

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-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.

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.

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.

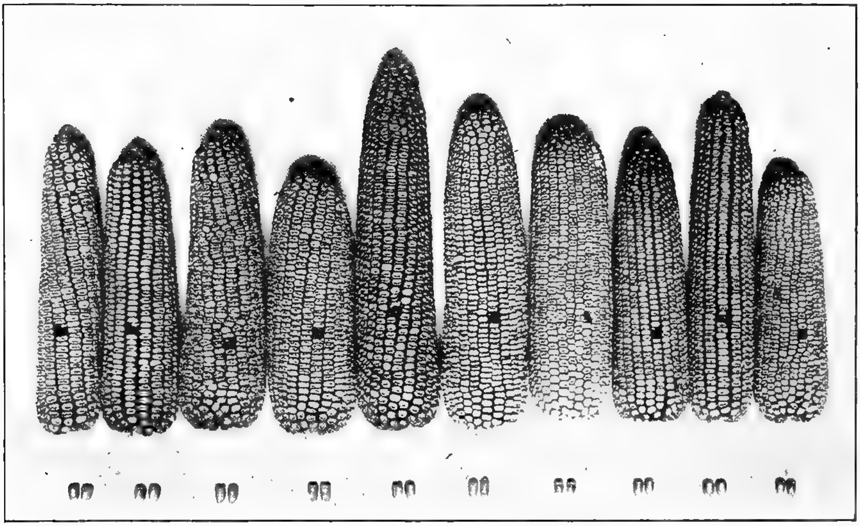
When all the samples are placed, a good plan is to walk around the tables once more to satisfy one's self that no samples of worth have been overlooked. Always maintain a respect for the opinions of those who may be on-lookers or owners. They are present to learn, if not to criticise. Answer questions 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.



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.

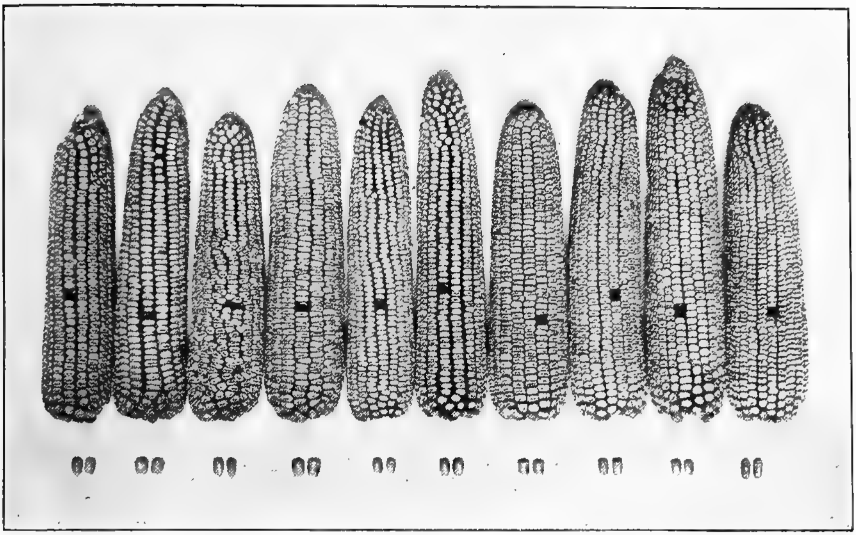


SAMPLE LACKING UNIFORMITY IN LENGTH OF EARS.

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.

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.

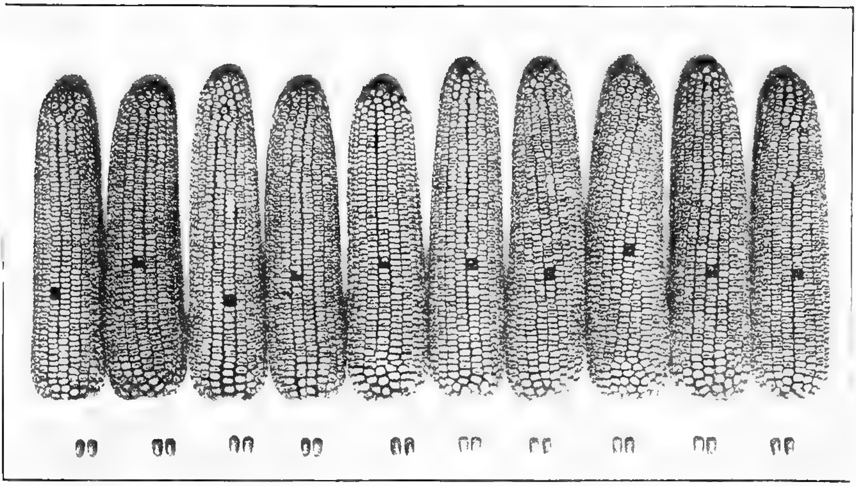
There is another class of samples that is very frequently found at corn shows in which the ears are of quite uniform size and shape, yet the kernels are greatly different.



SAMPLE SHOWING FAIR UNIFORMITY IN LENGTH OF EARS BUT THE KERNELS ARE OF DIFFERENT TYPES.

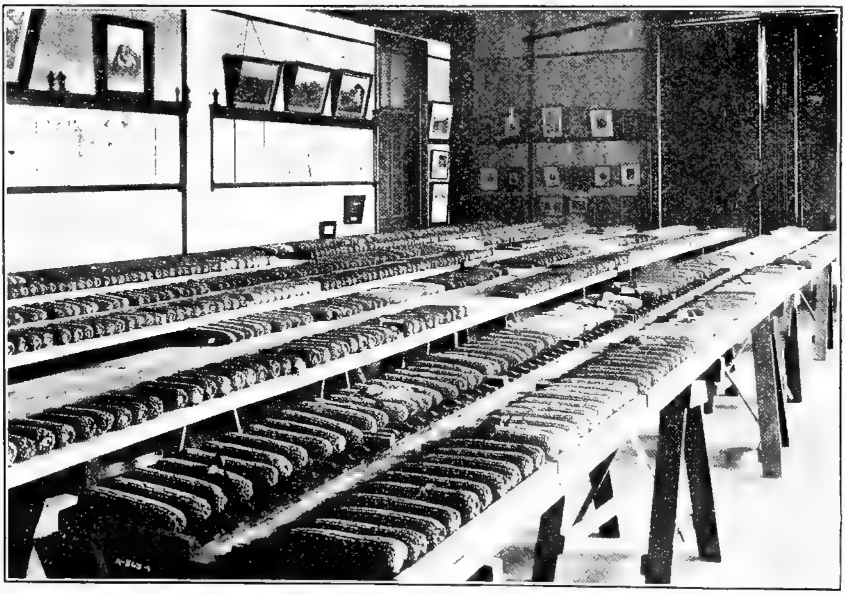
Very frequently at corn shows the following question will be asked by exhibitors: "Has a person a right to take kernels out of an ear to examine them before showing?" He most certainly has! It is impossible for him to be sure regarding the depth of the kernel without making an examination. The best way 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.

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



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



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.

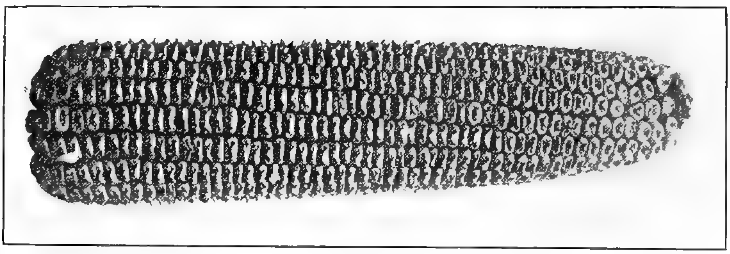
THE VARIETIES OF DENT CORN

NOW PRINCIPALLY GROWN IN THE CORN BELT

LEAMING.

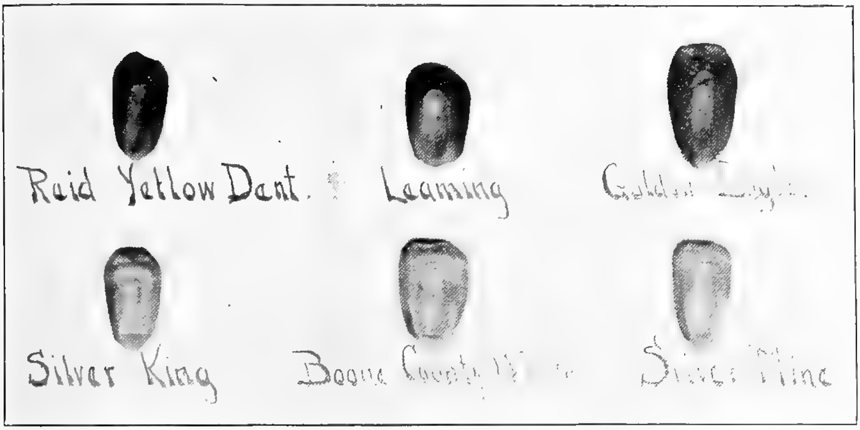
HISTORY. This is the oldest known variety of corn, having been originated by Mr. J. S. Leaming, near Wilmington, Ohio, in 1826. At this time he began selecting seed from the ordinary yellow corn grown in Hamilton County on the Little Miami bottoms. As soon as the ripening of the husks indicated that 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.



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.



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 with a deeper kernel. The cob is often large and the shelling percentage is seldom over 88 per cent.

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.

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. Maxcy, 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.

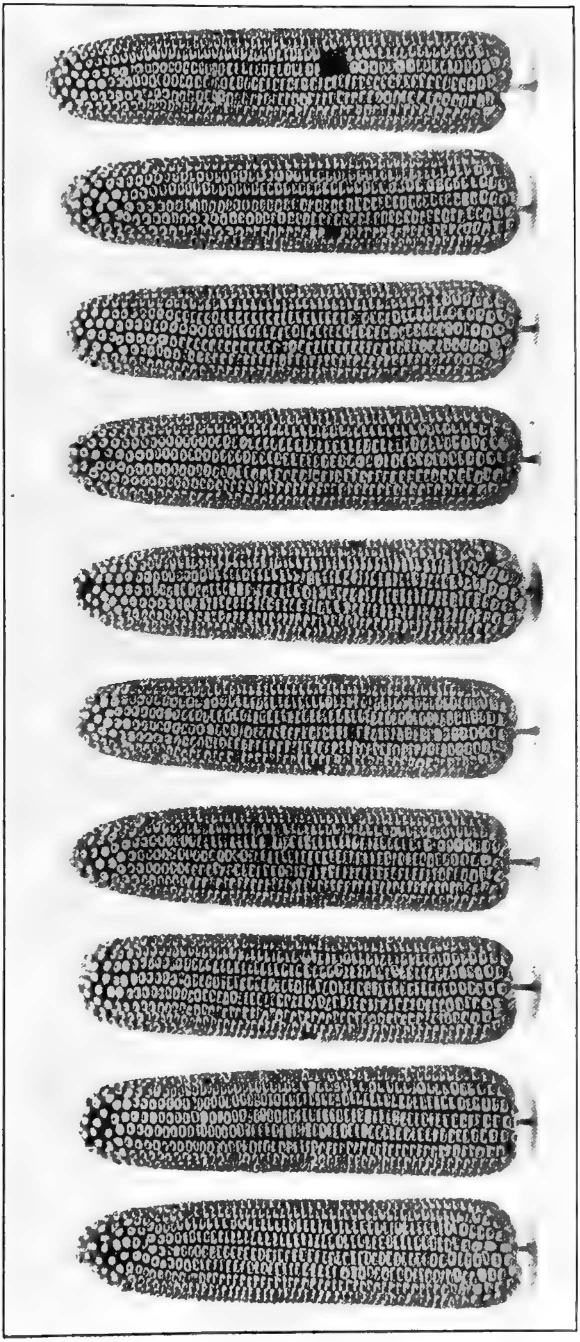
In Iowa, the Leaming strain is shown in almost all the unimproved corn throughout the state. The large shank and tapering ears are commonly present. This corn, however, has been a fair yielder and always hardy. Fred Woolley, of Garden Grove, Decatur County, is the only breeder who has tried to improve 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

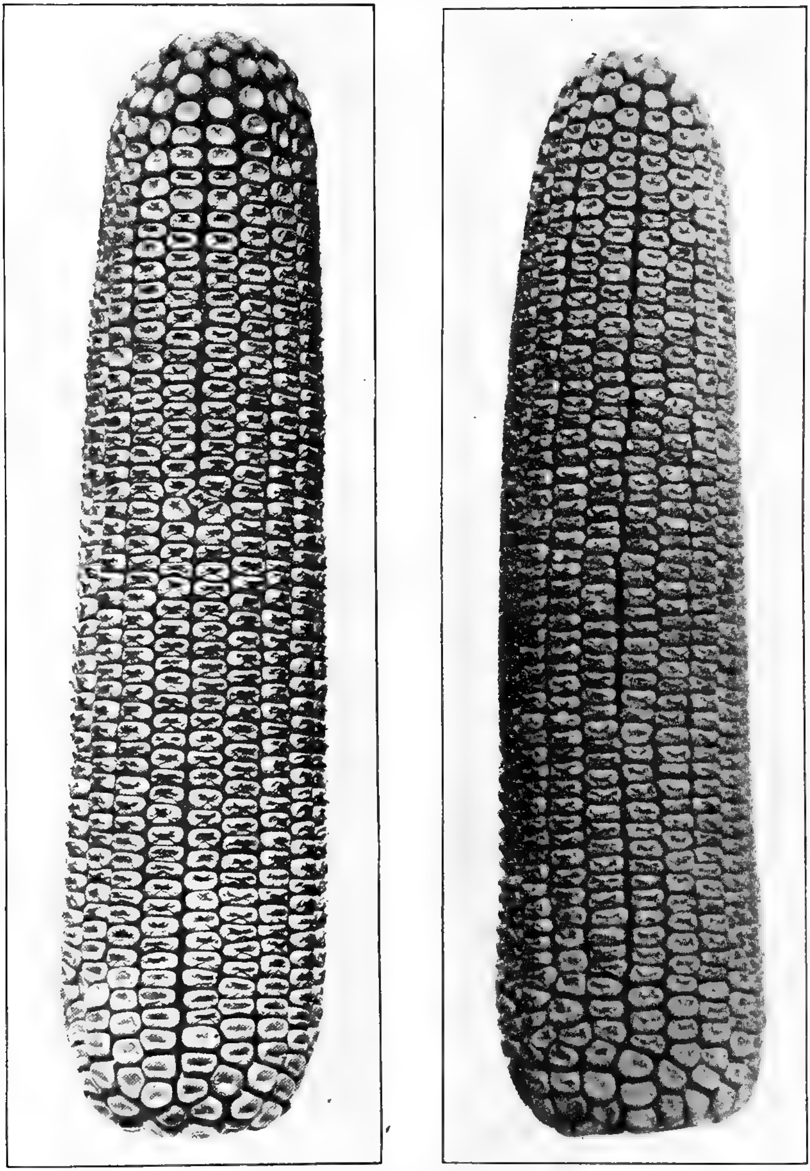
EARLY HISTORY. In 1846 Mr. Reid moved from Brown County, Ohio, to Tazewell County, Illinois, taking with him a reddish colored variety of corn known as the "Gordon Hopkins" corn, which was widely grown in the vicinity where Mr. Reid had lived. The corn was planted late in the spring of that year and 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.

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



REID'S YELLOW DENT. CHAMPION TEN EARS OF IOWA SHOWN JANUARY, 1907. GROWN BY BENNETT BROS.



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.

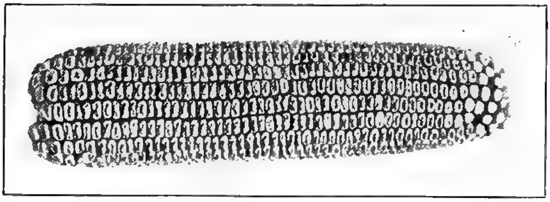
Kernels. The distinct pairing of the rows of kernels, the extreme triangular outline of the edges of the kernels which dovetail together and the large open-faced germ extending almost to the crown and covering the face of the wedge-shaped outline, are all characteristics of the Reid corn. Usually the 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.

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.

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.

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.



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.

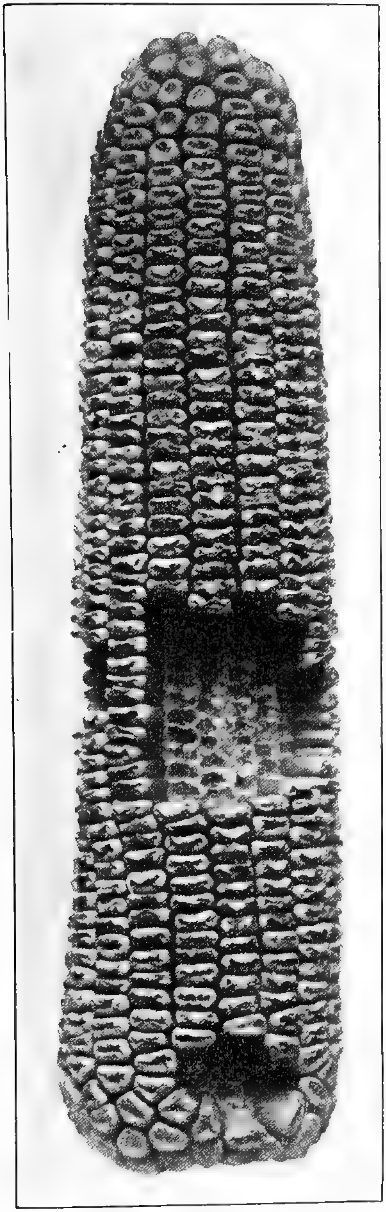
W. A. Hook, of Packwood, though starting in a small way, may be said to be keeping the closest records of his breeding work of any breeder in the state.

Among other men who are producing a consistent type of Reid corn in Iowa are John Sundberg, of Whiting; Bennett Brothers, of Ames; M. S. Nelson, of Goldfield; Fred McCulloch, of Hartwick; L. C. Hutcheson, of West Branch; Neal Brothers, of Mt. Vernon; George M. Allee, of Newell; W. P. Coon, of Ames; Charles O. Garrett, of Mitchellville, C. R. Bishop, of Altoona and Willard Zeller, of Cooper.

IOWA SILVER MINE

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.



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.

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 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.

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.

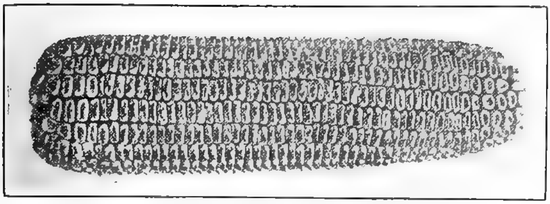
CONTEMPORARY BREEDERS. F. A. Warner, manager of the Sibley Estate, Sibley, Illinois, has bred the Silver Mine corn for a number of years. His type is somewhat larger than that of Iowa and is coarser in the cob and later in maturing.

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

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 they 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.



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.

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.

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.

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.

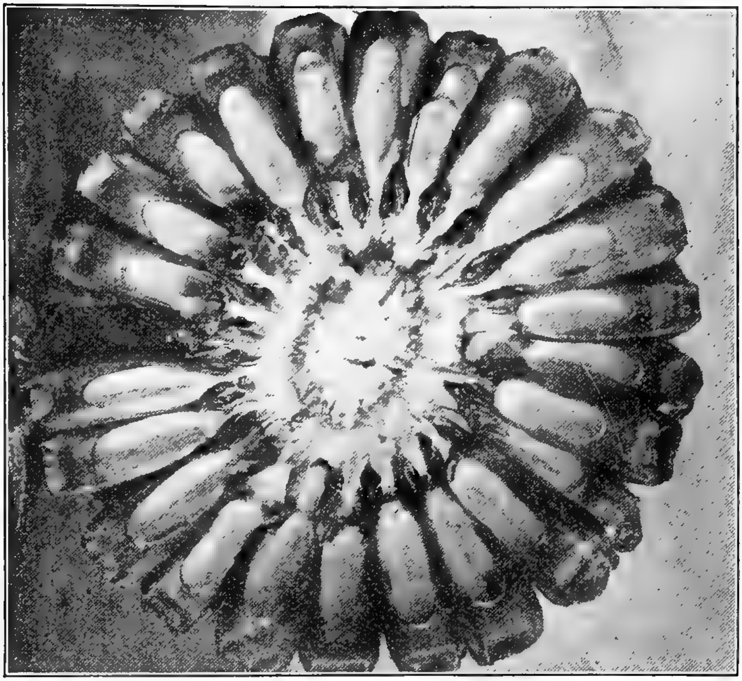
In Iowa, Lenus Hagglund, of Essex, on the rich soil of the Nishnabotna, has kept very pure and raised to high standard of productiveness and quality, a type of Boone County which, although of a rough dent, shows the original form. Because of the quality of this seed a considerable locality near Essex has taken up the variety. F. S. Bone, of Grand River, breeds the Riley type strictly.

LEGAL TENDER

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. The ear of Legal Tender when judged by the standards of other breeds seems to lack proportion. That is, its extreme length, 9½ 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.



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 narrow 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.

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

JOHNSON COUNTY WHITE

*The Johnson County White variety was originated in Johnson County, Indiana about twenty-two years ago. It is a cross between Boone County White and Forsythe's Favorite.

The first work done in producing this variety was in 1890, when Mr. J. D. Whitesides crossed a white variety which he had been calling Dungan's White Prolific (afterwards found to be Boone County White) with Forsythe's Favorite. Somewhat later Mr. L. B. Clore, who was also living in Johnson County, made the cross between Boone County White and Forsythe's Favorite, independently of Mr. Whitesides. At about this same time Mr. J. R. Overstreet began breeding this corn from seed received from Mr. Whitesides. Each man gave a different name to the corn, Whitesides calling it Whiteside's Imperial White Dent, Clore calling it Farmer's Interest, and Overstreet naming it Overstreet's Peerless. In 1899 the three men decided to combine and to call the corn the Johnson County White Dent by which name it is now generally known.

Excellent work has been done in breeding up this variety and it won the grand sweepstakes prize for three years at the National Corn Show.

The corn does not differ materially from Boone County White in size, but it is rougher and the tips have a sharper taper. In Missouri the length is ten and one-half inches to eleven inches, and the circumference seven and one-half to seven and three-quarters inches. The kernels are somewhat narrower and are nearly square at the summit, having straight instead of curved sides. They also average deeper than do those of Boone County White and are more starchy in composition, which gives them a rather starchy white color. The rows are straight and kernels uniform. The indentation is properly a deep crinkled crease to a short pinch.

*Missouri Experiment Station.

Johnson County White is a medium late maturing variety requiring a growing season of from 120 to 125 days; in which respect it is similar to the Boone County White. In stalk character also it is very similar to the Boone County, being plentifully supplied with foliage, and naturally requiring a fertile soil to produce a good quality of corn.

GOLDEN EAGLE. 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 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.

GOLDEN ROW. Golden Row originally came from Scioto County, Ohio, 41 years ago, but has been grown by Lee Smith & Son, of DeSoto, Nebraska, as a distinct variety for over thirty 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 7½ to 8½ inches. Although having a strong tendency to sucker it matures in from 110 to 120 days.

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 seed 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.

His selection was as follows: Kernels one-half inch in length and one-fourth inch in width; ears 11 inches long, 7½ inches circumference, with little space between rows. The White Superior is adapted to central and north central sections of the state of Illinois.

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.

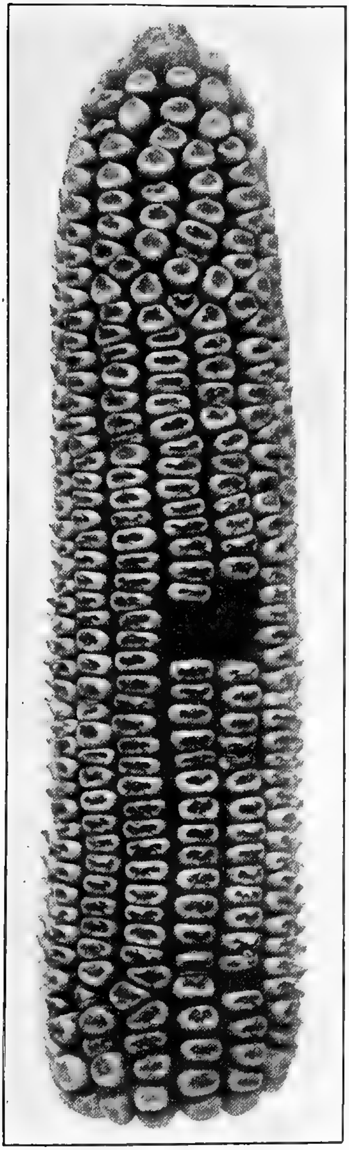
***History.** The Shenandoah Yellow has been a distinct variety or rather type, in the vicinity of Shenandoah, Iowa, for twenty years. It is the result of improving and selecting good strains of yellow corn brought there from Illinois by the early settlers. It represents the southwestern Iowa idea of 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.

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.

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 1870. Forty 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.



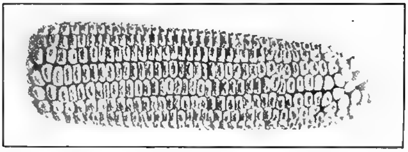
PRIDE OF THE NORTH.

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 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



SILVER KING.

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."

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.

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."

GOLDEN GLOW.

**Golden Glow corn, Wisconsin No. 12, is a cross between Wisconsin No. 8, a selection from the Minnesota No. 13 grown at this Station, and North Star, Wisconsin No. 11. The Wisconsin No. 8 was used as the male parent and the No. 11 as the female. The No. 8 is a rather small, very early-maturing corn, while the No. 11 is considerably

*Prof. R. A. Moore, University of Wisconsin.
**B. L. Leith, Instructor in Agronomy, University of Wisconsin.

larger and later maturing. The object of the cross was to obtain the early quality of the No. 8 combined with the size of the No. 11. The No. 8 and No. 11 were planted in alternate rows in 1905. The tassels of all of the No. 11 were removed, thus all the corn produced on the No. 11 stalks were of hybrid nature. Selection was made from this cross for earliness and size. The first few years showed considerable variation in type, but after rigorous selection for ten years a very uniform corn has been produced. As soon as the corn showed constancy of type it was distributed to the members of the Wisconsin Experiment Association and tested out in a large way throughout the state. From reports from hundreds of members each year, the Station was assured that we had a variety of corn of superior quality. It proved to be a good yielder and vigorous grower and was found especially adapted to the central part of the state.

Characteristics. The plant grows to a height of eight to twelve feet, is well leaved and vigorous. The ear is a deep yellow, or golden in color, length $8\frac{1}{4}$ to $9\frac{1}{4}$ inches, circumference $6\frac{1}{2}$ to 7 inches. The shape of the ear is nearly cylindrical, with a moderately rounded butt and tip. The cob is cherry red, from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter. The number of rows on the ear varies from fourteen to eighteen. The kernel is a medium wedge in shape, medium deep and crumpled indentation.

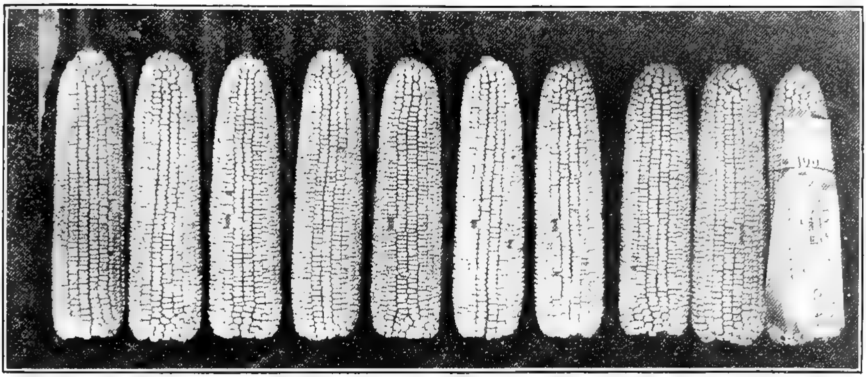
NEBRASKA WHITE PRIZE. Nebraska White Prize is a very strong heavy rooted variety, stands drouth well, and is extra free from suckers. The crop matures in 110 to 120 days and produces an ear 9 to 11 inches in length by $7\frac{1}{2}$ to 8 inches in circumference. This variety has been bred pure for 38 years. It has been selected to a definite type by Lee Smith & Son, of DeSoto, Nebraska, for the last 32 years.

BLOODY BUTCHER. Bloody Butcher is a variety that takes its name from its color, which is a mixture of red and yellow, and like all varieties which take their name from one characteristic, its other characteristics may show a wide variation. It is medium early and has a very deep grain. It has local names in some sections.

CALICO CORN.* Calico corn is another variety which takes its name from its peculiar color. It is a mixture of white and blue grains, although mixtures of red and white or red and yellow are also called Calico. The latter are, however, of the Bloody Butcher type. Calico is grown in many localities and it has no fixed characteristics.

*Ohio Circular No. 117.

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



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.

**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.

"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.

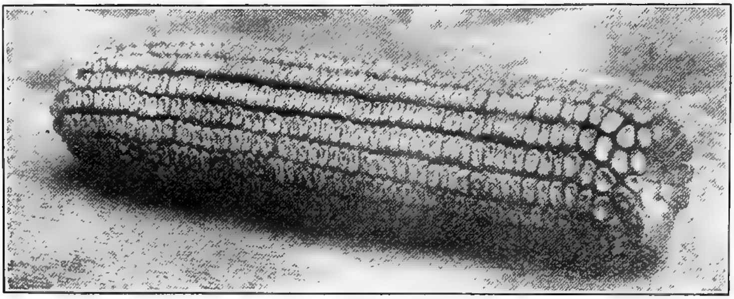
KANSAS SUNFLOWER. The Kansas Sunflower variety originated with John Moody, Eudora, Kansas. Although the ears are somewhat small in circumference, the length allows a very heavy yield. This variety is especially adapted to rather dry soil. The rich yellow color and deep kernel make it a good feeding corn, 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

*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.



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.

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.

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New Strains of Corn,
U. S. Report No. 83.

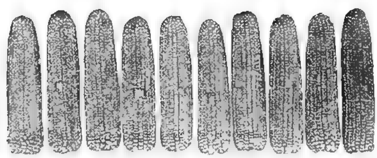
Variety Tests of Corn,
North Dakota Bulletin No. 75.

Variety Tests of Corn,
Virginia Bulletin No. 165.

Variety Tests of Corn,
Indiana Bulletin No. 124.

Johnson County White,
Missouri Bulletin.

Ohio Circular No. 117.



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.

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.

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 three. 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.

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.

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.

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 or 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.

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 undoubtedly 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.

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			Ear No.	WEAK SEED		
	Germination	Stand	Barren		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.

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.

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 spring with cool days and nights so unfavorable for the growth of the young corn plants, the amount of barrenness will be increased.

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.

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. These 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	Per cent Stand	Per cent Barren
	S. W. B.		
31	6—0—0	61.9	4.6
33	6—0—0	62.4	14.5

S—Strong. W—Weak. B—Bad or Dead.

HENRY COUNTY 1907.

Ear No.	Test	Per cent Stand	Per cent Barren
	S. W. B.		
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	Per cent Stand	Per cent Barren
	S. W. B.		
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 one 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 two causes.

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:

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	Per cent Stand	Per cent 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	Per cent Stand	Per cent 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.

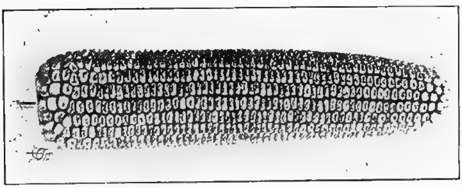
Examining Ear and Stalk. A study of the growing ear on the stalk is very important. The contrast in height will be found to be reproduced in a marked degree from year to year; likewise the regularity of rows and uniformity of kernels together with the early maturing qualities. Four feet from the ground 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 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.

EAR TOO HIGH ON STALK.

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 to 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.



CHAPTER XXI.

CORN BREEDING

FROM THE STANDPOINT OF REMAINING PERMANENTLY IN THE BUSINESS

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 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.

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 has been little done along the line of corn breeding; or 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.

It is to be expected of the corn breeder that he take greater care in the selection of his first or foundation stock. Fifty ears 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.

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.

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 the 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 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 corresponds 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.

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.

Individuality of Ears.

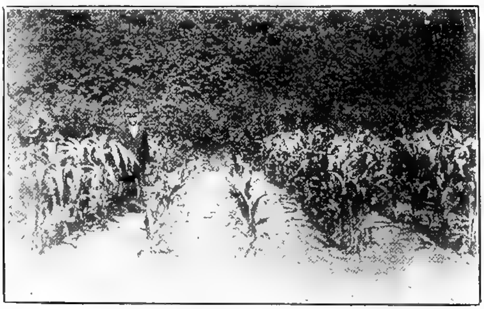
The productive power is now definitely known. For example, ears Nos. 1 and 50 may have yielded 90 bushels and 100 bushels respectively, while Nos. 30 and 40 may have produced in turn 20 and 35 bushels. The locality and fertility of the soil will determine the standard from which to base selections. Some 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

Ear No.	Breeder	Yield Mother Ear 1906	Test	% Stand	% Suckers	% Barren	% Smut	% Seed	% Market	% Nubbins	% Worthless	Weight	Bu. per A.	Breeders 1908	Numbers	
1	Iowa Exper. Station		600-600	68.1	28.0	7.4	3.8	6.3	82.5	11.2	0	62	62			
2	"		600-600	84.0	3.9	4.9	3.9	3.7	88.8	4.7	2.8	88	88	1	41	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		938	600-600	70.4	53.0	16.1	7.2	16.5	79.7	3.8	0	73	73	4	214-215-216-217	
10	"	911	600-600	84.5	15.7	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	3.3	2.7	5.4	94.6	0	0	60	60			
12	"	836	600-600	78.1	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	1.1	1.1	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	8.2	6.1	8.7	76.9	6.7	7.7	88	88	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	16.5	6.7	4.8	11.9	78.9	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	1.1	0	6.8	89.8	3.4	0	77	77			
38	Adolph Klopping		600-510	59.0	13.5	0	3.4	10.5	81.6	2.6	5.3	66	66			

RECORD OF CORN BREEDING OPERATIONS

yielded well, and have proved after a test the second spring that their 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 Nos. 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.



EFFECT OF INBREEDING

The two rows in the center are dwarfed because of inbreeding.

It will be seen that these two 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.

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.

DETASSELING CORN.
Pull out the tassel; do not cut it.

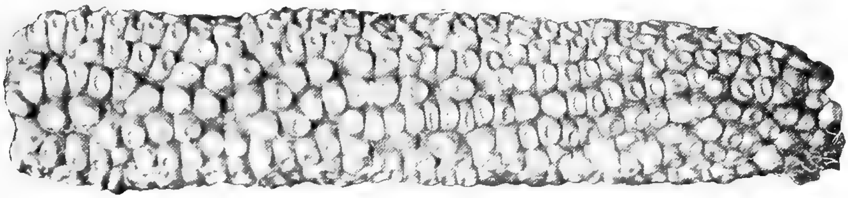
How to Detassel. Tasseling time usually comes during the harvest season. The farmer has plenty of work on hand. But just then the most important step in the process of advancement in corn breeding must be made. Every day for from seven to ten days new tassels will appear. Detasseling is a process which 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.

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

"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 Nos. 1 and 5, for example), select 25 to 30 of each. It is very likely



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.

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 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."

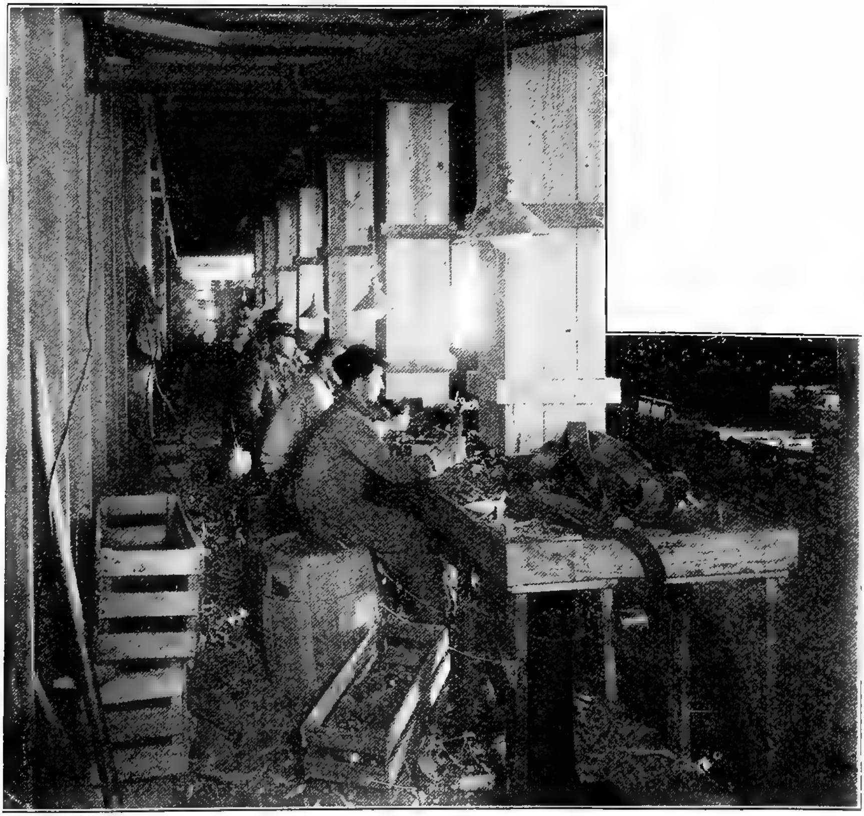
PURE BRED AND HIGH GRADE SEED. The corn produced in the increase beds may be classed as "pure bred" seed corn. As a definite line of breeding has thus been followed out, the parentage of the ears may be thus traced back to the individual ear row test. The corn breeder will, no doubt, have other of his 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 as 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.

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 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.

HAND PICKING SHELLED SEEDCORN.

The corn is carried over a belt.

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.



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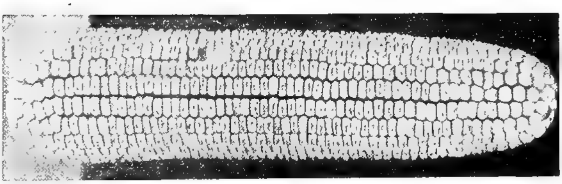

CHAPTER XXII.

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.

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.

"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 the kernels of which 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.

The method of selecting seed corn for high oil content on the basis of large germs is certainly well founded, because of the fact that more than 80 per cent of the total oil of the kernel is contained in the germ.

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.	Per cent Oil	Per cent Protein	Per cent Oil	Per cent 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.

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 was 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."*

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 contains 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.

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 Per cent Oil	Per cent Germ	Ear No.	HIGH OIL CORN Per cent Oil	Per cent Germ
4,474	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.

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.

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 protein 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 actually exists in 100 pounds of corn.

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

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