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FOR BETTER
CROPS -



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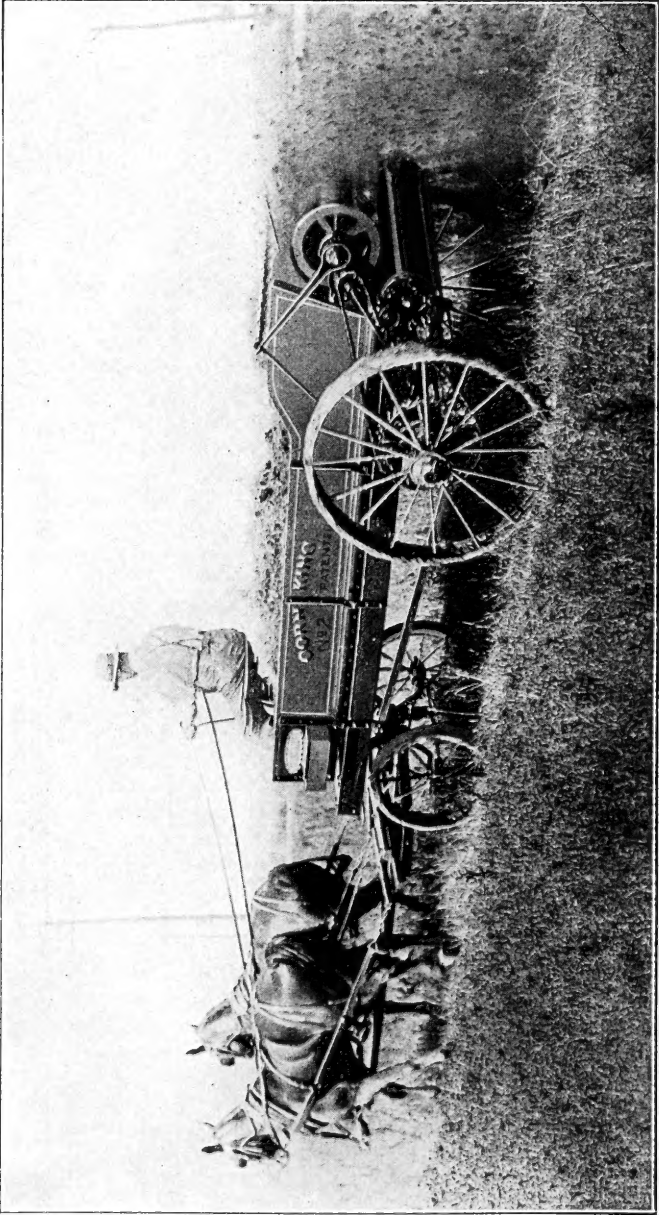
Introductory

THE subjects treated in this book cover a wide range of thought, and we present them in this form for the convenience of those who are endeavoring to make their acres yield larger and more profitable returns. Today the farmer is working toward a well-defined purpose—his constant aim is to do less work that requires muscle and brawn, but more brain work. He purposes to purchase machines that will do the drudgery and irksome tasks while he himself solves the problems of farm management—and the purpose of this book is to help the farmer achieve that end.

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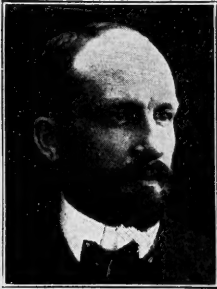
An I H C manure spreader making the acres more fertile

Increasing Fertility

ELEMENTS OF SOIL AND THEIR VALUE TO CROPS — FERTILIZERS AND SOIL BUILDING

By CYRIL G. HOPKINS

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IF he who made two blades of grass grow where only one grew before is a public benefactor, then he who reduces the fertility of the soil so that only one ear of corn grows where two have been grown before is a public curse.

Agriculture is the fundamental support of the American nation, and soil fertility is the absolute support of agriculture.

Without agriculture, America is nothing. The forest and the earth supply the timber, the stone, and the metal to build and equip railroad and factory, and the fuel to operate mill and locomotive, but directly or indirectly these great industries are absolutely dependent on agriculture for their continued existence.

The Two Functions of the Soil — The soil has two distinct functions to perform in crop production: First, the soil must furnish a home for the plant, where the roots can penetrate the earth upon which the plant must stand; second, the soil must furnish plant food, or nourishment, for the growth, development, and maturing of the plant.

To improve the physical condition of the soil is to improve the home of the plant; while to add to the soil, or to liberate from the soil fertilizing materials, is to increase the available supply of plant food.

One soil may furnish an excellent home for the plant, but a very insufficient supply of plant food; while another soil may contain abundance of plant food, but the physical conditions (such as imperfect drainage, or inadequate aeration) may be such as to make an unfit lodging place for the plant.

The Six Essential Factors in Crop Production — There are six essential and positive factors in crop production: (1) the seed, (2) the home or lodging place, (3) moisture, (4) heat, (5) light, and

(6) plant food. Some negative factors are injury from insects and plant diseases.

Good seed is exceedingly important, and the quality of the seed selected and planted is largely under the control of the farmer.

By proper drainage, by the use of organic matter, and by proper tillage, thus maintaining good physical conditions, the farmer may provide a suitable home for the plant, remove surplus water, render the soil more capable of absorbing and retaining necessary moisture, and control the temperature to some extent by lessening evaporation and by changing the color of the soil, as by the addition of organic matter.

More than five times as much heat is required to evaporate water from the surface of the soil as would be needed to raise the temperature of the same amount of water from the freezing to the boiling point. It is because of this that wet, poorly drained soils are cold. Dark soils absorb more heat and consequently are warmer than light colored soils.

Light is a factor over which man has no direct or positive control, but he has full control over some negative factors, such as weeds, which if allowed to grow might largely prevent the light from reaching the young plants. Indeed, the first and greatest damage caused by weeds is due to the fact that they shut off the light from the growing plants. If the supply of moisture or of plant food is insufficient for both the crop and the weeds, then the weeds may rob the growing crop of these essentials to some extent.

So-called nurse crops, such as oats or wheat when growing with clover, may grow so thick and rank as to injure to a marked extent the clover, by shutting out the light, also by robbing the clover plants of moisture and plant food. To avoid these injuries or difficulties, the clover should be started with a light seeding of wheat or oats (about one bushel to the acre) preferably planted in drills running north and south, which will permit the strong midday light to reach the clover plants.

If oats are seeded as the nurse crop, they should be an early maturing variety, or, they may be pastured off or cut early for oat hay. The surest method of obtaining a good setting of clover is to sow it without a nurse crop and pasture the field or clip the weeds with a mower if necessary.

The least understood and the most neglected essential factor in crop production is plant food. Food of required kinds and in sufficient quantity is as necessary for plants as for animals; and it is even more important to provide an ample and balanced ration for corn than for cattle, because cattle are usually able to move about and find some food for themselves, while the corn plants are stationary and limited to the food within reach of their roots.

The Ten Essential Plant Food Elements—There are ten different elements of plant food, each of which is absolutely essential to agricultural plants. These elements are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, iron, and sulphur.

Carbon, hydrogen, and oxygen, which constitute more than 90 per cent of most agricultural plants, are contained in air and water, the supply being unlimited. The two elements, iron and sulphur, although absolutely essential to plant growth, are required in very small amounts, while they are provided by nature in practically inexhaustible quantities.

On the other hand, the five elements, nitrogen, phosphorus, potassium, calcium, and magnesium, are required by plants in very considerable amounts, and soils are frequently found which are so deficient in one or more of these five elements as to limit



The old way was a disagreeable job

the yields of crops. It should be understood that soils are never found which are entirely devoid of these elements. Even the poorest and most unproductive soils still contain at least some small supply of each of these elements, and as a general rule such so-called exhausted soils contain at least one and frequently two or three of these valuable elements in large amount, the low productive capacity being due to the deficiency of one or two elements only.

Sometimes the element which the plant fails to obtain in sufficient quantity for its normal growth, the element which positively limits the yield of the crop, is actually present in the soil in very large amount. In such cases the practice should not be to add to the soil more of this plant food element, but to adopt methods of soil treatment and management by which

we can liberate a sufficient amount of this element for maximum profitable crop yields. This point will be further discussed in the following pages.

Nitrogen—The element nitrogen ought never to be bought in general live-stock or grain farming. The atmospheric pressure is fifteen pounds to the square inch. Of this, about twelve pounds pressure is due to the nitrogen contained in the air. If we compute the value of this nitrogen at fifteen cents a pound, the price commonly paid for the nitrogen in commercial fertilizers, we find about \$11,000,000 worth of nitrogen resting on every acre of the earth's surface.

It is true that such crops as corn, oats, wheat, timothy, cotton and tobacco have no power to make any direct use of this



A wasteful method of handling the manure

atmospheric nitrogen, but there is a class of plants known as legumes, including such valuable agricultural plants as red clover, alsike, alfalfa, crimson clover, cow peas, soy beans, vetch, etc., upon the roots of which there are or should be small nodules or tubercles, varying from the size of pin heads upon clover roots to that of peas upon soy beans, in which live great numbers of very minute microscopic organisms, called bacteria, which have power to take nitrogen from the air as it enters the pores of the soil, to cause this free gaseous nitrogen to combine with other elements in suitable form for plant food which is then taken up by the clover or other legumes for its own growth.

If the roots and stubble are left to decay in the ground, the nitrogen which they contain becomes available to succeeding crops of corn or other grains or grasses, but on land of moderate productive power the soil will furnish as much nitrogen to the

clover crop as will be contained in the roots and stubble after the hay and seed crops are harvested. If the entire legume crop is plowed under as green manure, then all of the nitrogen taken from the air is left in the soil for succeeding crops.

If the crops are fed to animals provided with plenty of absorbent litter or bedding, as straw or refuse shredded corn fodder, so that all liquid excrement is saved, then about 75 per cent of the nitrogen contained in the feed may be returned to the land in the farm manure.

In very intensive farming, as in market gardening near large cities, if the land is too valuable to be given up even for a part of a year to the growing of legumes for fertilizing purposes, then it becomes necessary to apply nitrogen; and this is also profitable, for the products of one acre frequently bring \$100 or more



Exposing the manure to the elements

for one season. In emergencies, commercial nitrogen, especially cotton-seed meal, may well be used for cotton, because of its high value per acre; but, as a rule, farm manure, or legumes as green manures, could be substituted with greater profit in the long run.

Where it can be obtained, stable manure is usually the most economical and satisfactory form in which to apply nitrogen in market gardening, although cotton seed or cotton-seed meal, dried blood, tankage, sodium nitrate, and ammonia sulphate are also used with profit at times.

Phosphorus—If the element phosphorus becomes deficient in the soil, the total supply can be increased only by making an actual application of some kind of material containing phosphorus.

It is well to bear in mind that about three-fourths of the

phosphorus required for ordinary grain crops is stored in the seed or grain, while only one-fourth remains in the straw or stalks. Consequently, when corn or wheat is sold from the farm, three-fourths of the phosphorus required to produce the crop leaves the farm in the grain.

When the crops are fed to growing animals or milch cows, about one-fourth of the phosphorus contained in the feed is retained in the bones, flesh, and milk, while about three-fourths is returned in the manure.

The total phosphorus content of the soil on any given farm may be increased by the purchase of stable manure, or by using manure made from purchased feeds, especially from grains or other concentrates, as bran, oil meal, or gluten feed; or we may purchase steamed bone meal from the stock yards companies who buy our cattle, slag phosphate from the steel works—if the slag contains sufficient phosphorus to make it valuable—or natural



When manure is left in piles, a large per cent of the plant food is lost through evaporation and surface drainage

rock phosphate direct from the extensive natural phosphate deposits in Tennessee, South Carolina, or Florida, where this mineral is being mined and ground in large amounts. It may be noted that the original stock of phosphorus naturally in the soil is powdered rock phosphate.

Potassium—Potassium, like phosphorus, is a mineral element contained in the soil, and if the supply in the soil is deficient it can be increased only by a direct application to the soil of some material. As a matter of fact, aside from peaty swamp lands and some very sandy lands, the potassium contained in most soils is practically inexhaustible. The average corn belt soil of central and northern Illinois contains as much total potassium per acre in the first seven inches as would be required for 100 bushels of corn (grain only) each year for nineteen centuries.

Of course the stalks, which are rich in potassium, should be returned to the soil, either directly or in manure. Even if they are burned (which should be the exception and not the rule) the potassium remains in the ash.

Peaty swamp soils are frequently exceedingly deficient in both available and total potassium as compared with normal soils, and, where the supply of farm manure is limited, commercial potassium salts may be applied to such land with very great profit. Potassium sulphate and potassium chloride (frequently, though incorrectly, called muriate of potash) are the most economical and satisfactory commercial potassium fertilizers.

Kainit is sometimes used, but it contains only 10 per cent of potassium while potassium sulphate usually contains 40 per cent, and potassium chloride contains about 42 per cent of the element potassium.

About 200 pounds of potassium sulphate or potassium chloride will supply sufficient potassium for a hundred-bushel crop of corn, and on very peaty land, where corn will not grow, such an application is recommended. The subsequent applications may be reduced in accordance with the amounts of potassium returned in the stalks and in the farm manure made from feeding the crop. But in dealing with soils of low productive capacity, of whatsoever class, it must be remembered that we must first grow large crops before we can make large amounts of manure, and if necessary we must always be ready to supplement our farm manure with any needed plant food if it can be obtained and used with profit.

Because soils deficient in potassium are usually abnormal and exist only in restricted areas, this class of soils will not be further considered except to mention in this connection that where such soils are found, as in some swamp regions, then the addition of potassium frequently produces most astonishing increases in crop yields. This is well illustrated by the results obtained on the University of Illinois soil experiment field near Momence, Illinois, in the Kankakee swamp area.

CROP YIELDS IN SOIL EXPERIMENTS
Peaty Swamp Land near Momence, Illinois

Plant Food Applied	1903 Corn Yield per Acre
None	7 bu.
Nitrogen	4 bu.
Phosphorus	5 bu.
Potassium	73 bu.
Nitrogen, phosphorus	4 bu.
Nitrogen, potassium	71 bu.
Phosphorus, potassium	73 bu.
Nitrogen, phosphorus, potassium	67 bu.

It will be seen that potassium increased the yield of corn by more than sixty bushels to the acre. It should be understood that some soils which are peaty in the surface with a heavier clayey subsoil within reach of the plow can be improved merely by deep plowing, for the clayey material is usually rich in potassium. It sometimes occurs that a subsoil exists which contains considerable amounts of total potassium, but this may become available slowly unless more actively decaying organic matter than peat is present. In such cases even light applications of fresh farm manure may produce an effect far exceeding that which is commonly expected.

Occasionally peaty swamp soils, like other soils, may contain some injurious alkali, as magnesium carbonate, in the sub-surface soil in such amounts as to prevent corn roots from living in it, and hence liberal amounts of available potassium provided in the surface soil may greatly benefit the crop. Deep peat and peat underlaid by clean sand are, as a rule, deficient in both available and total potassium.

It is well to remember that the seed or grain contains only about one-fourth of the potassium required for a crop, while three-fourths remain in the straw or stalks; also that animals retain practically none of the potassium consumed in the food, almost all of this element being returned in the solid and liquid manure.

Calcium — As an average, the normal soils of central United States contain only one-third as much calcium as potassium; while the average annual loss of calcium in drainage waters and in crops removed amounts to five or six times as much as the loss of potassium; so that in the maintenance of plant food the addition of calcium in limestone is of very much greater importance than is the application of potassium to the almost inexhaustible supply now present in such soils.

Magnesium — The amount of magnesium required by crops is appreciable, but not nearly so large as of the other four elements mentioned. Magnesium can be applied most cheaply and in readily available form by using dolomitic limestone, such as is found in great abundance at Kankakee, Joliet, Rockford, and many other places in northern Illinois. Dolomite contains about as much magnesium as calcium, and has slightly greater power to correct soil acidity than the ordinary high calcium limestone found for example at Quincy, Alton, Stolle, Chester (Menard), Anna, and many other places in central and southern Illinois.

Making Plant Food Available — It is an absolute essential in agriculture to have plant food in the soil. If it is not present in abundance it should be supplied in the manner that is most economical and profitable, and that which is removed in crops should be replaced so far as practicable and profitable, either by

returning it in farm manure, or by plowing under green manures, corn stalks, straw, and other coarse products, and by adding phosphate and limestone.

With a good supply of plant food stored in the soil, then the thing of greatest importance in the business of farming is the liberation of sufficient plant food during the growing season to meet the needs of maximum profitable crops. While thorough tillage aids in this process, by far the most effective and practical means within the farmers' own control for liberating plant food from the soil's supply or from insoluble material, as natural rock phosphate which may have been applied, is decaying vegetable matter.

The farmer or landowner whose farm practice includes these two points; that is, (1) plenty of plant food stored in the soil, or added to it when necessary, and (2) plenty of decaying organic



A wasteful practice

matter to liberate plant food for the crop needs, will have in operation a system of agriculture which is permanent.

The one point is no more important or essential than the other. The man who tries to maintain the fertility of his soil and who hopes to continue to grow large, profitable grain crops without the use of legume crops or plowing under farm manures or coarse products, but who uses high-priced soluble manufactured commercial fertilizers, is unwise, and ultimately his land will probably follow the history of the lands which have been practically ruined by such practice in the eastern states.

On the other hand, the man, who thinks the productive capacity of the ordinary prairie land in the humid regions of Central United States can be permanently maintained merely by the use of clover in crop rotation, is also unwise, for this is absolutely impossible. So far as phosphorus and other minerals are concerned, the use of clover in crop rotation is one of our most effective means of liberating those plant food elements from the soil so that they may be removed in subsequent grain

crops. Furthermore, clover and other legumes are themselves gross feeders on phosphorus, calcium, and potassium.

It is almost inexplicable that there are people who write and speak at great length and with great energy on the tremendous importance of adding nitrogen to the soil as an element of plant food, but who completely ignore and even deprecate the matter of maintaining in the soil a supply of phosphorus from which we can liberate sufficient amounts for large crops.

No man can afford to ignore the truth. If there are soils which contain so little phosphorus that we cannot by profitable means liberate sufficient to meet the requirements of large crops, then we should increase the supply; and every man should be sufficiently unprejudiced to ask frankly whether it is more sensible and more profitable positively to increase the total supply of any element of plant food in his soil, or to continue to decrease it by means of crop rotations and the use of decaying organic matter.



A uniform application of the manure makes all the plant food available

For the ordinary, strictly live-stock farm from which only hogs and cattle are sold, there is no such thing as reducing the supply of potassium if all liquid and solid manure is carefully saved and returned to the soil, because, as before stated, practically all of the potassium contained in the feed is returned in the manure. In dairy farming a small amount of potassium leaves the farm if milk is sold.

But even in live-stock farming with all manure saved and returned to the land, we still lose the phosphorus carried away in bones, flesh, and milk, and this fact should not be ignored by the farmer whose crop yields are already limited because of insufficient supplies of phosphorus, even with abundant use of decaying organic matter supplied in clover and farm manure. Indeed not infrequently we find farmers whose land is so rich in nitrogen and potassium that they grow great crops of straw and stalks, but the phosphorus is so limited that the actual yield of grain produced is only one-half or two-thirds what it should be.

Let us remember that a balanced ration is just as important for corn as for cattle, and that phosphorus is required largely for the grain.

Soils Deficient in Nitrogen—It should be understood that the nitrogen in the soil is measured by the organic matter, for the nitrogen is practically all contained in the organic matter. Consequently soils which are deficient in organic matter are also deficient in nitrogen.

There are two classes of soils which are commonly much more deficient in nitrogen than in other plant foods. These are the very sandy soils and the very rolling or steeply sloping hill lands.

Improving Sandy Land—While the sandy lands are not rich in phosphorus and potassium, they are as a rule moderately well supplied with those elements, and such soils are so porous that they afford a very deep feeding range for the plant roots, so that the actual percentage composition in mineral plant food does not fully measure the possible productive capacity of sandy soils as compared with more compact silt or clay soils.

As a general rule if the three elements, nitrogen, phosphorus, and potassium be added separately to three different plots of very sandy land, the nitrogen will increase the yield, while little or no increase will be produced by either phosphorus or potassium. After plenty of nitrogen has been provided, then the addition of potassium will still further increase the yield. Actual results obtained on the University of Illinois soil experiment field on the sandy land near Green Valley, Illinois, will serve to illustrate this:

CROP YIELDS IN SOIL EXPERIMENTS
Sandy Soil near Green Valley, Illinois

Soil Treatment Applied	1902 Corn Bushels	1903 Corn Bushels	1904 Oats Bushels	1905 Wheat Bushels	1906 Corn Bu.	1909 Corn Bu.
Nitrogen	69	65	44	24	63	59
Phosphorus	30	25	20	17	10	13
Potassium	23	20	17	17	8	13
Nitrogen, phosphorus	57	70	52	27	71	65
Nitrogen, potassium	70	73	55	37	75	74

It will be noted that where nitrogen was applied, the yield is more than double that obtained with either of the other elements. Except in 1902, phosphorus shows some effect when added to nitrogen, but potassium with nitrogen is more effective, especially in 1905, when it gave a yield of wheat thirteen bushels higher than was obtained with nitrogen alone. It should be stated, perhaps, that it is exceedingly difficult to select a number of exactly uniform plots for experimental use on this kind of soil

and small differences may be attributed to soil variation, but the marked and uniform effects of nitrogen, and of nitrogen with potassium, are characteristic of such soil, and the further addition of phosphorus may sometimes prove profitable.

These results help to explain the marked effect of farm manure on sandy soils, especially when used for a crop rotation which includes legumes. Both the legumes and manure will furnish nitrogen, and the manure is also well supplied with potassium, the bedding being rich in potassium, and all potassium in the feed being returned in the manure. It may be noted that on very sandy lands clover does not grow well, but either cow peas or soy beans is an excellent substitute for clover, as both do well on very sandy soil.

It is exceedingly important that so far as possible all crops shall be fed and the manure shall be carefully saved and returned to such land, not only for its plant food value, but also for the organic matter which is needed to improve the physical condition of the soil.

Improving Worn Hill Land—In actual field experiments on worn hill land on the University of Illinois soil experiment field, near Vienna, Ill., the following results have been obtained in a three-year rotation of wheat, corn, and cow peas. By "legume" treatment is meant the growing of legume crops or catch crops, as cow peas in the corn, or after the wheat, in the same season, which are turned under for the nitrogen and organic matter which they add to the soil.

CROP YIELDS IN SOIL EXPERIMENTS
Worn Hill Land near Vienna, Illinois

Soil Treatment Applied	1903 Yields	1904 Yields	1905 Yields
Wheat, Bushels per Acre			
None.....	0	7	1
Legume.....	1	1	11
Legume, limestone.....	1	10	18
Legume, limestone, phosphorus.....	8	15	26
Legume, limestone, phosphorus, potassium.....	11	18	30
Corn, Bushels per Acre			
None.....	9	31	38
Legume.....	5	36	43
Legume, limestone.....	8	49	62
Legume, limestone, phosphorus.....	7	49	57
Legume, limestone, phosphorus, potassium.....	11	45	57

The year 1903 was a very poor season for both corn and wheat. It will be seen that limestone and legumes (cow peas or clover) have very great power to improve this class of soils.

As yet the addition of phosphorus and potassium has not

increased the corn yields, although with wheat, phosphorus has given a marked increase and potassium some further gain, notwithstanding the fact that these two best treated plot series were naturally slightly less productive than the other three of the series. With more organic matter the effect of applied potassium will probably disappear.

Soils Deficient in Phosphorus — Phosphorus is the element of plant food most likely to be deficient in the common gently rolling prairie or upland timber soils of Central United States, as in Illinois, Indiana, and Ohio. Phosphorus is also commonly found to be one of the most deficient plant foods in long cultivated soils in eastern and southern United States.

The total amount of phosphorus contained in the surface seven inches of the commonest type of soil in the Illinois corn belt is no more than would be required for fifty crops of corn of 100 bushels each, or for about seventy such crops if the grain only were removed from the land. The next soil stratum is poorer in phosphorus than the surface soil and even a rich subsoil is of little value when buried beneath a worn out surface.

The common so-called worn out soil of southern Illinois contains but little more than half as much phosphorus as the corn belt soil. If clover failure is becoming more frequent than formerly on Illinois soils it is one of the strong evidences of insufficient phosphorus.

The results obtained from the University of Illinois soil experiment field near Bloomington, Ill., on the typical slightly rolling prairie land of the central Illinois corn belt will serve to demonstrate that phosphorus is the element which limits crop yields on soils of this character, notwithstanding the fact that this soil is valued at not less than \$150 an acre and is still producing very profitable crops even for land of that valuation.

CROP YIELDS IN SOIL EXPERIMENTS

Typical Corn Belt Prairie Soil near Bloomington, Illinois

Plant Food Applied	1903 Corn Bushels	1904 Oats Bushels	1905 Wheat Bushels
None	60	61	29
Nitrogen	60	70	31
Phosphorus	73	73	39
Potassium	56	63	33
Nitrogen, phosphorus	78	85	51
Nitrogen, potassium	59	66	30
Phosphorus, potassium	75	70	38
Nitrogen, phosphorus, potassium	81	91	52
Gain for phosphorus when added to nitrogen	18	15	20

It will be seen that the addition of nitrogen or potassium, separately or together, produces little benefit and sometimes the effect is a decrease in yield, although nitrogen did appreciably increase the yield of oats in 1904. After phosphorus has been applied, then nitrogen can be utilized with marked benefit.

Phosphorus produced a large increase in each crop even when applied alone, but when applied after nitrogen the increase was exceedingly marked, amounting to 18 bushels increase in corn, 15 in oats, and 20 bushels increase in the yield of wheat. While nitrogen was applied in commercial form (dried blood) in these experiments, these results emphasize the very great importance of using phosphorus in connection with clover and farm manure for improving this soil.

The use of commercial nitrogen was discontinued after 1905, but the addition of phosphorus produced 1.07 tons more clover in 1906, 19 bushels more corn in 1907, 12,2 bushels more corn in 1908, and 10.2 bushels more oats in 1909.

The possible effect of phosphorus on the clover crop itself may be seen in the results obtained in 1905 on the University of Illinois soil experiment field at Urbana, Illinois, which is also situated on good Illinois prairie soil. By "legume" treatment is meant the growing of a catch crop of cow peas or clover in the corn when it is "laid by."

CROP YIELDS IN SOIL EXPERIMENTS

Typical Corn Belt Prairie Soil, near Urbana, Illinois

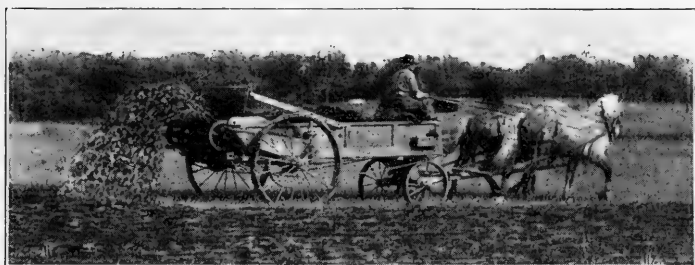
Soil Plot No.	Three Years' Average Before Treatment Corn, Bushels	Soil Treatment Applied	1905 Clover Tons per Acre
201	60	None	1.26
202	64	Legume	1.21
203	63	None	1.15
204	61	Legume, lime	1.32
205	61	Lime	1.21
	Aver. 61.8		1.23
	Bu.		Tons
206	64	Legume, lime, phosphorus	2.91
207	62	Lime, phosphorus	2.91
208	58	Legume, lime, phos., potass.	3.19
209	61	Lime, phos., potass.	3.19
210	62	Lime, phos., potass.	3.41
	Aver. 61.4		3.12
	Bu.		Tons

It will be seen that previous to the beginning of this soil treatment, the last five plots yielded no more than the first five; but after four years of soil treatment, the yield of clover was only 1.23 tons without phosphorus, while 3.12 tons of well field-cured clover hay were produced where phosphorus had been applied. The effect of potassium was slight.

Of course this increased crop of clover means a larger yield of corn to follow, and both clover and corn mean more farm manure for further soil improvement or maintenance.

As an average of the three years, 1907 to 1909, plots six and seven produced seventeen and one-half bushels more corn, seven bushels more oats, 1720 pounds more clover hay, and forty-three pounds more clover seed, per acre, than plots four and five; these increases being due to the application of phosphorus. In the later years the use of limestone is also producing profitable increases on the older prairie lands of the corn belt.

Soils Deficient in Both Phosphorus and Lime—Soils on which clover can not be grown successfully even before they are



The way to secure uniform fertilization of the soil

badly worn are usually acid and consequently deficient in limestone, but as a matter of fact such soils are usually deficient in both limestone and phosphorus.

The effect of limestone and of limestone and phosphorus in connection with legume treatment on the University of Illinois soil experiment field near Odin, Illinois, will serve to demonstrate the need of both limestone and phosphorus on such soils as are commonly called "clay land," which refuses to grow clover.

WHEAT YIELDS IN SOIL EXPERIMENTS

Typical Wheat Belt Prairie Soil in "Egypt," near Odin, Illinois

Soil Treatment Applied	Yield per Acre Average of Eight Years
None	11 Bu.
Legume	12 Bu.
Legume, limestone	17 Bu.
Legume, limestone, phosphorus	26 Bu.
Legume, limestone, phosphorus, potassium	28 Bu.
Gain for legume, limestone, phosphorus treatment	15 Bu.

On similar soil in Wayne county in southern Illinois, an experiment field was started on forty acres of land in 1905. A four-year rotation of wheat, clover, corn, and cow peas (or soy beans) is practiced on four ten-acre fields, so that each crop may be represented every year. Two tons of ground limestone and one ton of fine ground raw rock phosphate, per acre, are applied once in four years on part of each field, while no limestone or phosphate are applied to the remainder, which is cropped and treated alike in all other respects. At \$1.25 per ton for the limestone and \$7.50 per ton for the phosphate, the cost of these materials amounts to \$10.00 per acre once in four years; whereas, in 1910 the land treated with limestone and phosphate produced 17 bushels more wheat, 2½ tons more clover (in two cuttings) 20 bushels more corn, and nearly 8 bushels more soy beans, per acre, than the land not so treated. Here is very satisfactory profit and positive soil enrichment. Still greater benefit is expected in the future, because hereafter the manure applied or the clover and crop residues to be plowed under will be in proportion to the crop yields of the previous rotation.

The treatment recommended for these soils, which are well represented by the extensive worn "clay lands" in Ohio, Indiana, southern Illinois ("Egypt"), and Missouri, is as follows:

Apply 1,000 to 2,000 pounds to the acre of finely ground natural rock phosphate with as much organic matter as possible (manure, legume crops, etc.) and plow under, then apply two or three tons to the acre of ground natural limestone and mix with the surface soil in preparing the seed bed, and then grow a good rotation of crops, such as wheat, clover, corn, and cow peas, or wheat, clover, wheat, clover, corn and cow peas; or corn, cow peas, wheat, meadow and pasture (clover and timothy being seeded with the wheat crop for two or three years' meadow and pasture). At the end of the rotation another heavy application of rock phosphate in connection with all available farm manure, should be made, preferably to the pasture ground and plowed under for corn.

If necessary, limestone must be added occasionally to keep the soil sweet. About two tons per acre every rotation will be sufficient. (Blue litmus paper, which can be obtained from a drug store, if placed in contact with the moist soil for 20 minutes will be turned red if the soil is sour).

The Value of Farm Manure—Farm manure always has been and probably always will be one of the most important and abundant materials for soil improvement. It is a necessary product on every farm and on stock farms a product which accumulates in very large amounts. If not used for soil improvement, it becomes a worthless nuisance about the stables, whether in the city or in the country.



This pile of manure has been exposed to the sun and rain all year, and has lost from 40 to 50 per cent of its fertilizing elements

A conservative estimate places the annual production of farm manure in the United States at a billion tons. The actual agricultural value of fresh farm manure containing both the liquid and solid excrements is not less than \$2 a ton, whether the value is measured in terms of plant food elements actually contained in the manure as determined by chemical analysis of the manure and the market values of the elements, or whether the value is measured by the actual increase in crop yields produced by the use of the manure on ordinary long cultivated soils.

Waste of Farm Manure and Land Ruin—If fresh farm manure is thrown out and exposed to the weather for six months in summer, one-half of its total weight of dry matter is lost, and more than one-half of its value as a fertilizer is lost. In most newer countries there is enormous and shameful if not wicked waste of farm manure. In older countries it is the rule to save all possible farm manure with very great care, although this rule is too frequently broken by the careless, ignorant, or shortsighted.

As a whole, the unnecessary waste and loss of farm manure which occurs in the United States each year is equal in value to several times the value of all commercial fertilizers used in this country. Sometimes the waste of farm manure and the purchase of commercial fertilizers occur upon the same farm. In such cases the commercial fertilizer used is usually a so-called "complete" fertilizer, containing acid phosphate with a trace of nitrogen and potassium too small to add appreciably to its value, and it is commonly applied in amounts which supply less plant food than the crops actually remove, the small amount of soluble plant food applied being supplemented by that which the soil would naturally give up, together with what can be forced from the soil by the stimulating action of the soluble corrosive acid salts and manufactured land-plaster contained in such fertilizers.

One of the most common commercial fertilizers used in the United States contains the equivalent of two per cent of ammonia, eight per cent of falsely so-called "phosphoric acid," and two per cent of potash, corresponding to less than four pounds of nitrogen, seven pounds of phosphorus, and less than four pounds of potassium in 200 pounds, the most common application per acre; whereas a 100-bushel crop of corn removes from the soil not four, but 150 pounds of nitrogen, not seven but twenty-three pounds of phosphorus, and not four but seventy-five pounds of potassium.

Saving Farm Manure — In order to retain the full amount and full value of farm manure, it should be removed directly from the stall or covered feed lot and spread at once upon the land. Where the winters are moderately cold and free from

heavy rains there is little loss if the manure is allowed to accumulate during such weather in a small, uncovered feed lot, provided it is hauled out and spread upon the land in the early spring. Manure may be allowed to accumulate without much loss in deep stalls for several weeks if plenty of absorbent bedding is used, and then it may be hauled from the stall directly to the field and spread.

It should be the rule never to handle manure more than once. When taken from the stable or feeding shed it should be at once loaded onto the spreader and hauled to the field. If manure is produced at the rate of two loads or more a week, the convenience and importance of taking this manure directly from the stable and spreading it at once upon the field will certainly justify providing a manure spreader or special wagon to be used solely for this purpose.



This field requires a heavy application of manure

Increasing the Value of Farm Manure— While ordinary fresh farm manure is worth \$2 a ton for use on ordinary soils, its value can easily be increased to \$3 a ton net, by replacing in liberal amounts of low-priced, very finely ground natural rock phosphate, the element phosphorus, which the animals have extracted from the feed and used in making bone, thus leaving the manure poor in phosphorus as compared with the crops grown and fed.

It should be remembered that practically all potassium contained in the feed is returned in the liquid and solid excrements and that the nitrogen, which is in part retained by the animal and in part returned in the manure, can be fully maintained by supplementing the farm manure with clover grown in the crop rotations and plowed under.

By far the most complete and valuable work ever reported upon the subject of increasing the value of farm manure by the addition of natural rock phosphate has been done by the Ohio agricultural experiment station under the direction of Professor

Charles E. Thorne in an extensive and most trustworthy series of experiments extending over a period of thirteen years.

As a rule for use on land which is deficient in phosphorus, rock phosphate should be mixed with average manure in such proportions that at least 250 pounds of rock phosphate per acre would be provided for each year. Thus for a four-year rotation, including corn for two years, oats for the third year and clover for the fourth year, about 1,000 pounds of rock phosphate an acre should be applied to the clover ground in connection with all available farm manure and plowed under for corn. If the land is manured once in four years with ten loads of manure to the acre, then 1,000 pounds of rock phosphate should be applied with each load.

A very simple and satisfactory method of applying rock phosphate to the land, which involves practically no extra labor or



Manure spreaders on a Western farm

loss of time, is to load the manure spreader part full of manure, then scatter one hundred pounds of rock phosphate over it as uniformly as possible, finish loading, and drive to the field and spread the phosphated manure. This brings about a very complete and intimate mixture of the manure and rock phosphate, and this is exceedingly important, because the decaying organic matter must be in intimate contact with the rock phosphate in order to liberate the phosphorus for the use of the crops. Where manure is not available, more clover must be plowed under.

A System of Permanent Agriculture—This practice of applying liberal amounts of natural rock phosphate in connection with sufficient clover, or with all of the farm manure which can be made on the farm from the hay, straw, and other coarse products and from the oats or other low-priced grains, together with the use of a good rotation, including plenty of clover, provides for an absolutely permanent system of agriculture, even

though high-priced grains and animal products are sold from the farm. It is a system under which the land grows richer and richer and more and more productive and valuable, instead of becoming poorer and less productive, as has been the case with by far the larger part of the older cultivated lands in the United States.

For more complete data, simple discussion, and plain explanation of the most essential information the world affords, relating to soils and methods of soil improvement, the reader is referred to a book on "Soil Fertility and Permanent Agriculture," published by Ginn & Company, of Boston, Massachusetts.



Small Grain Growing

MAGNITUDE OF THE INDUSTRY—DEVELOPMENT OF
NEW VARIETIES—VARIETAL DIFFERENCES, ETC.

BY WILLET M. HAYS

Assistant Secretary of Agriculture, Washington, D. C.



Seven Farinaceous Small Grains —

Excluding corn, the big king of the cereals, we have seven farinaceous grains which for the purpose of this article we shall call the small grains.

These with their respective values for 1899, as shown by the twelfth census, are: Wheat, \$370,000,000; oats, \$217,000,000; barley, \$42,000,000; rye, \$12,000,000; rice, \$8,000,000; buckwheat, \$6,000,000; while for the millets or non-saccharine sorghums, the value was not determined.

As shown by the figures for the crop of 1910 published in December by the United States Department of Agriculture, the values of these crops had grown, respectively, to the following: Wheat, \$621,000,000; oats, \$385,000,000; barley, \$94,000,000, rye, \$24,000,000; rice, \$17,000,000; buckwheat, \$11,000,000.

Wheat the Golden Queen of the Harvests—Men are enchanted with the sowing of wheat seeds, with harvesting the golden fields of grain, with the hum of the great threshing machine, with the movement of the great cars and ships laden with the trillions of berries, with the burring of the mighty mills, with the mysteries of the bake oven, and with the never cloying pleasures of white bread covered with June-yellow butter.

If a grain of wheat could tell the story of its brothers, sisters, father, mother, uncles, aunts, and its other relatives near and remote, it would equal any fairy tale.

One kind of berry would tell of its origin in England, another in France, another in Germany, and perchance another in Russia; each with its forbears back in some remote neighborhood, or may be in still another country, with possibly a legend as to its unknown wild parentage.

Until in recent decades the history of the varieties of wheat, and of the other cereals is not of record. No doubt selection by man in more or less of a blundering way has gone on for many

centuries. Hybridizing, by natural agencies, also may have occasionally occurred often enough to aid materially in making new varieties by blending the good qualities of two or more parent kinds.

Few Varieties in World's Great Wheat Crop—At present there are thousands of varieties of wheat, most of which have been originated in recent years by wheat breeders working with more or less of system. But the world's great crop of wheat is nearly all produced by a few dozen varieties.

The fingers of both hands would enumerate the main varieties in this country, each of which spreads over not more than several states.

In Europe likewise there is a group of several varieties of wheat which make the bulk of the crop. And it is so with the other cereals, there is a relatively small number of dominating varieties.

Though the recent great activity in breeding wheat is resulting in originating thousands, if not tens of thousands of new selected and new hybrid wheats, this work is done with such care that only the relatively few best will escape the hands of the experiment station or other trained breeders.

Small Yield in America a National Disgrace—That American wheat yields an average of less than fifteen bushels per acre is a national disgrace which can be cured by using two means:

The betterment of the soil conditions under which the crop may yield more.

The improvement of the yielding power of the varieties planted.

Since the improvement of the fields may be discussed at once for all six of the small grains, that will be taken up first, and the breeding of each crop will be dealt with more in detail under the respective species.

Our national average yield of wheat should be increased from fifteen to twenty-five bushels per acre. By better preparation of the land five bushels of this increase can be gained and by wheat breeding the other five bushels.

More Careful Crop Rotation to Pay the Cost—The five bushels gain from better organized field and farm management will probably cost three dollars annually; and this must be paid by the grower in a more carefully managed scheme of crop rotation, in fertilizers, and in cleaner and better intercultural tillage of the hoed crops with which the wheat alternates in the rotation.

The five bushels from breeding and good seed will not cost ten cents an acre, and of this the national and state governments



An I H C tractor drawing five 14-inch plows

will pay part for breeding work on experiment farms. The farmer's part in obtaining seed of the new varieties and in raising, caring for, and preparing his seed will not be appreciably greater than now.

Place of Grains in the Rotation—Wheat and other small grains are somewhat sensitive to the condition in which the previous crop left the soil. They do not thrive well after a crop of small grain. In many cases they will yield twenty or thirty per cent more after a hoed crop, as corn or potatoes, or after a crop of grass, clover, or alfalfa than after a small grain crop.

Though these grains are benefited by a direct application of either barn or commercial fertilizer on poor soils, they are sometimes injured by the application of barn manure on rich soils.

Generally barnyard manure will give more final returns by the acre to the farm if applied to a previous cultivated crop as corn, or even to the grass crop, in rotation; the wheat, oats, barley, or other grain thus receiving the residual effect.

On new and other rich soils, barnyard manure often overdoes the small grain crop by causing it to grow heavy in the straw and to lodge and produce light, shrunken grain, though it helps without injuring the other crops mentioned, which are grown in rotation with wheat.

Some of the Best Plans of Rotation—A good five-year rotation for grain in some of the states of the middle northwest is first year, small grain; second and third years, meadow and pasture of grasses and clovers seeded the first year with the grain; fourth year, small grain; fifth year, corn, applying the manure before the corn crop; then, beginning the second five-year period, repeat the rotation.

A four-year rotation found useful on some farms is as follows: first year, small grain; second year, red clover; third year, small grain; fourth year, corn; and repeat.

A three-year rotation as follows gives splendid conditions for the wheat or other small grain: First year, small grain; second year, red clover; third year, corn; and repeat.

Small grain and corn in a two-year rotation place the land in good condition for each crop of grain.

In the south, cotton and cow peas can take the place of the corn and clover in a four, three, or two-year rotation; and in many cases the cow peas may follow the winter wheat, making two crops in one year, thus shortening the rotation by gaining one year in the four or three-year rotation.

By following some such method of natural farming the leguminous crops help to add nitrogen and organic substance to the soil surface of weeds and will provide the rather well compacted furrow slice needed to cause the small grain plant to stool well and to thrive throughout its growth.

Other Crops Benefited by Rotation Scheme—That the rotation scheme is not all to favor the small grain crop may be shown in case of the five-year rotation first named.

The wheat, by serving as a nurse crop, among which the newly seeded grass and clover may pass their first unproductive season without cost, prepares the land for the two crops of grass. The grass crops by cleaning, resting, and enriching the soil prepare the land for a good crop of small grain the fourth year. The second crop of small grain which may often be followed with a crop of rye or turnips sown in spring to make pasturage among the grain stubble in autumn, furnishes conditions under which the manure may be hauled out and plowed under in fall, winter, or spring in preparation for the corn crop. The corn grown the fifth year reduces the manure from too great activity, clears the surface soil of weeds, and compacts the furrow slice so that it is in nearly an ideal condition under which the small grain may be put in with shoe or hoe drill or broadcast and disked in or covered in other suitable ways, and the second series of five yearly crops is thus started out in good condition.

Chemical Fertilizer Tests Not Expensive—It is not expensive to make trials of chemical fertilizers on a given farm, or on a given soil type. Thus a farmer, or a group of co-operating farmers, can easily test their soils.

Corn is a splendid crop to use in the north, and corn or cotton in the south. The plots may be marked and the marks preserved for a year so that the residual effect on the following crop of grain may be observed, provided the effect is recorded.

In making the trial with corn, the following general plan may be pursued: Apply to plots three or more rows wide and ten or more rods long, on land where uniform plots may be obtained with alternating check plots not manured between, such amounts of nitrogenous, phosphoric, and potash fertilizers and lime as may be advised by the agriculturist of your state experiment station; and follow his instructions as to time and manner of application also.

When the corn or cotton is ripe, harvest the fertilized plots and the check plots separately, and measure or weigh so as to determine whether the fertilizer gave any additional yield. It is wise to have one or two alley rows between each two plots, because corn roots reach over across the row, often extending five feet from the hill.

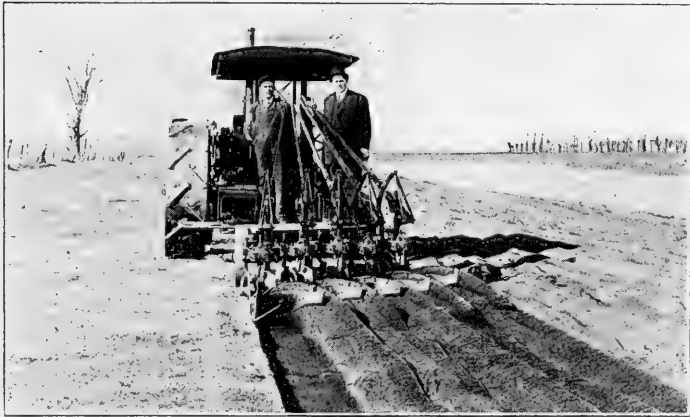
If these preliminary trials show that the soil is weak along any one line of plant food, or needs lime to correct acidity, the experiments should be continued along that line to determine how much fertilizers to use and to which crop in the rotation to apply them.

Allotment of Land to United States Crops—This country has about a billion acres in farms, half of which is improved land and half unimproved.

Of the 500,000,000 acres of improved land, corn covers about 100,000,000 acres and the small cereals a similar amount, while cotton covers a third as much as corn, and grass lands for hay and summer forage cover two-thirds as much as corn.

There are probably 200,000,000 acres in grass, and a total of 300,000,000 acres in all other field, orchard, and garden crops.

Thus of the 500,000,000 improved acres we have 200,000,000 acres in pasture grasses, 100,000,000 in corn, 100,000,000 in small cereals, 100,000,000 acres in hay, summer forage, potatoes, beans, and other minor field crops and the more intensified crops of the orchard and garden.



Making the acres smile

Cereals from Canada to the Gulf—Cereal growing extends from the Canadian partition fence down nearly to the Gulf of Mexico, and from Maine to California, and our Dominion brethren grow wheat some distance northward in their broad estate, especially in the expansive plains west and northwest of Winnipeg.

In the Euro-Asiatic continent there is a similar band of small cereal areas which extends from far north in the Scandinavian peninsula and in northern Russia down past the Holy Land and even into elevated regions in India.

There is a temperate zonal strip in the southern hemisphere also, where the cereal band crosses southern South America, southern Africa, and southern Australasia and includes many islands.

Where it Pays Best to Raise Cereals—On what part of Uncle Sam's estate does the cultivation of the small cereals

most naturally belong? Only a small part of the wheat, oats, and barley should be grown below Mason and Dixon's line, because the yield is not sufficiently large to justify it in comparison with values produced by crops of cotton, corn, rice, cow peas, and garden and orchard crops.

Above that line and well toward the Canadian border winter wheat yields moderate value to the acre. It here holds a splendid place in the rotation, because it follows corn so well, requires labor at a time of year when other crops are not suffering and serves as a nurse crop for clover and grass seeds planted to make a crop the following year.

Along the northern border and over in Canada spring wheat takes the place of the winter wheat, though its average value to the acre is even lower.



The work of harvest made easy

Oats do not thrive well so far south as does winter wheat, not having been as yet bred for hot summer weather, but are grown nearly to the Gulf. The barley zone is still further north than the oats.

Rye sown in the autumn is hardy to the northern counties of the United States and thrives south to Mason and Dixon's line. The millets and non-saccharine sorghums are grown well to the north and kaffir corn has an especial usefulness on the droughty plains where it produces grain with light rainfall.

Great Advance in Rice Growing in America—Rice on the other hand has a distinctly southern habitat and is local. The rice area recently has mainly moved from the Atlantic coast states to Louisiana and Texas and its area has greatly extended. Its method of cultivation too has radically changed, and it has now come under America's broad plan of farming by machinery.

Rice has been made more plentiful and cheaper. Broader acres, machinery, better varieties, and better knowledge of methods of cultivation have in the last five years revolutionized rice growing.

Flax is not one of the cereals, but as it is grown at the same place in the rotation, requires the same preparation of the soil, and affects the land in much the same way as do the small cereals, its cultivation may be discussed with theirs.

It is certain that economic factors have determined the present distribution of the small cereals.

In North Dakota, for example, wheat, oats, flax, barley, and millet seed pay better than corn; therefore the farmers are constrained to grow as large an acreage of these money crops as is consistent with keeping their lands free of weeds, in good condi-



Harvesting heavy wheat

tion for grain, strong in fertility, and otherwise in condition for good crops of these grains.

Alternation With Fallow in Semi-arid West— Out in the western semi-arid regions, instead of rotating the grains with corn and grasses they alternate them with the bare fallow, thus to keep down weeds, to secure good mechanical preparation of the furrow slice, but especially to conserve the water of the alternate year so as to supply the growing crop with the surplus water of two years instead of one.

The frequent droughts, too, make frequent seeding to clovers and grasses uncertain, so that the plan in these western-north-western parts is to grow grain for some years continuously and then to seed to grass for some years, possibly injecting one crop of corn in among the crops of grain.

Thus a rotation is arranged as follows: First and second

years, grain; third, fourth, and fifth years, grass and clover; sixth and seventh years, grain; eighth year, corn; then repeat by eight-year rotation period.

Stock Feed More Profitable in Iowa—In Iowa, on the other hand, where corn, mainly fed to live stock, and pastures of clover and grasses, yield more value to the acre, the grains are being crowded down to a limited area.

There these crops are often chosen because of the need of a nurse crop to produce during the year of seeding, the timothy and clover sown for hay or pasture in following seasons. And though wheat and flax do not average as much value to the acre as corn and oats, barley and rye do not produce as much feed value to the acre as corn or grass; and though all these small grain crops deplete the soil more than crops of corn or grass, yet in limited areas they round out the farm management plan.

If we can sell more live stock products Iowa and surrounding states can afford still further to reduce the acreage of these soil consuming, weed increasing crops, unless prices for these commodities increase. The world needs the amount of cereals now grown, but other countries where labor is not so dear are willing to produce them at a rather low price per acre and per worker.

Only better varieties for each and all of the many localities, better preparation of soil by rotation, good cultivation, and cheap effective fertilization will make it practicable to retain our present acreage.

Handicap in Competition with Live Stock—Live stock and the crops they require are a paying proposition with which grains for sale must compete. They have two great handicaps—they bring in less money and they leave the soil impoverished instead of richer.

As a matter of practical business most of the small grains in American agriculture are produced in connection with live stock products. By alternating them with the crops fed to live stock, the land is prepared for the grains; often at the expense of the future crops for live stocks.

From Illinois eastward and southward, commercial fertilizers are gradually coming into extensive use, placing the production of these crops on the same basis as that on which grains are grown in much of Europe. The use of commercial fertilizers for this purpose will of necessity gradually extend westward, and to other regions where the lands are now new.

The world will not rapidly change the proportionate amounts of cereal and live stock products it demands, and these, the one competing with the other, will each regulate the price of the other.

The great cities which consume the surplus of these products

keep bowling along in their growth and in their ever-increasing ability per capita to purchase meat as well as bread.

The world's most rapid expansion of acreages of grain and live stock production was passed during the earlier years of railway and steamship transportation when the body of the world's great continental prairies was upturned with the plow.

The next expansion of production will no doubt be largely due to the better farm methods and the better breeds and varieties which the bounding growth of agricultural science is ready to bring forth.

Every Farmer Should Plan His Campaign— Every farmer should work out his own farm scheme, map it out on paper where he can project it forward ten years or more under a definite rotation system.

When the ten years are up, the record of yields for each year placed in ten annual farm maps will enable him to average the several crops and determine what each yielded to the acre.



Binders in the field

Before that time his state experiment station will probably have given him items of average cost so that he can calculate the average cost to the acre of each kind of grain grown and of each kind of crop fed to live stock. His neighbors also will have begun more of system and many of their figures will serve to guide his future operations.

Let the farmer block out his farm scheme, submit it to farmer friends for criticism, and finally send copies to the professor of agriculture in his state agricultural college, who may be able to give advice as to kind of crops in the rotation; as to the plan of rotation; also as to the preparation and fertilization of the soil.

Farm Management Developed as Science—The agriculturalists of the state experiment stations and of the national Department of Agriculture are seriously taking up the matter

of farm management, and as far as their time permits are ready to give advice.

They need a specific, intelligent statement of the farmers' problem and his point of view, that they may the better understand how to investigate farm management in all its manifold bearings.

There have already begun to appear writings on farm reorganization and management from a number of men who ere long will be regarded as masters along this line of scientific instruction and advice.

The experiment stations and the U. S. Department of Agriculture have begun to accumulate a valuable body of knowledge along this line, and teachers are beginning to reduce to pedagogic form a system of teaching farm management to be comparable with teaching other lines of engineering and business organization.

The Various Soils Best Suited to Cereals—The cereals are suited to a wide range of soils. On light sandy, leachy, or drouthy soils these crops usually make a crop of good quality but poor in quantity.

The new durum wheat and kaffir corn are adapted to the drouthy regions of the semi-arid plains; durums well to the north, and kaffir from Nebraska southward in this "plains region."

There are few soils too heavy or wet for the small cereals, and rice grows in soils kept flooded so much of the time that few weeds can encumber the soil.

Like most crops, these grains are best suited by soils which are a happy medium in texture from being made up of coarse and fine materials combined, as where the great glacier, crucible-like, has left its mixture of sand and clay to the northward of the Ohio and Missouri rivers.

Soils Adaptable to the Cereal Crops—As was stated earlier, these crops like to follow corn, potatoes, or other hoed crops, and the grasses, as on sods of timothy, clover, or timothy and clover sown together.

The sod of the long-standing blue grass pasture, or of the long-established alfalfa meadow also suits these crops; though if the soil is naturally rich and the season unduly wet, these crops are liable to overgrow in stems and leaves on rich land, and falling down, or even continuing too late their mere vegetative growth, make grain of poor quality and not large in quantity.

Flax is less liable to be overfed, while the varieties of oats as yet available for most localities are peculiarly liable to lodge and to be overdone with much plant food.

Why the cereals do not yield nearly as well following cereals as after alternating crops mentioned, is not fully understood.

It is known that a specific bacterial disease of flax gets in the soil and destroys the flax by the disease called flax wilt.

Crops Believed to Leave Poison in Soil—It is believed that some of these crops leave in the soil substances which are toxic or poisonous to the same plants grown the next year, and that this is one of the reasons why the yield is so low when one of these crops follows itself, or even follows one of the other small grains instead of following corn, grass, or clover.

It is observed by all that these crops allow weeds to ripen and the furrow slice to become full of weed seeds; especially if the stubble is allowed to stand unplowed for weeks after the grain has been harvested from over the weeds theretofore suppressed.

Flax grown for seed is the worst sinner along this line, because its leaves do not form a dense covering, allowing the weeds free growth, and because it is often so late in the ripening that many weeds have an opportunity to mature before the flax is harvested.

Winter rye and winter wheat generally ripen before many of the annual weeds have had time to ripen; and oats, barley, buckwheat, and millet often grow so dense and so rapidly that the weeds which start to grow are smothered out.

Grain Stubble Should be Plowed at Once—It is very important that grain stubble in which no grass seeds have been sown, be plowed or even disked, or better, plowed shallow at once after the grain is harvested.

This prevents most of the weeds from ripening and the land can be plowed again later in the autumn, or if corn, potatoes, or other cultivated crop is to be planted there, plowing may be done in the spring. This plan often serves well to provide a place into which the winter's crop of barnyard manure may be plowed under.

In the south a crop of crimson clover sowed with the cereal and allowed to develop among the stubble may be plowed under in the autumn or the next spring; or a crop of cow peas may be sown after the grain is harvested in June. Wherever the grain stubble can be plowed under early and a crop of peas or other leguminous crop, or even corn or other plant which produces much green matter can be grown and plowed under, adding fresh, active, vegetable matter, humus will be added to the soil.

Feeding Legumes to Stock Best Plan—These leguminous crops are valuable as green manure on account of the nitrogen and the humus-making organic matter they contain. But where they can be harvested, fed to live stock; and half of these substances can be returned to the soil as manure dropped in the field or carted from the barns, that is generally the best plan.

Where the crop is carted from the field, nearly half the nitrogen and humus-making materials are left in the roots and in the bottoms of the stems and in the leaves and other portions of the plants not obtained in gathering the green forage or the field-dried fodder.

The live stock secure sufficient toll from the crop to pay for more than the one-fourth of the total manurial value finally lost. Besides, feeding out a crop of forage makes live stock necessary, and there is another compensation in the grain which must be usually fed with the roughage, thus keeping also on the farm more of the manurial value of the grains raised on the farm or purchased.

Live stock are great agencies for building up and conserving soil fertility. When "the pig roots off the mortgage," he has also rooted greater value into the soil saved from the money lender; and the cow has well-nigh usurped the "golden hoof of the sheep" in many states because "she ships out, in the form of golden butter, sunshine for dollars," leaving practically all the fertility contained in her food to be returned to the soil.

Preparation of the Grain Crops' Seed Bed—These grain crops are generally good feeders, but they want to feed near the surface as well as deeper down. They can send their water-finding roots four or even six feet deep, but they know that the richest part of the soil is the furrow slice and they want that in the best possible condition to feed in. In most climates they like to have the furrow slice a year old, so that its lower half has had a year in which to become compact and well-knit together.

They like to have only the upper part of the furrow slice loose to easily take in falling rain and to serve as a dust blanket or dirt mulch to retard its wasting by evaporation from the surface of the ground. Fall-plowed land is as a rule, therefore, better than spring-plowed land. Corn and potato fields often leave the soil in excellent condition for these grains. This is true of fields in which the surface was stirred several times to the depth of two or three inches the previous year. Thus the lower part of the furrow slice is allowed to become compact, its upper part is kept mellow and many weed seeds are brought into the sprouting zone, the resulting plants from which are at once destroyed.

Cases of Advantage in Replowing in Spring—On very heavy lands far to the north, in rare cases it is best to replot the land in the spring to prevent its becoming too dense.

In some climatic conditions in the dry plains regions, plowing in the spring gives better yield than fall plowing. There the evaporation into the dry atmosphere is so rapid, and the supply of soil moisture is so meager that the whole depth of the furrow

slice is needed to retard the loss of evaporation of water from the surface of the ground.

The plants can better give up having their roots in the lower half of the furrow slice and feed in the subsoil than do with less water. These soils are rich in plant food to great depth and the conservation of water instead of the conservation of plant food is the prime necessity.

Seed Bed Should be Fine and Smooth—The immediate preparation of the seed bed should be such as to have it fine and smooth, that the seeds may be placed at a moderate depth, one to two inches for flax and millet, and one and one-half to three inches for the other grains.

Under dry, late, warm conditions, the deeper depths should be approached, and under cool, early, wet conditions, the shallower planting should be made.



Shocking wheat

The best time for seeding must be worked out for each locality. Sometimes unusual conditions control, as where it is necessary to plant winter wheat late in the autumn so that it may escape the Hessian fly. As a rule, spring wheat should be sown very early, oats a little later, barley still later, millet not till corn planting time, while flax and buckwheat have a wide range from the time danger of frost is well passed till in June.

Planting at Uniform Depth in Moist Soil—The planting should be done in such manner that the seeds are placed at a uniform depth in moist soil from which they may at once absorb the necessary moisture to induce germination, and to provide a water contact between rootlets and soil particles through which plant food may at once go from soil into root and plant.

There has been great improvement in machinery for seeding small grains. The hoe drill, and especially the disk drill and the shoe drill, place the seeds in the moist bottom of a freshly made furrow and allow the soil to at once fall back as a covering.

Following with a Scotch harrow or other drag to complete the covering is often an aid to uniform germination and to care of plantlets in escaping from the seed bed.

Conditions Determine Amount of Seed—The amount of seed varies greatly with the openness or closeness of texture of the soil, and its fertility; also with the temperature and rainfall, and with the earliness or lateness of planting.

When conditions such as dense, moist, cool soil prevail for a long period, inducing the grains to stool well, less seed will be necessary. On the other hand, an open, drouthy, infertile soil, warm weather, and a short stooling season, will make necessary a larger amount of seed for a full stand of plants.

Some of these conditions are in conflict, as the inability of a soil poor in fertility to support a heavy crop.

The amount of seed best to use in each agricultural district for each crop, each kind of soil, and each time of seeding must be determined by formal experiments or by wide practical experience of farmers in that district.

Since the farmer cannot predict with certainty what the weather is to be following a given date of seeding, he must take into consideration all other available facts and use his best judgment; not departing too widely from what is known to be the best average amount of seed to be used.

Some General Rules as to Amount of Seed—About one-sixth less seed is needed when the drill is used to place the seeds at a uniform depth than when they are broadcast and placed at different depths by cultivating them in. Only the average extremes in amount of seed to sow are given here, because local requirements differ so widely.

They may be stated as follows: Wheat, five to eight pecks; oats, eight to ten pecks; barley, seven to nine pecks; rye, seven to nine pecks; millet, two to three pecks; flax, for seed, two to three pecks; buckwheat, two to three pecks.

As a rule little more can be done for the growing crop of closely drilled or broadcast grain than to pull out by hand large weeds or such weeds as wild mustard, the seeds of which ripen with the ripening grain and reseed the field.

In some foreign countries, women and children are employed to pull out the weeds and even to hoe between the narrow drill rows when the plants are several inches high. We are glad that our country has such high rates of wages that this is impracticable; and that our farming is on a broad basis of machine

farming under which our farmers and farm laborers can get good and just remuneration for their work.

Shocking an Art to be Taught by Example—Modern farm machinery has blocked out a rapid, easy, and effective way of handling the small grains. These crops are practically all bound in bundles by the self binder, and the bundles are bunched ready for the shocker, who is the only man who needs to touch the bundles with his hands.

Shocking is an art that is easily taught by example, but not so easily described on paper. Different arrangements of the bundles suit different purposes. For wet grain, or for quick drying, that the grain may early go to the stack, barn, or threshing machine, "two by two" shocks are often best. Sometimes these should be set closely, and under other conditions they should be set open so as to give to the air the freest possible circulation.

A simple round shock is made by placing four bundles in the middle and then placing around them a circular row of compactly placed bundles, each slanting toward the center. These bundles should be firmly set on the ground, and unless rapid drying is needed, each successive bundle should be set compactly against its fellow so that the wind may not get a hold and tear the shock to pieces. Generally two bundles with both butts and heads broken over should be used to set into and lap over the shock so as to serve as shingles in shedding water, and so placed that they will withstand wind pressure.

Fighting Dampness and Weevil from Grain—As American farmers accumulate wealth, they build great barns, if not sufficient for all their hay and unthreshed grain, at least to store the neat grain until such time as good prices or needs of the bank account warrant its being taken to market. Only where the newly threshed grain is damp, is there usually need of extra precautions in storing grain. Then some means of drying must be employed. Large barn floors on which the grain is spread and turned with shovels twice or oftener daily, to avoid heating, and to induce drying, is often the most available method.

In rare cases grain weevils need to be fought. Then the bisulphide of carbon treatment can be effectively used, and your experiment station or your Uncle Sam's Agricultural Department will send a bulletin for the asking.

It may be applied directly to the infested grain or seed without injury to its edible or germinative qualities by spraying or pouring, but the most effective manner of its application in moderately tight bins, or other receptacles, consists in evaporating the liquid in shallow dishes or pans or on bits of cloth or cotton waste distributed about on the surface of the infested grain.

Insects Killed by Evaporation of Liquid—The liquid rapidly volatilizes and being heavier than air, descends and permeates the mass of grain, killing all insects and other vermin present.

The bisulphide is usually evaporated in vessels containing one-fourth or one-half pounds each, and is applied at the rate of a pound and a half to the ton of grain. In more open bins a larger quantity is used. For smaller masses of grain or other material an ounce is evaporated to every 100 pounds of infested matter.

The grain is generally subjected to the bisulphide treatment for twenty-four hours, but may be exposed much longer without harmful results. Since this chemical is inflammable, all lights and matches should be kept away from it.



Harvesting wheat

The time will surely come when grain will be sold for the cleaned grain, and then all the farmers will be induced to keep the weed seeds and other foreign matter to be fed to live stock on the farm where they were raised.

During recent years great improvements have been made in grain cleaning machinery, both in the threshing separator and in the barn fanning mill. With one of the modern fanning or grading mills, which is both efficient and rapid, the grain can be re-cleaned before sale at no great cost of labor. As a matter of fact, many threshing separators in good hands put only clean grain into the farmers' granaries.

The Most Profitable Marketing of Small Grains—It pays to market some small grains "on hoof;" that is, feed them to live stock; but the larger part must go to feed the men and horses of the cities, and to make linseed oil and other non-food products.

As a rule, farmers market their grains as soon as convenient after they are garnered, as most of the commercial crops of these grains are produced in the north temperate zone. This puts the bulk of these commodities on the market in our northern autumn and early winter.

Since the purchasing agencies are better organized than the original sellers, the producers, it is believed that this tends to place the farmers under some disadvantage as to price. The ability to prognosticate prices has been successfully developed by comparatively few farmers, while many of those who make trade a business have developed a peculiar ability along this line.

Scientific investigations are being made of the marketing of farm products; and in some cases growers have met combinations of buyers with combinations of sellers. This brings barter



A modern binder in operation

and sale to a more equal basis, often with only a single representative, or better, with a committee, on either side. The deal is then on a broad basis and all the facts may be available to both sides.

Effect of Reports and Organization—The development of government reports of crops, of stocks on hand and in transit, and of demand, and the organization of buyers and sellers offers a most interesting phase for study in our rural economics.

The world is becoming more co-operative, even more sensibly socialistic, using that word in its true sense, than it has yet recognized. Farming is to be the one great industry where individualism is conserved for the business and family life, and where only those things where co-operation is necessary and best, are given over as public or co-operative functions.

Individualism under co-operative organization was made

possible by our farmstead scheme, where "the farm business and the family form a unit" calculated for the best production of men and women.

Progress in Breeding the Small Cereals—That the American farmers are ere long to have varieties of grain which yield ten or even twenty-five per cent more than those now in use is certain.

The introduction of the best old or newly bred varieties, varieties from foreign countries, and from state to state, and the improvement by breeding the varieties of each state suiting them to each and every agricultural district, are proved methods, capable of adding \$1.00 to \$3.00 per acre to the value of our 100,000,000 acres of small cereals.

These possible hundreds of millions of increased crops annually, at a cost of much less than \$10,000,000, is finally interesting the national and state governments, as well as seed firms, also a larger number of private breeders of field crops.

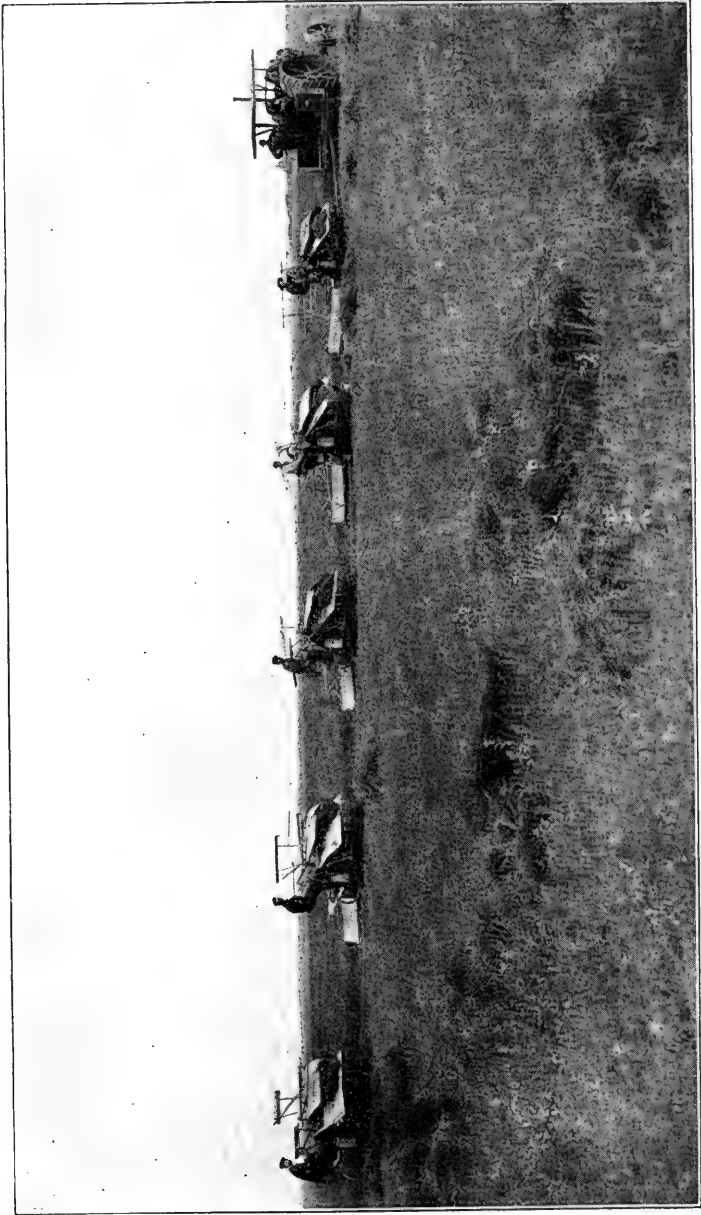
The introduction of durum or macaroni wheats to the semi-arid lands of the great west has made possible tens of millions of added crop, and the cost has been very slight. These durum varieties are now serving as bases on which plant breeders at various experiment stations are building better varieties by the art of selective breeding, and by breeding by hybridization followed by selection.

Notable Increase by Spring Wheat Breeding—Some of the spring wheats have already been bred so as to yield fifteen and eighteen per cent more grain on millions of acres upon which rapidly spreading varieties from the Minnesota experiment station are now grown.

The United States Department of Agriculture is co-operating with a number of state experiment stations, and new selected and new hybrid pure-bred varieties of each of the small grains are being originated by the tens of thousands.

On one experiment farm alone 2,000 new hybrid winter wheats have been originated. It is believed that at least a few of these new sorts will be as hardy as rye, and will extend the winter wheat zone to the Manitoba boundary, thus greatly increasing the yield.

Continuous Snow Makes Large Crops—When the winters are such that snow covers the ground during the winter season, winter wheats yield thirty to fifty per cent more than do spring varieties. The combined autumn and spring cool periods greatly extend the stooing period, and besides, winter wheats, by ripening earlier, escape much of the bad effects of the hot, dry summer weather and much of the ravages of insects, and especially of wheat rust.



An I H C gasoline tractor drawing five 8-foot binders

A new variety of flax, named Primost, or "Minnesota No. 25," has been supplied to the farmers under co-operative plant breeding work of the United States Department of Agriculture and the Minnesota experiment station, which yielded 15 bushels to the acre, as compared with 11.9 bushels of common flax grown under the same conditions. This gain of 3.1 bushels per acre or of 26 per cent is worth several dollars an acre. The breeding of this new variety did not cost more than one thousand dollars.

Other new varieties of each species of the small grains, which are now incubating on various experiment farms, will rapidly come forward, and all farmers should be ready to buy as each new and thoroughly tested and authenticated variety is brought forward by these public institutions.

Scientific Method of Breeding Cereals—Methods of breeding the several kinds of cereal crops are being worked out in the most scientific and practicable manner and resulting therefrom, many new varieties, which add 10 to 25 per cent and even more to the yield of these crops, are coming forward for general distribution to farmers.

The best varieties of a given grain are obtained by an experiment station and are tested in field plots as to their yields and the quality of grain. Those which are manufactured are also tested in the mill, and wheat and rye are tested in the laboratory as to their bread making qualities.

When field and laboratory tests show that a given variety has superiority in its power to produce values per acre, it is planted in the field preparatory to its serving as a basis for breeding. Often the best variety to serve as a basis for breeding is one already commonly grown. The plant breeder now selects from as many heads, say 5000 seeds, and plants them in a short row. When the wheat is ripe, the plant breeder selects from these rows those stocks which show superiority, usually throwing away all but ten per cent of the whole. Grain to be planted the next year is harvested from each of those stocks reserved during the head-to-row test.

The next year three or more drill rows one rod long, or hill rows one rod long, or possibly rectangular plots are planted; or perchance, all three of these plot tests are used. A comparison of the plots is made on the basis of both yield and quality of the grain. All of the least desirable stocks are discarded. Seeds are saved and similar plot tests are made the next year. Usually from this large number of mother plants a small number of exceedingly large yielding varieties are thus discovered.

The five, ten, or more, most promising varieties are now taken to field tests, where they are grown in a field way, usually for three years, two or three duplicate plots being grown each year. Any variety which is outstanding in its promised value per

acre is at once taken to the fields and multiplied as rapidly as may be for its early distribution to growers.

While increasing the seeds of the promising new variety it is also sent to other experiment stations and branch stations of the region where it is likely to prove valuable, that it may there be tested also. By the time the variety has been increased to some thousands of bushels for distribution to growers of pure bred seeds the general facts are known as to its yield at experiment stations of various regions, and if it be a wheat, its milling and baking qualities can also have been determined on a practical scale.

Class of Pure-Bred Seed Growers Needed—For rapidly distributing the many valuable new forthcoming varieties of field crops, that they may quickly replace poorer kinds, and that they may be kept pure from diseases and clean of weed seeds, there needs to be developed a class of pure-bred seed growers, as we have now growers of pure-bred live stock.

In some states the experiment stations select the men to whom they will sell at a good price their valuable new creations, that every county and every neighborhood may have the seeds grown for them near home and at a fair, though profitable price.

In some cases these growers of pure-bred seeds have formed state seed growers' associations. This plan of distribution of new varieties helps to give to growers of valuable seeds that added profit, and induces them carefully to produce and market the needed large amounts of each valuable new kind of seeds, so that all will grow them instead of the old-fashioned, poor yielding kinds. It is both an honor and a profit to be a grower of pure-bred seeds, and this plan is profitable to the mass of farmers who need the good seeds.

American grain growing is looking up because it is fast becoming a part of general farming, because the fields are becoming better prepared for grain, and because science is making vast improvements in machinery, in methods of cultivation, and in transportation, and, especially, in the inherited power of the varieties of grain themselves.



The Corn Crop

BY P. G. HOLDEN

Vice Dean and Professor of Agronomy, Iowa Agricultural College, Ames, Iowa



“More corn of better quality on every acre of ground” is the motto of every corn-grower in Iowa. Let us each strive to grow more and better corn this year than we did last. This is the secret of success. This will make us love our work. Drudgery is work without thought, without interest, without love for it. “The man who can make two ears of corn, or two blades of grass, grow on the spot where only one grew before, would deserve better of mankind and render more

essential service to the country than the whole race of politicians put together.”

The average yield of corn in the United States today is about 25 bushels per acre. It can be increased to 30, then to 35, and ultimately to 50.

To produce a good crop of corn we must have good land, good seed, good preparation of the ground and care of the crop, a good season, and last but by no means least, a good man. Important as these things are, I must omit from this short discussion all of them except the question of good seed.

If I owned the farms of the United States and could give but four orders regarding corn, those orders would be as follows:

1. That every ear of corn intended for planting be tested, that is, not less than six kernels (better ten) be taken from each ear and sprouted and all weak and bad ears discarded.

2. That every ear intended for planting be harvested before the fall freezes, and properly preserved.

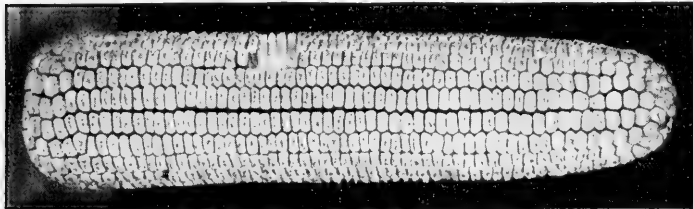
3. That the corn be graded and the planter tested and made ready to drop the proper number of kernels.

4. That the corn be improved by selecting, for the average farm, say, 100 of the best ears and planting them on one side of the corn field. The seed for the following crop to be selected in the fall from the part of the field where the best seed was planted.

Notice that all of these are things which can be done by every one; that they cost practically nothing except a little time and

work; that no loss can possibly come to any one from properly testing, harvesting, grading, and improving his seed.

It is difficult for us to comprehend the enormous wealth which would be added to the United States if these four orders were carried out by every farmer; and let me again add that



A champion ear of corn

they can be carried out by every one and at practically no increased expense.

To illustrate: I presume that there is hardly a person in Iowa but will agree with me that if every ear of seed corn had been tested this spring before planting and the weak and bad ears discarded so that nothing but strong seed was planted, it would have added on the average not less than 10 bushels per acre to the crop. In one average county of Iowa with 90,000 acres planted to corn annually, there would be an increase of

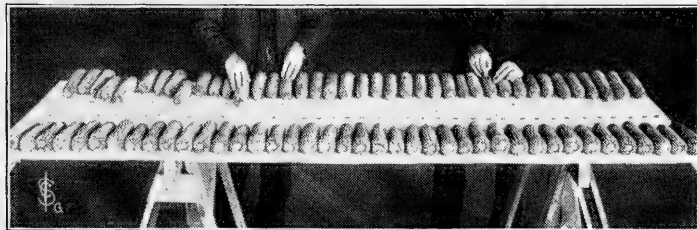


Plate No. 1

From each of the remaining ears remove 2 or 3 kernels. Examine these kernels and discard those ears which have poor kernels and thus save the work of testing ears which show from appearance that they are not fit to plant.

900,000 bushels worth \$450,000. But there are 99 counties, each growing an average of 90,000 acres of corn.

It is true that the seed this year was much worse than usual owing to the sappy condition of the corn last fall, the early freezes, and the unusually severe winter weather; but I am perfectly safe in saying that the annual average yield for Iowa could

be increased 10 bushels above the present if the four orders given above were carried out on every farm.

Testing Every Ear of Corn — There are two fundamental reasons for testing each ear.

1. It enables us to discard those ears which have been weakened or killed by freezing, mould, or premature sprouting in the fall.

2. It enables us to discover the scrubs or runts and discard them. Let me here caution you against the delusion which some men have that they can tell whether or not corn will grow by just looking at it or knifing it.

How to Make the Test — Lay out the seed ears side by side on tables or planks arranged for the purpose. Go over these

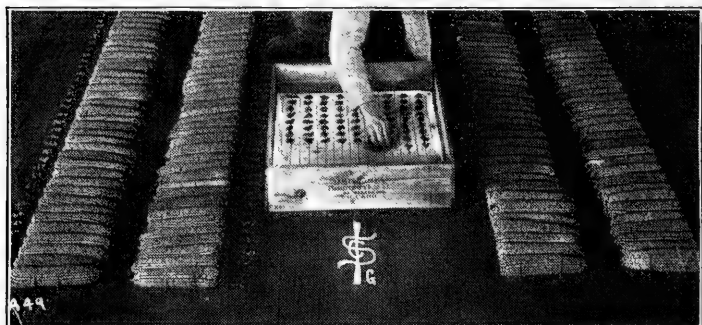


Plate No. 2

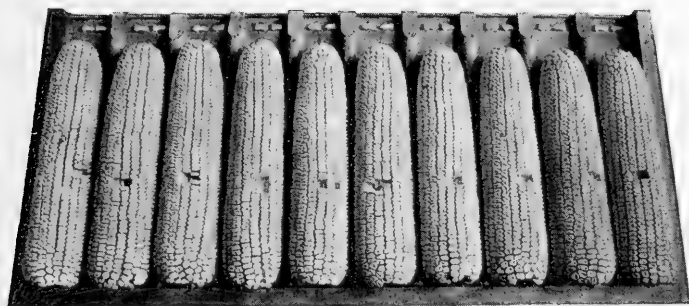
Putting the kernels in the germination box from ear No. 1 in square No. 1. From ear No. 2 in square No. 2, and so on.

carefully and discard the poorer ears. From each of the remaining ears remove two or three kernels with a pocket knife, placing them at the butt or tip of their respective ears. From a study of these kernels you will be able to discard many more ears, some or all of whose kernels are mouldy, frozen, barren, immature, or are too shallow or too deep, too wide or too narrow, or whose germs are small, indicating poor feeding value, weak constitution, etc.

The remaining ears should now be arranged on the planks side by side for the final germination test. Remove not less than six, better ten kernels, from each ear and place them in the germination box to sprout. The places or squares for the kernels in the box should be numbered to correspond to the number of the ear from which the kernels were taken. This will enable us to discard those ears whose kernels in the box fail to grow or show only weak sprouts. Think for a moment what

it means to use one bad ear for seed: 900 missing places, equal to 300 hills,—on an acre, not less than 4 bushels of corn. It means wasted land and wasted labor. Then, too, the weak and sickly sprouts will betray many other ears which are really scrubs and can be discarded, ears which yield 10, 20, and sometimes 30 bushels less per acre than others.

It is certain that not less than 35,000 farmers tested every ear of seed they planted this spring in Iowa. Every farmer who grows corn, whether he lives in the north or south, in the east or west, should test each ear to be planted. It is proverbial that a "runt pig" is always a "runt pig." In the struggle for existence he is at a disadvantage at every turn. He is crowded from his comfortable sleeping place and rooted out of the feed trough. So it is with the 800 or 900 weaklings from an ear. They are in reality runts, scattered there and here throughout the field, and



Ten champion ears of corn

robbed of plant food, moisture, and light, by their more vigorous growing brothers.

Often they are barren; i. e., produce no ears, but these stalks do produce tassels with millions of pollen grains which drift over the field and fertilize the ears of the good stalks. In other words, these barren stalks become the fathers of millions of kernels of corn in the field, thus perpetuating their weakness. Remember that you cannot injure the seed by testing it. You cannot possibly lose. It costs nothing but a little time and labor. This work can and should be done in the winter before the spring work opens up. In this way none of the other farm work is neglected.

How to Make the Germination Box—One of the simplest and best methods for testing each ear of corn is by the use of what is known as the sawdust germination box.

Make a box 3 inches deep and 30 x 30 inches in size; fill it about half full with moist sawdust and tamp firmly with a brick.

Rule off a piece of good white cloth (sheeting) into squares $2\frac{1}{2} \times 2\frac{1}{2}$ inches each way, checker board fashion, and number the squares 1, 2, 3, etc. Place this cloth, which should be the size of the germination box, on the sawdust and tack it to the sides and ends of the box. Lay the ears of corn to be tested side by side on the floor or table. Remove six kernels from six different places in ear No. 1 and place them in square No. 1 in the germination box germ side up and crown pointing from you. Then remove six kernels in a like manner from ear No. 2 and place in square No. 2 in the germination box, and so on. When the squares in the germination box are all filled, lay a piece of good cloth over the kernels and dampen by sprinkling water over it. Place over this, a cloth considerably larger than the box and fill

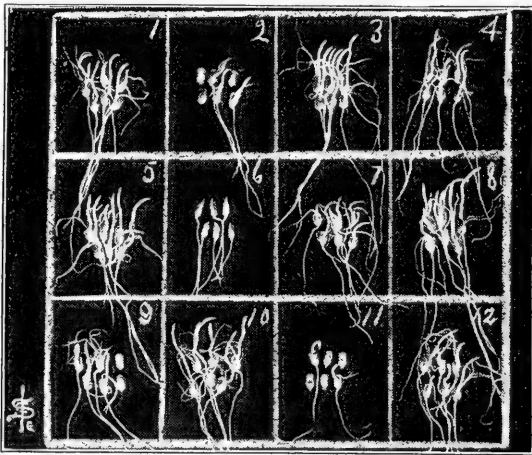


Plate No. 3

the box with moist sawdust, tamp with a brick or board or tread on it with your feet until firmly packed on top of the corn. Keep the box in a place where it will not freeze; raise the upper side of the box or the side toward which the crowns of the kernels point, 3 or 4 inches; the stem sprouts will then grow up and the root sprouts down, thus making it much easier to read the test. It requires about eight days for the corn to germinate. At the end of that time roll back and remove the cloth containing the top layer of sawdust. Now remove the second cloth as carefully as possible and examine the six sprouted kernels in each square.

The above box when completed and set away for germination may be described briefly as follows: Two inches of sawdust packed firmly in the bottom of the box. On this is laid the

cloth ruled off in squares, then the kernels laid in the squares, a second cloth spread on the kernels and dampened, then a third cloth much larger than the box, on which is placed 2 inches more of damp sawdust packed firmly. The edges of the larger cloth may be folded over on the top of the sawdust.

Important Things to be Remembered—Soak the sawdust at least 2 hours—better, over night.

Use a good quality of sheeting for the cloth that is ruled off in squares and also for the cloth covering the kernels.

Do not use a cheap, porous grade of cloth, as the sprouts will grow through it and greatly interfere with the work.

Leave a 2-inch margin around the edges of the box to prevent freezing and drying out.

Make the squares to receive the kernels $2\frac{1}{2} \times 2\frac{1}{2}$ inches.

Never use the box more than once without thoroughly scalding both the sawdust and the cloths.



Plate No. 4

To insure accurate reading, the stem sprouts should be at least two inches long when examined.

Throw out all ears which show weak germination as well as ears whose kernels fail to grow.

Do not guess that an ear of corn will grow and grow strong. Test it, and find out before you have wasted upon it a whole year of labor and the use of your land.

Test six kernels from each ear and discard the bad and the weak ears.

Ears 3, 5, 8, and 10 are strong.

Ears 1, 4, 7, and 12 are only fair.

Ears 2, 6, 9, and 11 should be discarded.

Is there anything more foolish than to guess that 800 or 900 kernels on ears like 2, 6, 11, etc., are all right, when we can find out at practically no expense?

You say that your field was infected with cut worms, grubs, etc. How much more need then of strong seed that you may have something left for yourself after feeding the worms. You

say that the spring is cold and backward and that this accounts for your poor stand of corn. All the more need then of strong seed. Tens of thousands of farmers in Iowa this year have good stands of corn, while there are tens of thousands of their neighbors with poor stands, and tens of thousands of others who are replanting, which is always most discouraging and most disappointing in results.

You say that your ground is poor and foul; that the season was too wet, or too dry, and the care of the crop bad. You know as well as I do that strong, vigorous plants will stand these unfavorable conditions better than poor, weak ones. If your land is rich, well prepared, and the season good, how absolutely foolish it is to go out to this field and plant it with poor seed, much of which fails to grow or gives only weak stalks.

The time is past for guessing that the 900 kernels on an ear are strong. We must know before the year's labor is put upon them.



The corn binder operating in heavy corn

During the past seven years more than 10,000 fields of growing corn have been examined. In no year has the average exceeded 72 per cent. of a perfect stand. It has been as low as 64 per cent. The average has been 67 or 68 per cent of a stand. In other words, the average corn grower spends three hours of every day that he works in the corn field traveling over plowed ground that produces nothing.

There are many causes which contribute to a poor stand of corn, yet every one who has given the question much attention will agree with me that poor seed is by far the greatest cause of the poor stand.

Better Care of Seed Corn—We must take better care of our seed corn. We must harvest it in the fall before the severe freezes. In Iowa and the north half of Illinois the last ten days in September will be about right. It should be hung up,

not piled up. It is circulation of air that is needed and not heat. Especially is this true during the first two weeks after the seed is harvested, while it is still sappy. There is no place better than an up-stairs room or attic, where the windows can be left open until the seed is dry. Again I will repeat, hang it up, don't pile it up.

Plant the 100 Best Ears Together—One hundred or so of the very best ears should be selected in the spring when we are testing our seed, shelled, and mixed together. This best seed which comes from the finest ears should be planted on one side of the corn field. Next fall from this seven or eight acres should be selected the seed for the following crop. Is there any good reason why any of us should fail to do this? We all recognize the great law that "like tends to produce like." In planting the field it takes no longer to put this best seed in our planter and plant it out first.



Alfalfa Culture in America

EARLY HISTORY—DISTRIBUTION AND ADAPTATION —PROFITABLENESS OF ALFALFA

BY JOSEPH E. WING

Expert Agriculturist, Mechanicsburg, Ohio

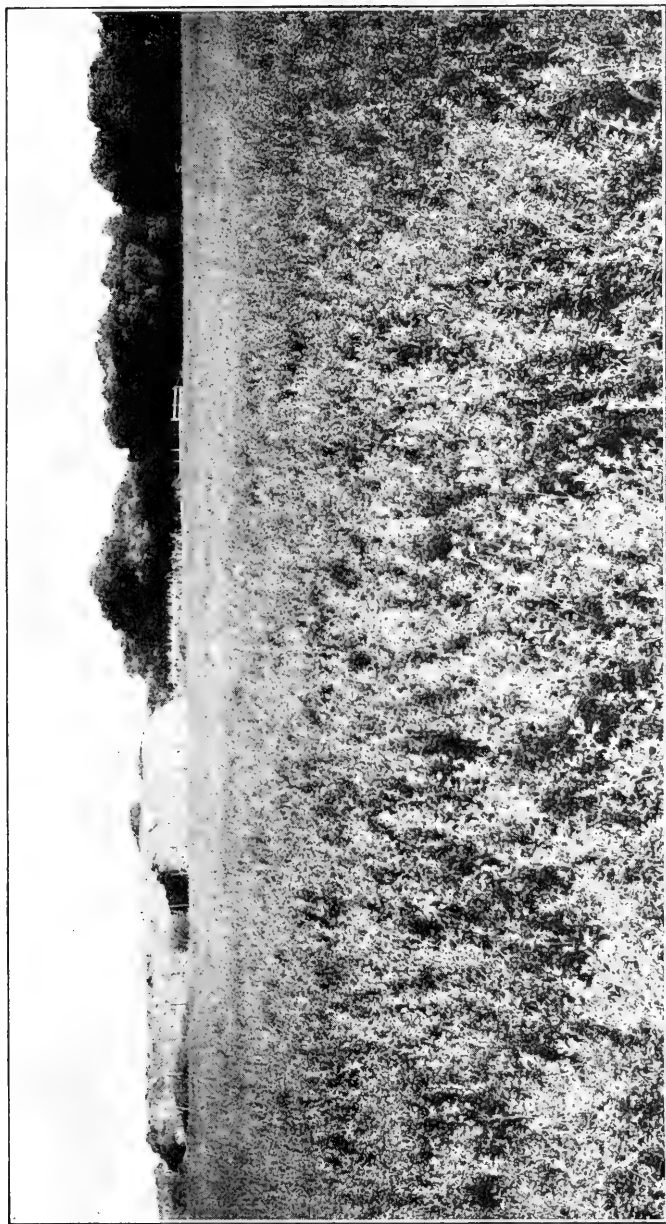


WHERE it Came From—So many centuries ago that history does not record, the alfalfa plant was adopted into the family of mankind. It was grown long before the days of the Romans, and fed to the saddle horses of the desert. It was in esteem during Roman times, and old Roman books on agriculture tell how to sow it and how to till it and how to nourish it; and how, when it is grown, it "is good for all manner of famished beasts whatever." Doubtless the

chariot horses that Ben Hur drove were fed on alfalfa hay. From that day to this it has been a plant held in high esteem wherever the best agriculture has been practiced, especially in dry and warm climates where irrigation is practiced.

Introduction into America—The introduction of alfalfa into America proceeded from two sources. The English settlers in Virginia and the Atlantic colonists brought it with them, and at one time many years ago it was in repute, under the name of "lucerne," in New York, parts of New England, and Virginia. It was recognized as having remarkable value, yet as acting strangely under cultivation, responding finely for one man, refusing to grow for another; growing beautifully in one field, refusing to grow in an adjacent one. It failed to make much seed, and eventually its culture died out almost entirely in the Atlantic region.

Introduction to the Pacific Coast Region—The Spanish people brought alfalfa to Chili, Mexico, Peru, and in a small way to southern California. It thrived in the dry, warm valleys, in soils rich in mineral elements and well watered by irrigation. Its influence was unfelt in the United States until the settlement of California. The earlier settler sought only gold, but soon there appeared another class who sought by tillage of the soil to gain wealth by feeding the gold hunters. Thus there grew up a sort of pioneer farming in California. One of the



An alfalfa field in bloom

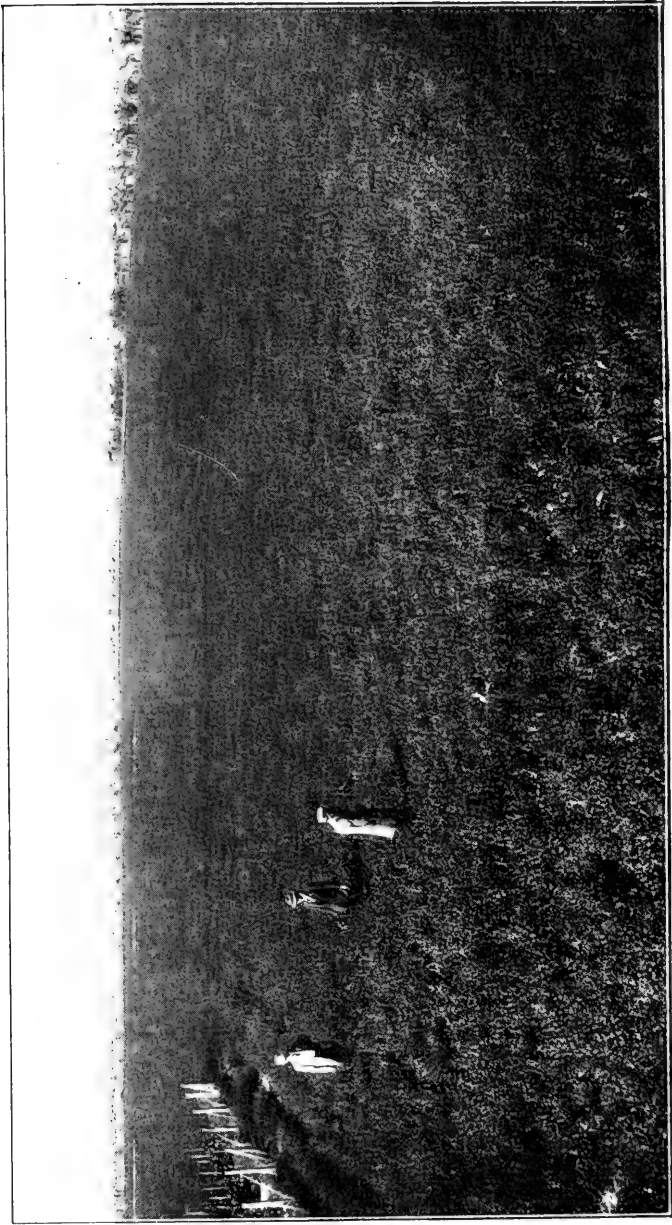
earlier stockmen there, Henry Miller, killed cattle in San Francisco. In order to have always at hand a supply of available beef steaks, he bought land in the San Joaquin valley, and tried to grow forage crops there. In 1873 he began to make serious attempts to grow alfalfa, importing the seed from Chili. It was a plant that many voyagers from eastern America had noticed growing luxuriantly on the plains of South America. Henry Miller succeeded in making his alfalfa grow. He fed it to cattle, and with the profits bought more land to sow more alfalfa. When the writer some years ago visited the ranches of Lux and Miller, he found feeding there on green alfalfa, more than a hundred thousand cattle, with very many sheep. Thus had the alfalfa plant heaped up wealth for these far sighted ranchers! Doubtless there were other men experimenting with alfalfa growing in California as early as this or perhaps earlier, but Henry Miller is perhaps the first man to exploit the plant on a large scale.

From California the plant spread eastward to Utah, to Colorado, to Idaho and Montana, to Kansas, Nebraska, and, later, to Ohio, Illinois, Indiana, Wisconsin, and New York; and now in these blessed days of prosperity it has gone to nearly every state in the Union, is grown in Alberta, Canada, and many of the islands of the sea.

Alfalfa Growing in its Infancy—And yet, with all its spread, alfalfa growing has only just begun in the eastern states. One farmer in ten in favored regions is growing it, and he is growing only half or maybe a tenth of what he will some day. The other nine farmers will learn—they must—or else be crowded out by their more favored competitors. It was held for a long time that alfalfa growing must be confined to certain climatic belts. Now it is known that it thrives, so far as climate is concerned, almost equally well from the Atlantic to the Pacific, from the Lakes to the Gulf. Certainly, it gives more crops in warm climates where it has a longer growing season, but any part of America, saving the high mountain plateaus, is warm enough for two crops a year.

Later, it was thought that only certain soils would grow alfalfa. Now it is known that, while it prefers rich, loose limestone soils, it will grow luxuriantly on strong, stiff, limestone clays, once they are made dry with tiles and fed with manure. It grows on sand, when the sand is made rich. It grows away from limestone, when the land has been sweetened with lime. In truth there is hardly a type of soils in the Union that is not now growing alfalfa, under enthusiastic culturists, who persist in giving the conditions that it needs and deserves.

Easily the queen of all clovers, and of all the plants of the meadow, is alfalfa. It is the hardiest of them all, the most



A field of alfalfa in Oregon—the fourth crop

lasting, the most productive, the most efficient soil enricher. It is the most beautiful, and it yields hay of the highest quality.

Alfalfa is not new to the United States, but only within recent years has its culture been well understood, and a few essentials of its success been learned. It revels in dry land made sweet with lime (where this is needed), and rich with manures. Alfalfa is the most energetic soil enricher of all the clovers, but it must find fertile soil on which to begin, and cannot, like sweet clover, begin on wornout lands. Once it is well established, however, its ability to build up the field on which it stands, and the adjoining fields (from the manure made by feeding the hay), is nothing less than marvelous.

The New Jersey experiment station has shown that the yield of an acre of good alfalfa contains fertilizing ingredients that in the shape of commercial fertilizers would cost on the market



Harvesting alfalfa

at least \$65.00. So it can readily be seen that once alfalfa is established on a farm, and the hay fed thereon, and the manure saved, that farm must very rapidly increase in productiveness.

Alfalfa is a perennial, enduring on well drained soil from five to fifty years with one sowing. It may be cut from three to five times a year, and will yield, in the regions of the corn-belt, from three to six tons of hay per acre. The composition of alfalfa hay is such that it has almost the same nutritive value as wheat bran, and may be substituted for wheat bran in the ration of clover with good results. As a feed for all classes of live stock it is unexcelled. Every animal upon the farm loves alfalfa, and thrives upon it. As a pasture plant it has no equal in the amount of gain upon animals that may be made from an acre of it, as much as 600 pounds of pork per acre being frequently reported where hogs have grazed it. It is also the best horse

pasture known, and is sometimes used as a pasture for sheep and cows, although one must observe due care in de-pasturing it with these animals since they may bloat.

As a soiling crop alfalfa easily heads the list. It yields the most herbage and of the highest quality, and indeed, it is much better for the meadow, and usually for the animals, to feed it off by soiling rather than by de-pasturing.

Alfalfa Seeding—Much needless mystery has been made of the alfalfa seeding question. So much mystery, in fact, that many farmers are afraid to try it at all. Jones recommends one method and Smith another; and how is the farmer to tell which is right? We began the study of the alfalfa question twenty-five years ago, and since that time we have carefully watched fields of it in almost every state in the Union. We have corresponded with thousands of successful growers, and with thousands of other growers who were having troubles, and we really believe now that we are able to furnish reliable data as to just what it is necessary to do in order to succeed with this plant.

We could almost sum the matter up in four words: Lime, drainage, humus, and inoculation. Perhaps we have given these in order of their relative importance. Lime is necessary on soils not naturally of limestone formation or filled with limestone pebbles. The importance of this is impressed upon us more and more each year; in fact, we believe today, that there have been more failures throughout the United States on account of insufficient lime in the soil than from any other cause.

Then as to drainage; there is no use in planting alfalfa on any soil where water may ordinarily be found at a depth of less than three feet. The alfalfa may grow all right until its roots strike this water, but then it will probably die.

Fertile soil contains enough humus. Impoverished soils may be so deficient that special preparation must be made before alfalfa can possibly succeed. Stable manure, where obtainable, is the very best thing for adding the proper humus to the soil; and we would urge its liberal use wherever possible. It might be best to use this a year in advance of sowing alfalfa, and follow with clean cultivation to overcome what weeds might be sown with the manure, or, a good way is to top-dress the alfalfa during its first winter, using a manure spreader and applying the manure evenly without large chunks that might smother the young plants. On impoverished soils, we would recommend preparation for alfalfa one or two years in advance, growing such crops as crimson clover, mammoth clover, cow peas, Canada field peas, or soja beans, and preferably turning them under or else pasturing them off, so as to give the soil the greatest benefit possible from them.

We recommend inoculation, not that it is always necessary,

but it is an inexpensive process, and in five cases out of six it will actually pay. This subject is fully discussed later on.

Having determined that our soil is sweet, well drained, and sufficiently supplied with humus, the only questions that remain are: The preparation of a good seed-bed; sowing at the proper time of year; and the use of good seed. For the seed-bed, it is essential that the ground be carefully fitted. It must be plowed, unless it is old ground, such as corn stubble, which may be thoroughly disked instead of plowing. It is better to firm the subsoil a little, so that only the surface is really loose. This, because if the entire soil is very loose, the seed may be planted too deep, and also because the alfalfa seems to prefer the sub-surface being a trifle firmed.

Time of Seeding—On Woodland Farm, for many years it has been our custom to sow alfalfa at oat-seeding time, about the first week in April, using beardless spring barley as a nurse crop. The barley is usually cut for hay the last of June, and after this we sometimes secure a good cutting of alfalfa hay the first season, although we do not count on this, and are not disappointed if we do not obtain it. We sow about three to five pecks barley to the acre—on real rich ground not more than one bushel—and eighteen to twenty pounds of alfalfa seed at the same time, usually using a disk drill and throwing the alfalfa seed in front of the drill, unless the ground is very loose, in which case we throw the seed farther back to prevent its being covered too deeply. The alfalfa seed should be covered about an inch. The advantages of this system are that the rains usually come about the right time for the young alfalfa, which makes a strong growth throughout the entire season, generally giving us with the barley enough hay the first year to pay the expenses of planting, and goes into winter into vigorous shape with about ten inches or a foot of stalk standing, enough to hold the snow throughout the winter and induce a fine, vigorous start in the spring. We find barley to be the best nurse crop obtainable. It takes the place of the weeds that would otherwise come, gives us some very excellent feed, and with us, does the alfalfa good and no injury. Oats are not so good, because they shade the ground more and are much more inclined to lodge. We find that the barley hay with the small amount of alfalfa we obtain with it makes a forage second only to the pure alfalfa itself. We cut this when the barley is in the milk or dough stage. It is not always necessary to cut the barley for hay, as it ripens its grain about July 12th in this latitude, and it is rarely that alfalfa is suffering much by that time. Many of our neighbors cut their barley for grain, and still secure admirable stands of alfalfa. Where no nurse crop is used, it is seldom safe to plant alfalfa before the 20th of June, because the weeds will almost

certainly choke the young plants, and no amount of mowing will prevent their doing so.

Many of our customers prefer seeding during the summer months, and this is certainly a very excellent way, frequently succeeding as well as our own, although sometimes failing on account of summer drought preventing the young plants from obtaining sufficient growth to go through their first winter. Many farmers become prejudiced against the early spring seeding, owing to their using oats as a nurse crop, but if they would use the beardless barley, they would doubtless be well pleased with the earlier sowing.

For summer seeding we recommend as a good method having the alfalfa follow a crop of early potatoes, or it may be possible to plow wheat stubble early enough to secure a stand before winter. An excellent way is to plow the ground early in the spring, harrow it as frequently as the weeds appear, and sow the alfalfa during July. If the rains come right, such alfalfa should make excellent growth before winter and be certain to succeed. We really believe that where beardless spring barley may be used as a nurse crop, the early spring seeding is advisable in the states of Ohio, Indiana, Illinois, Michigan, New York, and much of Pennsylvania. The late seeding is certainly preferable in some of the New England states, in Virginia, and the states south of the Ohio river. The reason for the late seeding in these states is that their climate seems to be such that the alfalfa thrives better when sown late than when sown early, and also in part of these places quack or crab grass and other weeds will give so much trouble that the early seeding is almost sure to fail on account of them. The farther south one goes, the later is it safe to seed alfalfa. We have many customers in Georgia, Alabama, Mississippi, Louisiana, and Texas, who seed as late as November 1st, but their winters are so mild that the alfalfa never winter-kills, and it comes on the next spring in just as good shape as if it had been sown earlier in the season.

Fertilizers — We find that on nearly all soils, phosphate does alfalfa more good than any other fertilizer. We recommend basic slag on soils that are acid, and where you do not wish to sow lime or untreated phosphate rock on limestone soils that are not acid. For the quickest and best results on these limestone soils, use one hundred pounds acid phosphate and nine hundred pounds untreated phosphate rock per acre. The untreated phosphate will absorb acid from the acid phosphate, and the combination will bring the quickest results of any form of phosphate which can be applied. Also, applied in this way, the superfluous acidity being taken up by the raw phosphate, there will be no danger of making your land sour. Good barnyard manure as a fertilizer for alfalfa cannot be beaten; it should,

however, go hand in hand with the phosphate; neither is complete without the other. They should be applied at the same time for best results.

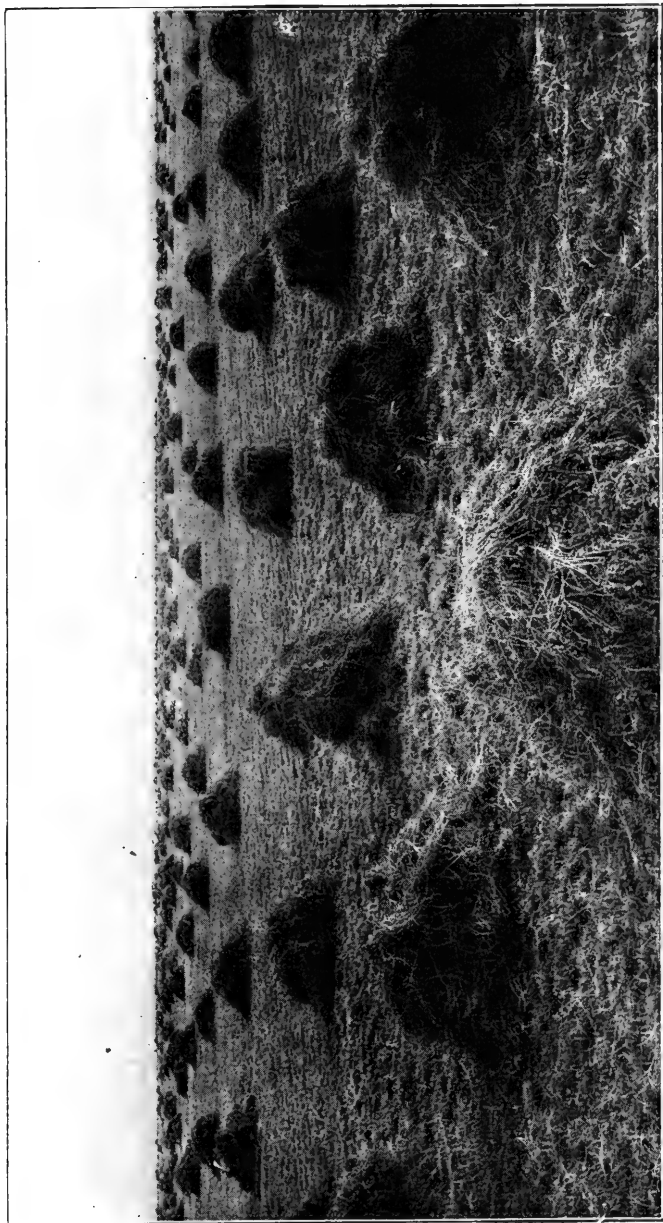
Seed— Good seed is of great importance. Alfalfa seed coming from Arizona, South America, or Arabia, will grow all right the first year, and then will probably winter-kill the first winter, especially in any of the northern states. We find that the very best seed in the world, that which is freest from dangerous weeds and which possesses the greatest vitality, is produced in our own United States, particularly in the northwestern part. Also it is better if grown on non-irrigated soil.

In some of the far southern states, an enemy constantly to be fought is the Johnson grass. In some of these states alfalfa seed is produced, and is very likely to be mixed with this pest.

We guarantee our seed absolutely free from this Johnson grass, and growers in any country who are troubled with it, may with perfect confidence purchase our seed.

Alfalfa for the Poultryman— The poultryman will find great profit from having a run of alfalfa. This should not be too small a space, but large enough so that the poultry can forage at will without injuring the plants, and so that he may cut the hay regularly and save it for winter feeding. Poultry thrive upon a diet composed chiefly of alfalfa, with some grain in addition.

Alfalfa for the Dairyman— No other food forms so good a basis for the ration of a dairy cow as alfalfa, the reason being its extreme richness in protein, and its easy digestibility, and the additional reason that the cows love it so, and eat it so greedily. Alfalfa growing countries have a great advantage over other countries in the dairy business, so that it is well for the dairyman, wherever he is situated, to begin to consider how he may make his own soil an alfalfa-growing soil. It has been found that the cost of milk production can be cut square in two by the use of home-grown alfalfa. A ton of alfalfa hay, early cut and nicely cured, as food for the dairy cow is worth as much, pound for pound, as the best wheat bran. In order to get its full feeding value, it should be ground. Even ordinary alfalfa hay is worth nearly as much as wheat bran; so that it is clear to the eastern dairyman, who must pay \$25.00 a ton for wheat bran, a field of alfalfa yielding no more than three or four tons per acre is a veritable gold mine. Governor Hoard has found that with alfalfa in the dairy ration, it is necessary to use only about half the amount of grain that must be fed when other forage is provided. In truth, with alfalfa hay and corn silage, little or no feed is needed to keep the dairy cow in the most profitable producing condition. We thus emphasize the importance of alfalfa to the dairyman, because among the many thousands of



A field of alfalfa ready to be stacked

eastern dairymen, the margin between cost of production and selling price of their products is so small that they are in a rather discouraging condition, and this condition, alfalfa will relieve better and easier than any other thing. There was a time, only a few years ago, when it would have seemed not worth while thus to attempt to raise the hopes of the dairyman, for then it had not been demonstrated that alfalfa could be grown away from the "alfalfa belt." But since then we have learned the few simple requirements of the alfalfa plant, and we do not hesitate to affirm that we can grow alfalfa anywhere, upon any farm in the United States not at too high an altitude, if the few simple but essential conditions are complied with.

Time to Cut Alfalfa—We usually cut it when about one-fifth of the plants begin to show bloom. A somewhat better way of ascertaining the proper time is to watch for the buds at the base of the plants and cut when they appear above the ground. These buds are the beginning of new stalks, and their appearance indicates that the plant is ready to make another crop.

Alfalfa as a Pasture Crop—It is especially adapted to being de-pastured by horses and hogs, and perhaps the greatest profit comes from such use. The practical difficulty with de-pasturing alfalfa with sheep and cows is, that being a clover, it sometimes causes bloat, similar to clover bloat. The best preventive of bloat is to have the alfalfa mixed with grasses in the pasture. When this is done, the animals eating the two together are very much less apt to bloat. The best grass to mix with alfalfa for pasture is brome grass (*bromus inermis*.)

In pasturing alfalfa, to get the best results, one should not turn stock on it before the plants have grown nearly to the blossoming stage; furthermore, the pasture should be so large that the animals will not eat it down close. It should be mown at least twice during the season and made into hay. It will not do, however, to pasture the field with sheep or cattle immediately after it has been mown, this being the surest known method of inviting disaster. After alfalfa is mown, it is not safe to turn stock onto it until the plants have reached the woody stage. Thus treated, alfalfa pastures will last for years, and afford an astonishing amount of nourishment.

All stock should be taken off of alfalfa pastures by the first of October, or, in the eastern states, at the beginning of hard frosts; this, both for the good of the alfalfa and for the good of the animals themselves. It is dangerous to de-pasture frozen alfalfa, and it is not even wise to cut it for hay. A profitable scheme sometimes practiced, is to break an old blue grass pasture, plow it rather deep, fertilize it well, and seed it down to alfalfa. A good stand of alfalfa is almost assured by this method,

and while the blue grass comes up immediately and fills in between the alfalfa plants; within a few years, the amount of combined herbage yielded by this practice is almost incredibly great, the grass itself yielding more than it did before the alfalfa was sown upon it. Alfalfa thus sown will not last as long as when the grass is absent, but while it is there, it is extremely profitable.

In any of the states east of the Missouri, we think that farmers who pasture alfalfa with cattle and sheep may be reasonably sure to have some losses, no matter how careful they are. We have never succeeded in pasturing it ourselves without some losses, but we believe it is sometimes more profitable to pasture alfalfa and lose a few sheep or perhaps a steer, than it is to handle our stock on other feed without this loss.

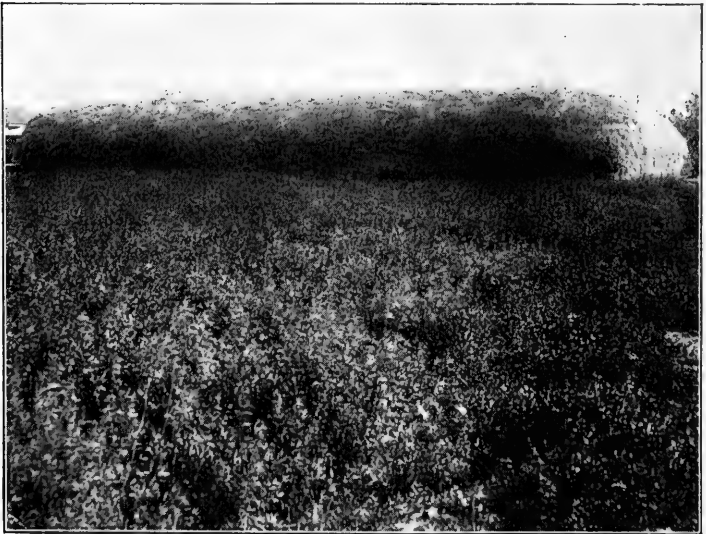
Alfalfa Turning Yellow—This may be caused either by a leaf spot or rust, or it may indicate that conditions are not right with the plant, that it needs lime, drainage, or inoculation. Mowing will usually check the rust; the other troubles are fully discussed later on.

Inoculation—All legumes have tiny bacteria that work on their roots, forming "nodules." These bacteria draw nitrogen from the air, and both supply the plants with it and also add it directly to the soil. Without these bacteria the legumes will soon perish, although most of the legumes seem to find their proper bacteria in almost any soil. Alfalfa is an exception, and it nearly always pays to supply its bacteria artificially. This may be done very inexpensively. Obtain soil from some near-by alfalfa field and apply it at the rate of one hundred pounds per acre, sowing it late in the afternoon and harrowing it in immediately before allowing the sun to strike it. This is the best way to inoculate. Soil from around the sweet clover or melilotus roots answers equally well. The government will furnish inoculation of another sort free; this usually succeeds, but not always. Another excellent way is to sow a few pounds of alfalfa seed with your red clover. After the clover is plowed up, sow to alfalfa, and you will probably have the field inoculated.

Lime in the Soil—Alfalfa thrives best on soils that are most abundantly supplied with lime. It absolutely fails where lime is deficient. Nothing will take the place of lime, and we believe that there have been more failures throughout the eastern states owing to this deficiency than from any other cause.

Kinds of Lime—Ground limestone is now manufactured in many places in the United States, and sold usually, where made, for about \$1.25 per ton. The finer it is ground, the more quickly is it available. It should be applied at the rate of about one hundred pounds per square rod, which is at the rate of eight tons per acre; although where it is inaccessible, and therefore costly,

much lighter applications are used with good results, although not so lasting. Sometimes one can get crushed limestone screenings, much of it as fine as sand. This stuff is used for concrete work, walks, and ballast, and often may be bought as low as fifty cents per ton or less. When the ground limestone is not available, and this coarser material is, we advise its use. Put on more of it, and eventually every bit of it will become available. It will last for many years in the soil, giving out its beneficial influence constantly. Many farmers having ledges of limestone upon their land can well afford to grind their own limestone at home; and a machine capable of grinding a little



A heavy crop of alfalfa

more than a ton an hour and taking in stones 11 x 13 inches in size costs about \$600.00. These machines are very durable and the expense of operating them quite light.

Other Forms of Lime—When limestone rock is burned, the carbon is driven off, and caustic lime remains. Burned lime has lost about one-half its weight, so that a ton of burned lime has as much power to sweeten soils as two tons of unburned or carbonate of lime. The one difficulty with burned lime is that it has this caustic nature, and is said to destroy part of the humus of the soil. Burned lime is more easily secured, and the freight rates on it are often less than with the ground limestone. From one to two tons per acre of the caustic lime are used. It may be ground very easily after being burned, and then drilled into the

soil; or it may be slaked with a little water so that it falls into a white powder, and then distributed. "Agricultural lime," often sold at absurdly high prices, is simply burned lime slaked and ground, and is in no way better than the lump that any farmer can slake at home.

Air-Slaked Lime—If you do not use ground limestone, air-slaked lime is the only thing that you should use. It requires one and one-half to two tons of it to do as much work as one ton of caustic lime, but while caustic lime attacks the humus of the soil, air-slaked lime probably does very little injury in this way. We do, however, recommend that this lime should have not less than six months' time in which to air-slake, and a year would be still better. In this time, if the lime is well burned, all the lumps should slake, making it much easier to apply, and also very much safer to use on your ground. We advise using air-slaked lime at the rate of two to four tons per acre. It is unwise to sow lime and acid phosphate at the same time, as the lime would neutralize the phosphate; probably this would not apply to untreated phosphate rock.

Lime Not Everywhere Needed—Because of the widespread interest in alfalfa and lime, we get letters asking about the application of lime, from regions where we cannot think lime is needed. Hardly anywhere is it needed in the arid region, in the Dakotas, in Nebraska—perhaps nowhere in alkaline soils; probably not in any place where limestone gravel is mixed through the soil by the glaciers would additional lime be especially needed. When it is somewhat difficult to get stands of red clover; when "sorrel" comes in the land; and crab grass crowds out the alfalfa; when the alfalfa plants that come have a sickly yellow appearance instead of a dark vigorous green; then one may safely assume that lime is needed; and in the humid regions of the east, wherever Kentucky blue grass and white clover is not the natural carpet of the soil, alfalfa growers should take heed of the need of more carbonate of lime before sowing their seed.

Alfalfa and Tile Under-Drains—The question is often asked: "Will alfalfa stop tile under-drains?" On Woodland Farm with probably eighteen miles of tile under-drains, only a few hundred yards have given trouble from being stopped with alfalfa roots. These places where trouble has occurred are where running water flows through the tile continuously from perennial springs. In no instance has the alfalfa given trouble to ordinary farm drains where the tiles become dry in summer.

A Thin Stand of Alfalfa—It rarely pays to try to thicken alfalfa. The seed will usually come up all right, but for some reason it will mostly perish throughout the first season. Disking

will make the alfalfa stool out more and thereby help the stand, or clover may be sown with the thin alfalfa with good results.

Another very excellent method which we recommend, is plowing the alfalfa up, and plowing it quite deeply. This will not kill nearly all of the young plants. Then immediately re-seed, and the second time you will be almost certain to secure an excellent stand of alfalfa.

Weeds in Alfalfa — Good soils are frequently stored with weed seeds; yet a thorough cultivation of the ground the year preceeding the sowing of alfalfa will accomplish much. Ordinary weed seeds are pretty well destroyed by the mower running over the ground two or three times the first season. Canada thistles are said to be eradicated by the growing of alfalfa; and many other serious pests, including *convolvulus arvensis* variously styled bindweed, wild morning glory, or wild pea vine.

Sometimes a little sweet clover (*melilotus*) is unavoidably present in alfalfa seed. This need give no concern, since the natural mowings given the alfalfa will eradicate it in two years. There are weeds, however, that will get the better of alfalfa, and that right speedily. One of the worst is dodder. Not many farmers know dodder when they see it. It is a parasitic vine, having an almost leafless, yellow stem as large as a small twine string, which runs through the alfalfa, twining around the stems, sending little rootlets in to suck the juice of the plant. Dodder begins its life from a seed dropped to the earth when the alfalfa is sown; but after having had a brief experience with its roots in the soil, it leaves the earth and roots only in the growing alfalfa, which it binds together in a death grip, making a dense tangle of yellow vines and slowly dying alfalfa plants.

Farmers cannot afford to treat dodder as they would any other weed. It is so deadly that it must be stamped out immediately, or it will become a very serious pest, and the methods used to exterminate other weeds will not answer for this one. If there are only occasional small patches to be found, mow the alfalfa in these patches before the dodder begins to bloom; then in a few days, scatter straw over the infested areas, and burn it. This may kill the alfalfa plants, but it will probably kill the dodder also. If your field is badly infested, there is nothing to do but to plow it up, and plant it to corn or some cultivated crop for one or two years.

Dodder infests clover just as frequently as it does alfalfa, and it is just as dangerous in the clover as it is in the alfalfa. Farmers should take great pains to prevent this pest from becoming established in their land, and should send samples of their seed to their experiment stations for analysis before seeding.

Alfalfa in Corn — We cannot recommend seeding alfalfa in corn at the last cultivation, as many wish to do, because the

corn nearly always shades the alfalfa so much that it will not thrive until after the corn is cut; also the corn takes practically all of the moisture from the soil, causing the alfalfa to suffer from drought; and it usually happens that we have most of the dry weather between the time of the last cultivation of corn and fall, so that all three of these causes will operate against the alfalfa. We have seen many splendid successes from this method, and many failures. We think the chances of success by this method to be about equal to the chances of failure.

Soils Best Suited to Alfalfa—While it is true that alfalfa may be grown by devoted enthusiasts anywhere, yet it has affinity for certain types of soils, and is most easily grown thereon. These soils are deep, pervious to air and water, well stored with mineral elements, and somewhat alkaline in their nature. Thus



Stacking alfalfa

alfalfa revels in the arid west, when water is supplied, because there has never been any leaching of mineral fertility, and the land is very rich in potash, phosphorus, and lime. This alkalinity favors the growth and development of the bacteria that grow upon the alfalfa rootlets and makes the plants thrive. In the more eastern sections, along the Missouri river, there are great areas of a peculiar whitish soil called the Loess deposits. These soils are the result of wind deposit, made many centuries ago when the land was desert. On these very deep and fairly fertile Loess soils alfalfa revels, its roots penetrating to very great depths, sometimes as far as thirty feet.

Yet farther to the eastward are the prairies of Iowa and Illinois, black with stored humus and rich in plant food. On these prairies alfalfa does not naturally succeed very well. This is owing in part to a lack of drainage; in some instances,

through the decay of too much vegetable matter, there is acidity in these black soils. In many other cases there is some difficulty in establishing bacterial energy, and the reason for this is unknown. However, the remedy has been found to be applications of barnyard manure, which works like magic on these black prairie soils, and when coupled with tile underdraining, where it is needed, alfalfa is found to grow with remarkable vigor and profit on the black corn soils of Iowa and Illinois. The reader, if he dwells in this land, should consult the bulletins of the Iowa and Illinois experiment stations for help to make his alfalfa surely grow.

Soils on which it is Difficult to Grow Alfalfa—It is more difficult to grow alfalfa on some soils than others, and on some of them it is not wise to make the attempt. First, any soil that is not more than two and one-half feet above the water line is too shallow for continual alfalfa growth. It needs a depth of at least three feet to water, and if the distance is even greater all the better. In laying tile underdrains for a foundation to an alfalfa field, seek, then, to get the level of the water line down at least three or four feet.

On peaty soils with little clay or sound earth within them, it is not often that alfalfa will thrive. There are some exceptions to this rule, though they are not well understood.

On nearly barren sands it is doubtful if it is worth while trying to establish alfalfa fields. They must be continually fed in order to produce this forage, so rich in mineral elements, and it must be remembered that these mineral elements must come from the soil.

Clays—While the most luxuriant growth of alfalfa is usually from a porous soil, a loam or gravelly alluvium, yet clays drained and stored with vegetable matter are producing some of the best growths of alfalfa in the United States. This is especially true of strong, tough limestone clays that, when in their natural state, hold water "like a jug," but when underdrained and well manured become more open and pervious to both air and moisture. On such clays alfalfa revels, and when plowed up and other crops are planted on the land, it is astonishing to see with what vigor they grow, revealing plainly the very great benefit that the alfalfa has been to the soil, both by adding nitrogen through the decay of its leaves and roots, and by bringing up mineral matters from the sub-soil, and by decaying and leaving air and water passages through the clay, always before too dense to permit these helpful agents to work their will. And when alfalfa is sown again upon these clays after one or two years of grain or hoed crops, manure being scattered over the land in the interval, it is found that the alfalfa responds wonderfully and yields better than it did after its first seeding.

Advantages of the Alfalfa Crop—What, briefly, are the advantages of the alfalfa plant over other forage crops? First, that it roots so deep in the soil. It is safe to say that alfalfa roots penetrate as deep as there is any soil. If the soil is three feet deep, the roots will penetrate three feet. If the soil is ten feet deep, the roots will go down ten feet. And if the soil is thirty feet deep, the root will go down thirty feet. Thus the whole soil is utilized.

The Whole Season—Next, remember that the plant uses the whole of the growing season, and it is the one crop that the farmer grows that does this. It is very hardy and does not much mind cold. As soon in spring as the sun has slightly warmed the earth the alfalfa is up and is growing. It does not mind light frosts, but keeps right on growing. Soon after the corn is planted the alfalfa is ready to cut—by the first of June in most of the region of the corn belt, earlier in the South, and not much later anywhere. Thus the soil has yielded one crop almost before the corn has begun to take hold at all.

Next, consider what happens when you cut off that first cutting. It should be taken away as soon as little buds appear on the lower part of the stems, showing that a new growth is ready to start up. At this time the plant will be partly in bloom and the leaves dropping from the larger stems. Then is the time to cut it down and make it into hay. The hay making must proceed rapidly, for soon after this first crop is laid low these buds start into action, and in about fifteen minutes after the mower has passed over the field there is a second crop under way. This makes it needful to get the crop off the field promptly and let the next one come on. In thirty days from the time it is cut there stands a second crop ready for the mower. And after that in thirty-five or forty days there is yet a third crop ready. And if it is taken off on time there is the fourth cutting. Much of the yield of these later cuttings depends of course upon the presence of moisture in the soil, but it is sure that the alfalfa will use all of the moisture from rainfall, and if irrigation is possible it will use a very large amount of irrigation water. Thus it uses to the best advantage all of the soil, all of the season from early spring till late fall, and all of the soil moisture. Of no other crop can this be said.

Value of Resultant Crop—The best of all is that the forage that the alfalfa plant produces is the richest and most palatable that the farmer can grow. The alfalfa plant, cut at the right time, and rightly cured, is very rich in protein. What is protein? It is what makes the red flesh and red blood of the animal. It is what makes nerve and brain and vital process. Alfalfa is rich in bone. It is the best feed for the baby on the farm, for the baby colt, the baby calf, the baby lamb, pig, and chick. It is

good for the baby because the baby must have protein to build his little body. And as it is best for the baby so it is best for the baby's mother. It makes her full of milk and restores her tissues. It builds the unborn young within her, and after its birth it fills her with milk to make the baby grow.

For Working Horses—There is no one thing so good as alfalfa for the working horse. It builds his wasting muscles, it keeps him strong and healthy. He needs much less grain when he can have alfalfa hay. And he is fuller of life and spirit than when fed upon any other hay. It is only necessary to remember that this hay should be fairly mature when it is cut, and well cured so that it shall not be mouldy or musty. There ought to be no dust on alfalfa hay. There are no hairs upon alfalfa stems and leaves as there are on clover leaves; therefore alfalfa hay has no tendency to bestow "heaves" upon horses. For old and hard worked horses in thin flesh alfalfa has great restorative powers. For driving horses it should be fed in moderate amounts, else it will make them fat and soft. Even working teams may be fed too large amounts of alfalfa hay. It should be steadily borne in mind that early cut and well cured alfalfa hay is nearly as rich, pound for pound, as wheat bran, so that to feed too great an amount of it is not merely wasteful, but puts an undue strain upon the excretory organs to eliminate the unnecessary food substance from the tissues. The over feeding of alfalfa hay to horses has in some localities caused the use of it to become unpopular, and to raise an outcry against it. To offset that it may be said that the writer has fed no other hay to his horses, both working teams and driving horses with mares and foals, for many years, and has yet to observe the first instance of evil result, save that the driving horses when not used regularly become soft and easily sweated.

For Mares and Foals—There is nothing else so good for the mare, while she is carrying her unborn colt, as to run on an alfalfa pasture, and eat alfalfa hay in winter. Her colt comes strong and well developed, and after it has come she is full of milk for it. Then if she is in the alfalfa meadow the colt early learns to nip the delicious herbage, and thus takes in additional nourishment at the time when he is best able to make use of it. It makes his bones grow and covers them with good, firm muscle, it hastens his development greatly, it adds to his beauty, and spirit, and usefulness. The best thoroughbreds in the United States often come from the alfalfa meadows of California, and the breeders of race horses in Kentucky are beginning to add alfalfa to the bill of fare of their petted darlings. The great Percherons of France eat alfalfa with the bloom on it when they are lusty foals in their native land. The horse breeder wherever he is should at all times endeavor to call to

his aid this crop that is, par excellence, the one best suited to his use. While there is some danger in grazing alfalfa with sheep or cows, there is none whatever in grazing it with horses, and thus not only the best but the cheapest possible development may be secured.

Alfalfa for the Dairy Herd—Calves grown on alfalfa develop rapidly and are ready to become mothers earlier than when developed on other foods. Pregnant cows fed alfalfa come in strong and well nourished, with full udders. Milking cows fed alfalfa hay as part of their ration give milk as with no other possible combination. Not to go into figures or tables of percentages, suffice it to say that alfalfa leaves are a little richer in protein than wheat bran, that alfalfa stems, cut early and nicely cured, are nearly as digestible as wheat bran, and nearly as palatable. Thus alfalfa may well take the place of a large part of the grain ration, and may be made to form nearly the whole of the needed protein. Thus not only is the ration very greatly cheapened, but the animals give far greater returns than when they do not have alfalfa hay. On most farms in the corn belt there is a decided scarcity of foods rich in protein. Corn itself is deficient, and enough corn can not be fed to cows to make them give their greatest amount of milk; whereas if the attempt is made, disaster results because the excess of fat forming food consumed leads to disorders of digestion or makes the cow herself too fat to be long a profitable dairy animal. Furthermore, the corn fodder and stover, the timothy hay and blue grass, the oat straw, sorghum, silage, nearly the whole list of common farm crops that can be grown for the dairy, are deficient in protein, so that alfalfa has for the dairy farmer a very great value, coming as it does to balance up these other more fattening and heat making provenders. This is not mere theory, but a fact most abundantly proven by experience in the west, in the middle states and later in the heart of the best dairying section, through New York, Pennsylvania, and New England, where some of the farmers are producing their own alfalfa, and others are securing it from their more fortunate brothers of the west. The writer has himself sent alfalfa hay to a gentleman milking one of the best herds of Guernseys in America, animals fed as well as science and skill could devise, and had word afterward that the addition of alfalfa hay to their ration made an increase in milk yield of twenty per cent!

Alfalfa and Silage the Cheapest Dairy Ration—With good alfalfa hay and good sweet corn silage, made from corn that has been allowed to mature well before being harvested, the cheapest and best milk yields are secured. With this ration there is indeed very little need of any other grain. That great dairy authority, ex-Governor Hoard, has found in practice that with

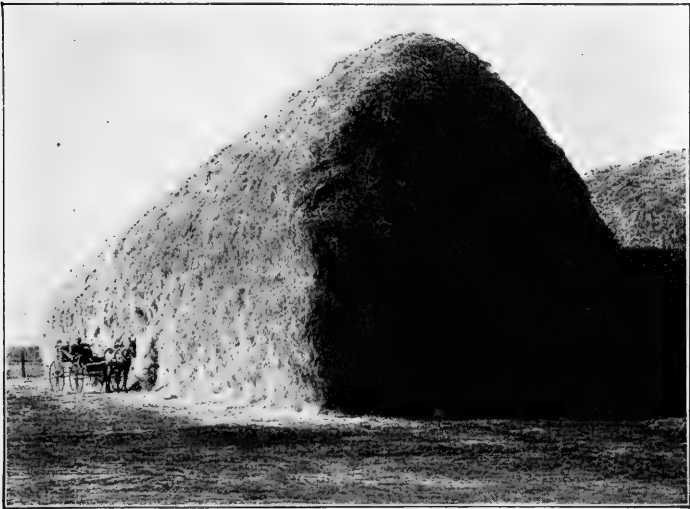
this combination, and as little as four or five pounds daily of grain, not only has he had the maximum returns in milk and cream, but he has seen the dairy herd maintained in remarkable health and vigor. It is time the farmer should break away from the bonds that bind him to the miller and the dealer in food supplies, and learn to produce on his own farm nearly all that his animals need, including that most precious and costly thing of all, the protein content of his animals' ration.

Alfalfa for Sheep— With lambs selling for \$7.00 to \$8.00 per head, and wool soaring, men begin to ask what sort of foods best agree with sheep. The answer is, if there is one thing that alfalfa is especially suited to, it is to the flock. Sheep love alfalfa above all other forage, and for a good reason. It is the one thing best suited to their needs. They, more than other animals, need a ration rich in protein. The growing lamb needs it to build his muscles, blood, brain, nerves, and bone. The pregnant or nursing ewe needs it to replenish her system fast drained by the demands of her offspring. The ram needs it to keep up his vigor. The wool bearing sheep, and all breeds bear some wool, need alfalfa because it has in it the peculiar elements that make for growth of good, healthy, strong fibered wool. And thus all sheep crave and love alfalfa hay. Think for a moment what it means for an animal to like a food. Liking in the animal world is not whim or caprice. Man is the one animal, save a worm, that chews tobacco—the only animal that drinks whisky. All animals crave things that are good for them. Why do they hunger for fitting foods? Because the very cells of their bodies are calling to be built, and thus instinct tells them that tough grasses nourish feebly if at all, that tender, rich alfalfa leaves and stems have in them substances that when assimilated go directly to build the eager body cells, to reinforce the muscles and strengthen the bones and link together the nerves. It is a fact that sheep once accustomed to a diet of alfalfa will scorn prairie hay and turn from good red clover; they seek that which nourishes best and digests most easily, therefore that tastes best to them.

The Pregnant Ewe— The pregnant ewe needs alfalfa to make grow within her that highly organized body made up mostly of protein compounds, her unborn lamb. She needs it to repair the waste in her own body. She needs it to store her udder with milk against the time of coming of that feeble baby head bunting unsteadily against her and seeking nourishment. With alfalfa in abundance she comes in strong, her baby lamb is strong, her milk flow assured. There is need that she should have not quite as much alfalfa as she would consume, else she might overdo the matter, and the lamb be born too large for

safe delivery. She should have exercise and a liberal supply of fresh air. Then her safe lambing is assured.

The Milking Ewe—After the lamb is born there is no longer any need to stint the ewe in the amount of alfalfa she is fed; her own instinct will tell her how much. And it should be of the earliest cuttings, and nicely cured with the leaves all on. With this alfalfa, very little grain indeed will be needed to make her give liberally of milk before grass comes. And after the first green grass of spring comes, it is fine if she can have her regular ration of alfalfa hay to supplement the grass, prevent scours, and make her keep strong and in good flesh. Of course her little lamb will eat alfalfa hay from the time it is three days old, the



Alfalfa in the stack

tender leaves first, the stems later on, and there should be a special rack for it where the ewes can not come to disturb. With alfalfa hay and a little corn added, soaking both in mothers' milk, the baby lambs will soon attain a beautiful baby maturity that will enable their owners to sell them for many, many shekels of the coin of the realm.

Alfalfa for Feeding Lambs—For fattening lambs born on the great ranges and kept there till weaning time in the fall, nothing can take the place of alfalfa hay, if the greatest facility coupled with the largest profits are sought. The lamb feeding business has grown to magnificent proportions in Colorado, where the abundant streams coursing down from the giant snow capped

Rockies spread their life giving waters over the fertile plains. There alfalfa is at its best estate, and nothing else is quite so profitable, saving perhaps the crops that naturally follow on alfalfa sod—sugar beets, melons, or truck. Enormous amounts of alfalfa hay are stacked up on these plains where the long, dry summers favor hay making operations very greatly, and when winter comes the lambs are bought and placed in feed lots, and fed till spring on alfalfa hay with a little Nebraska or Kansas corn or native barley or wheat. These lambs often come from the ranges half starved, having perhaps endured long drives and been held in corrals and shipping pens until they are little more than bones strung on end, but after they have eaten alfalfa hay for a time they become strong once more and ready to make good use of corn.

Alfalfa Fed Beef Cattle—What has been said of the mare and of the ewe applies as well to the beef cow. If she has a sufficiency of alfalfa in winter she needs no grain at all. After her calf comes she may have a little grain, and she and the calf all the alfalfa they care to take. Her calf should be developed largely on alfalfa. It may eat alfalfa hay every day of its life, may be soiled with alfalfa during the growing season, may possibly be grazed on alfalfa pasture; though by far the better way is to cut the alfalfa and bring it to the calf. By this manner of feeding good flesh is produced and stature assured. It is too common among breeders of beef cattle in the corn belt to confine their animals to rations composed mainly of corn and grass, neither having in them enough protein, thus there is a steady loss in size, in "scale," the animals soon become fat, undersized, "bunty" and "bunchy." The difficulty is that you have been asking impossibilities of the animal, asking it to make bricks without straw, or to build without bricks at all. Therefore breeders of pedigreed cattle find it necessary to have frequent recourse to Canadian and English herds to maintain the character of their own. In these other lands less corn and more clover and other foods rich in protein are fed than in our own. There is blood in a turnip. There is blood and form and breeding in alfalfa, a plant that gives character to whatever it becomes. Therefore, let the breeder of beef cattle see to it that alfalfa is one of his chief reliances.

Alfalfa for Feeding Steers—Fattening cattle might be thought to be an exception to the rule heretofore insisted upon; they are desired to be fattened as rapidly as possible, why, therefore, need they be fed any foods rich in protein? Why not feed them in the old-fashioned way with corn alone, to quickly cover their ribs, and then let them go forward to market?

The theory sounds well, but does not work well in practice. These animals find waste going on in their own systems.

Digestive processes require muscular action, and there is need to repair muscular tissue. Nerve force is to be maintained. Then, after all, when these animals come to the feed lot they seldom have an adequate frame of lean tissue on which to build the fat. Moreover, the modern trade demands lean flesh intermixed with fat, not fat laid on in masses. And, finally, digestion goes on better when there is fed a variety of foods containing both fats and muscle builders. So theory backs up practice, and that tells always that steers fatten more quickly, more cheaply, and better, when they have all the alfalfa hay that they want in connection with their corn. It is astonishing how much the cost of fattening these cattle may be reduced if they are bought young and fed plentifully on good alfalfa hay, and only moderately with corn. And when this beef goes to the killer he finds it by far the most profitable. There is no doubt of the great place that alfalfa should fill in the cattle feeders' business. The younger the cattle, the truer they are "babies," and the better it pays to feed them alfalfa hay.

Alfalfa for Pigs—The problem of maintaining brood sows in complete health in winter time is a serious one in the corn belt. They are voracious and must be fed. If fed sufficient corn to satisfy them they become too fat and have weak litters of pigs, or so unwieldy that they destroy their offspring through their very great clumsiness. If they are deprived of sufficient corn to do this and given no other food, they do not keep in health, since it is nature's way to have the stomachs and digestive tracts of the sow distended with bulky food. Therefore unless this is done there is set up within her an unnatural craving that ends in causing her to eat her pigs at farrowing time. Now if she is fed a liberal allowance of alfalfa hay she finds in it nearly all the nourishment that she needs, she finds her alimentary canal distended comfortably, she is satisfied with same, and she brings into the world a fine litter of pigs, and has milk for them. She has use of her natural instincts and seldom destroys her pigs, either by accident or intent. It is wise to allow her an ear or two of corn each day in addition to what early cut alfalfa hay she will consume.

If it is summer time and she can have the run of the alfalfa field she will thrive with very little grain in addition until the pigs come. After that time it will pay to feed her a little more grain. The sucking pigs will soon learn to nip the tender leaves and stems, and that will add greatly to their thrift and growth. It pays largely, however, to feed corn in addition to alfalfa pasture to shotes. It is not necessary to feed so much as when they do not have access to alfalfa; about half the usual amount of grain will cause a fine, thrifty growth. At the close of their life period it is well to give whatever amount of corn they will eat

up clean. In this manner is made the cheapest and best possible pork. Fed in this way an acre of alfalfa pastured with hogs has made a clear profit in one year of as much as \$25.00.

Grain to Feed with Alfalfa—Corn is the best single grain to be fed in connection with alfalfa. Corn is rich in fat and low in protein. Alfalfa is very rich in protein and somewhat low in fat. These two should not be separated where flesh is desired. They most admirably supplement each other. Either for the fattening lamb, pig, calf, or steer the ration of corn and alfalfa is an ideal one, for they very nearly balance each other, and both can be produced on the farm, and both are adapted to most parts of the United States and much of Canada.

After corn, however, come barley and oats and wheat, valuable to supplement alfalfa, though of the three barley is best, being richer in fat making elements. Very good lambs are made with alfalfa and barley, or alfalfa and wheat, or alfalfa and oats, or with a mixture of them all together. Yet when corn is available at nearly the same price it is very much to be preferred.

Alfalfa for Poultry—The alfalfa field is a rich storehouse for the poultry keeper. In summer time fowls forage far and wide, eating the tender alfalfa leaves, rich in protein, and finding insects. In winter time fowls will consume great amounts of alfalfa leaves and the fine stems. Sometimes alfalfa is ground into meal for poultry and swine. This is well, though when it is in large supply it is not necessary to do this, as it is cheaper to waste a part of the stems than to grind them into meal. Fowls given all the alfalfa that they desire are more healthy and lay many more eggs than without it.

What Alfalfa Does for the Soil—Supposing that all that has been said is true, as the reader may well believe, there must arise within his mind a doubt as to whether there can be any further cataloguing of the virtues of the alfalfa plant. Have not its virtues been exhausted by now? By no means! One of the very best of its gifts to man is yet to be related—alfalfa enriches soils. It is a clover, and enriches soils in the same manner that all clovers do by the growth upon its roots of bacteria, that have the power to fix nitrogen from the air. By this means it wonderfully improves soils. Then by its very deep roots it feeds upon the lower depths of the soil and draws up the stores of fertility that may be down there. After alfalfa has grown upon a field for two, three, four, six, or more years, when that field is broken it will be found to have been enriched beyond what was ever known of it before. Whatsoever is planted upon that land will yield wonderfully, and again when it is laid down to alfalfa that will in turn grow better than it did before. That is perhaps because of the inoculation that has taken place and

that enables one to get a perfect stand of alfalfa sooner, and because the decay of the long roots has opened up the subsoil and made it more readily permeable.

How Alfalfa Hay May Build Soils—The amount of fertilizing material that will come from an acre of first class alfalfa is equal to what would be bought in the bag for \$60.00. Now if the owner of a depleted soil can get one small field established in alfalfa, and will save the hay and feed it with care, saving all of the manure and putting it out upon another tract, he can thus enrich this sufficiently to make it grow alfalfa. Now let him have the two fields producing alfalfa, and using the hay again and saving the manure he is ready to enrich the third field. And thus gradually he may extend the area of his alfalfa land until some day, if that man has faith and keeps on, some day he may sweep the poverty altogether off his farm and find it redeemed, glorious in beauty in summer time and yielding him a steady and very great profit. This may not be so well understood by readers who, living in the arid west, find all of their land ready to take alfalfa, but in the older clays of the rainy east, little land is naturally now in condition to take the seed until it has been first enriched.

How to Start an Alfalfa Field—Naturally the ways of sowing alfalfa vary with the location and climates. In the arid West it is a simple matter. The land is usually plowed in winter or early spring, worked down to a good seedbed and the seed sown alone in middle spring time. It is irrigated occasionally according to the nature of the soil, and crops are often taken from it the same year, though it is not at its best until the third year, but it will yield very heavy crops the second year. In some countries it is a practice to sow a light seeding of oats with the alfalfa, in other regions this will not do since the oats will lodge or bed down and smother the slender alfalfa plants. In general the better practice in the arid region is to sow the alfalfa alone.

The amount of seed to the acre varies between four and thirty pounds. The smaller amount of seed is sometimes sown when seed is desired from it, as it seeds better not to be thick. There are 14,448,000 seeds in a bushel of alfalfa seed. Therefore to sow half a bushel to the acre would put 166 seeds to the square foot. To sow fifteen pounds would put on eighty-three seeds. Seeing that this is true, it is evident that it is more essential to have good seed and good distribution of the seed than to use a great amount of seed. About twelve to sixteen plants to the square foot are all that will ever stand, and on rich, deep soils they will not long endure even that much crowding.

Clipping the Young Alfalfa—Weeds often come up to crowd the young alfalfa. To destroy these weeds clip the field with the mower, setting it to run as close to the ground as possible. There may come a yellowish rust that attacks the leaves. To destroy this clip close with the mower. Therefore when preparing land for alfalfa, see to it that the field is left as smooth as practicable, so that the mower may run over it in security. This trouble of the leaf rust will not be so much in evidence in western lands as in the lands east of the Mississippi river.

Pasturing on Young Alfalfa Seedings—It is not well to allow any animals to graze upon a young alfalfa meadow. They will likely do far more damage than the good they will get will pay for. When it is time for the alfalfa to be clipped, take the mower to it, and if there is enough stuff on the ground to be worth while, rake it up and take it away. After the first season pasturing may be resorted to if it is thought desirable, and little bad result will be seen if the field is not over stocked.

Seeding Alfalfa in the Middle West—In the region from the Mississippi river to the western limit of the rain belt, alfalfa thrives well but more care is needed to get stands than in the arid region proper. Spring sowings are usual, without a nurse crop. A better plan is to plow the land early in spring or during the winter, and to work it up with disk or harrow as soon as the growing season has started weed life, and thereafter to harrow it after every rain until some time in late May or June, when the seed may be sown with confidence that it will not be choked with weeds, and that there will be enough moisture stored in the soil to carry it triumphantly through the hot summer. The essential thing in this plan is, however, to be certain to harrow thoroughly after every rain, not only to destroy germinating weeds, but to conserve all of the moisture. When the seed is sown it should be sown if possible with a drill, about one and one-half or two inches deep. Earlier in the season it is not necessary to sow it so deep. The depth that alfalfa seed may be sown varies according to the soil, but in most of this region the soils are black, loose, and loamy.

Field Seeding in Iowa—A method that has given very fine results for the past few years has been practiced in Iowa; it is the sowing after a crop of wheat or oats in mid-summer. To accomplish this the crop of wheat or oats is removed as early as possible and at once the land is plowed. Each day what is plowed is prepared with care to permit the escape of as little moisture as possible. The alfalfa seed is sown alone. It needs no clipping that year, goes safely through the winter and the next year gives three large crops of hay. The advantage of this method is that there is no loss of land and no trouble with

weeds or fox tail grass, the great pest of alfalfa growers in the corn belt. Should the late summer prove unusually dry, this method might not be successful, and in case it is to be sown on clay that naturally freezes and thaws often during the winter and heaves badly, the young alfalfa roots might not be strong enough to resist. Thus far, however, it has given excellent results at the Iowa experiment station and is being adopted in other parts of that state. It is probably a system adapted to Illinois conditions, especially in the northern part.

Need of Manure in Iowa and Illinois—The soils of this region are black and quite rich. And yet for many years they refused to grow profitable crops of alfalfa. It was found to be very difficult to grow alfalfa upon them. When it did grow it seemed often to be without nodules upon the roots, and therefore devoid of bacteria. A few years ago it was discovered that when stable manure was spread upon that seemingly fat, black land, alfalfa was easily established upon it and inoculation came naturally and abundantly. Now on all the soils of this region when well enough drained, alfalfa may be very profitably grown if care is taken first to liberally distribute over the fields stable or yard manure, working it into the soil to create there the ferment or yeast needed in that soil to start the bacterial life, and after it is once established it will endure profitably for a number of years; how long it is not yet possible to say.

Sowing Alfalfa on Eastern Clay Soils—The best method of sowing seems to be to break the land, after having thoroughly well manured and drained it, and plant one year to corn, keeping the corn clean of weeds and fox tail grass. The next year it should be again plowed as early in winter or spring as it can be and deeper than ever before. After danger of hard freezing is over, say in late April, the seed is sown upon a nicely pulverized seedbed, at the rate of from ten to fifteen pounds per acre. At the same time a bushel of beardless spring barley is sown for a nurse crop. Oats are not admissible, since on this well manured land, they usually lodge and destroy the young plants beneath. The barley is taken off when ripe for grain and the young alfalfa is clipped at the same time. It may need one or two subsequent clippings, and it may not. The safe rule is to let it alone as long as it continues to grow thriftily. When it rusts and stops growing, or when fox tail grass or weeds crowd it, it should be mowed off close. The object of the barley is to discourage that marauder, fox tail grass, which it does quite effectually. Thus you will gain also the crop of barley for the use of the land. It is not usual to get much alfalfa the first year of sowing. If any of the clippings make hay enough to be worth raking off, save them. Keep all animals off the field the first season.

Never Allow Animals to Tread on Alfalfa Fields in Winter—It is sure death to the crowns to be tramped upon in cold weather, especially in the eastern states. Neither should wagons ever pass over the meadows in winter.

Making Alfalfa Hay—The time to cut alfalfa is when it has begun to bloom, the lower leaves to turn yellow and drop off, and buds to start out from the base of the stems. Cut then, for it has in it the greatest amount of nutrients. Allowed to stand longer, the stems become woody, some of the leaves are lost, and the hay is not so palatable, nutritious, nor digestible. If cut too soon, before the buds have set on the stems, sometimes the succeeding crop is seriously injured, for what reason is not yet known.

Rush the Hay Making—If possible, all of one crop should be cut down within a week, seeing that it is all ready at one time. Thus the hay is secured in best condition and the following crop is benefited by being given the space in which to grow. Wide cut mowers are convenient things in the alfalfa field. After the hay is laid down the haymakers should keep close watch, and as soon as it shows signs of drying and before the leaves will fall from the stems, it should be raked into small windrows and permitted to cure in part in the windrow, or in the cock, according to where you are and what sort of climate you must work in. Alfalfa dried in the swath loses many of the leaves when raked.

Side Delivery Hay Rakes—These machines work well in alfalfa meadows, since they leave the hay loose, in good condition for drying. In eastern meadows, under showery conditions, the hay is best cocked up in small cocks while it is yet tough. Such cocks will turn rain well and may be afterward opened out on a sunny day, or they may become dry without opening. Then, too, hay caps may be used on the cocks to advantage.

The Test of Sufficient Dryness—Take a wisp of the hay, choosing a damp part of it, and twist it violently into a rope. If no moisture can be made to exude from the stems the hay may be put into the mow or stack, especially if many tons are to be put together. If only a ton or two will be put into a small mow it should be well dried before putting away, since it is more apt to mould and become musty than when much is piled together.

Need of Drainage in Illinois and Parts of Iowa and Minnesota—There is a serious need in much of the black soil of this corn belt of more complete drainage than it has at present, before it is really fit for alfalfa culture. Men growing only corn, or corn and oats and timothy hay, have not usually a vivid con-

ception of how wet their lands are during a good part of the year. In Illinois very much of the draining that has been done has been done superficially, with tile too close to the surface. These should be deepened so that none of them is at a less depth than thirty-six inches, and if they can be put down forty-eight inches all the better. Then there are needed other drains between the ones now in use. When this is done and some manure made use of, there is no doubt that very fine alfalfa fields can be maintained in Illinois.

Comparison of Corn and Alfalfa—It is hard for a farmer in the heart of the corn belt to consider seriously the demands of any other crop, yet if he will study alfalfa a little he will see that he is accepting no inferior plant when he puts it in place of some of his corn fields. Alfalfa will make on good land in



Motor baling press in operation

that region a total yield during the season of from four to eight tons per acre. Taking six tons as a standard, and calling the hay worth \$8.00 per ton, there is thus derived from that acre a gross revenue of \$48.00. To equal that amount the field must yield 120 bushels of corn which must sell at forty cents per bushel. Or, put it according to the amount of available and digestible carbohydrates and protein produced by these crops, the alfalfa will yield fully three times as much protein as the corn and double the carbohydrates, too! Furthermore, the alfalfa is not depleting the soil, while corn is a robber crop.

Alfalfa Seeding in the Eastern Regions—East of Illinois begin the clays, gravels, and loams that extend through Indiana, Ohio, New York, Pennsylvania, and the sister states. Few indeed of these soils are ready for alfalfa in their natural state, yet all of them will yield it most profitably when made fit for

it. The requirements of alfalfa in these states are simple. It needs, first, to have the land drained, if it is not naturally dry. It requires that the land be sweet. In parts of Indiana, northern Ohio, in some of Pennsylvania and New York there are acid soils. These must first be sweetened with lime before they will grow good alfalfa. The third requirement is that these soils be stored with organic matter, with humus. That means that they must be spread over with stable manure. After these three conditions have been met there is nothing but a little knowledge of the plant necessary to make it thrive admirably. The farm on which the writer lives grows now annually about 350 tons of alfalfa hay, though ten years ago little of its area was adapted to alfalfa at all. Tile underdrains and manure have made its growth possible, and it has proven very profitable.

Plowing Alfalfa Sod—Alfalfa sod is very hard to plow; with indifferent tools, impossible. It can be done with comfort, but it requires, first, a good team of three strong horses; next, a plow, preferably a walking plow, in good repair, with a very sharp share. Next, it needs a sober and Christian hearted man. And it is a great aid to carry a file, and frequently file to a knife edge the cutting edge of the share. A little V shaped wing running horizontally out from the landside under the edge of the uncut land about three inches is a great help, since it makes the plow run steadily and renders the next furrow far easier to turn.

Some of the alfalfa roots will not be cut off, and they will live over, doing no harm in the succeeding crop. All that are cut off will probably die, and there is no danger of alfalfa spreading beyond the original limits of its field.

Alfalfa Makes Little Seed in Rainy Regions—It seeds best in the dry parts of Kansas, Nebraska and westward. Usually the first crop is allowed to make seed. It is easily threshed, and in favorable seasons yields heavily, from one to fifteen bushels per acre being reported. The only seed worth much is the common alfalfa, but it is wise not to get seed from a latitude south of you.

Inoculation—Alfalfa will not thrive without the right bacteria upon the roots. Nor will milk sour without the bacteria of souring being present. And yet milk sours, and yet women folks do not add bacteria, knowingly, to their milk. Nevertheless milk will sour more rapidly if a little sour milk is added to the sweet at milking time. So alfalfa will surely become inoculated by natural processes if grown on fit soil, but it will the sooner become inoculated if earth from an old field is dried in the shed and pulverized and sown broadcast over the field



Baled alfalfa

and harrowed in. There are also cultures available that are used to inoculate the seed. They are sometimes of use. They often fail to be of use, through some defect in the method. It is not worth while to bother with cultures. It is worth while when sowing alfalfa on land that has never had it before to use soil from either an old alfalfa field or a sweet clove (*melilotus*) patch. The bacteria that live on *melilotus* are the same that live upon alfalfa.

Do not sow either alfalfa or bacteria upon soils not a fit home for bacteria. That means that the land should be dry, sweet, and stored with vegetable matter.

Some Other Things About Alfalfa—Bees love the blooms, especially in the western lands. Alfalfa honey is prime. Alfalfa covers the land with perennial beauty. It makes work for many laborers to gather the harvests and to feed the hay. It causes new homes to spring up, puts paint on school houses, and sends little urchins trudging along country lanes with full dinner pails and smiling faces. It is one of God's richest gifts to man.



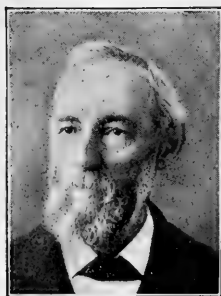
The Wheat Crop

PREPARATION OF SEED BED—SELECTION OF SEED—
VARIETIES—SOIL CONDITIONS, ETC.

BY WALDO F. BROWN

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Revised by A. E. and F. C. BROWN



A World Problem—Wheat production is a world problem. American investigators have been at work for years upon this subject. As a country grows older the food supply becomes a more complex problem. New soils give back in prodigal measure food for the eater and seed for the sower. There are certain underlying principles in wheat production applicable to all soils and all countries, and American investigators have been busy collecting and classifying data from all

ages and all countries for the benefit of the American farmer in his search for the best methods of seeding, best varieties of seed, and most profitable ways of handling the wheat crop. The farmers of the eastern part of the United States find they can produce the best crops by early summer plowing and continual working of the seed bed until time for planting; while, with worn out soils where the problem of returning lost fertility is added the question becomes a scientific one, and the farmer may turn to our agricultural experts for help.

Some of the essentials to be considered in successful wheat growing are natural or artificial drainage, a compact seed bed, intelligent warfare against insect enemies, and a selection of seed suitable to locality and soils. A wise rotation of crops is also important in maintaining the fertility of the soil. In some sections a three-year rotation is followed with success; in others a five-year rotation gives paying returns.

Fertilizer—Wheat and clover are inseparable in many sections, and no cheaper or better fertilizer can be obtained. There are a number of leguminous plants valuable for green manuring—clover, cow peas, soy beans, Canada field peas and vetch—but all things considered clover stands easily at the head of the list. Clover produces a network of roots which penetrate the soil far

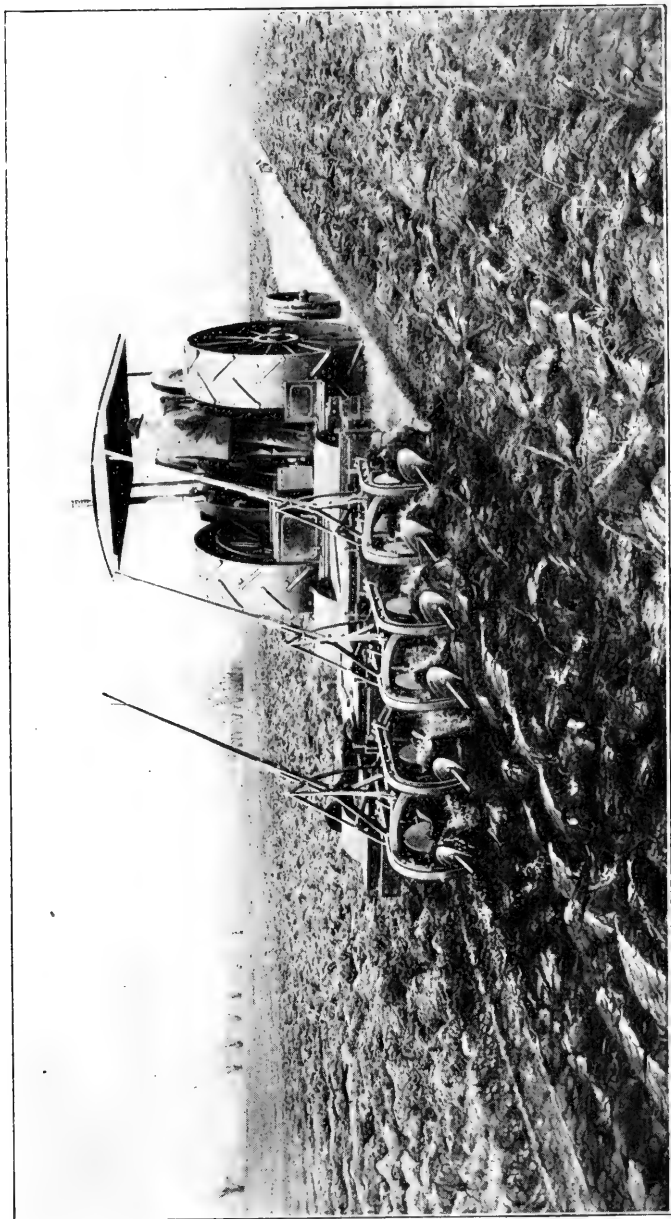
below the reach of the plow and contains more organic matter than the foliage. The fact that a profitable crop of hay may be cut and still leave fertility in the soil equal to ten or twelve loads of stable manure to the acre, makes clover an ideal crop for keeping up the supply of plant food. Even when the crop is cut once for hay and once for seed the land is greatly benefited.

Plant Food Elements—The question naturally arises, What elements, besides nitrogen, does clover add to the soil? The analysis given below of the clover plant, roots, stem, leaves, and flowers, taken at a time when the flowers had begun to fade, gave the following result—in order to obtain the mineral elements the plant was reduced to ashes and the analysis showed :

Phosphoric acid,	5.82
Lime,	35.02
Potash,	18.44
Soda,	2.79
Sulphuric acid,	3.01
Earthy matter,	34.92
	100.00

From this table, the large proportion of lime and potash are seen at once, and they are two important elements in wheat production. To get the best results from the clover crop, a good stand is necessary, and this is much easier to obtain on fields where the grain has been drilled instead of broadcasted. It is often advisable to make two sowings of clover to overcome adverse conditions, if either seeding fails to make a good stand. Some soils are not adapted to growing clover; usually this is caused by too much acid in the soil. The application of lime will correct this; or other legumes than clover may be substituted, as they will grow where clover will not.

Compacting the Soil—When cutting the grain, the sickle should be set high in order that the stubble may protect the clover plants. Care must be taken in giving back to the land any growth of green manure. A heavy growth plowed under just before seeding time will almost certainly insure a failure of the succeeding crop. This is because a heavy growth of any kind when first plowed under produces a loose soil which will hold water and freeze and thaw to a greater depth than well compacted soil. To prepare an ideal seed bed for fall sowing of wheat the ground should be plowed as soon as the hay crop is cut. The depth to plow will be determined by the character of the soil. To obtain the best results from green manuring, the soil should be compacted as soon after plowing as possible. If but one team can be used in preparing the land, the plow and roller should be used alternately, leaving the land both plowed



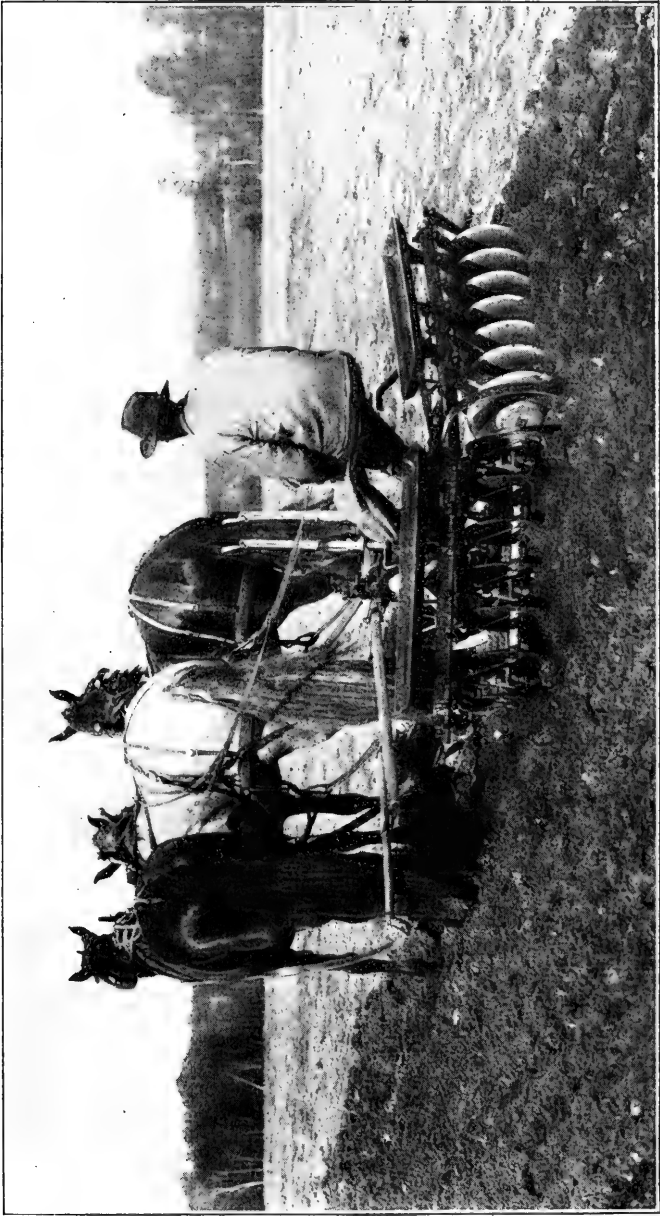
The work of plowing made easy

and rolled at the end of each day. If, however, weather conditions are favorable and the ground moist, the roller need not be used at once, but where the land is dry and the sun hot, prompt rolling is important. It is wonderful what power fine soil has to retain moisture. A field that has been thoroughly compacted and mellowed on the surface can be seeded after a shower that would have little or no effect on a cloddy surface. The lack of available moisture in the soil robs the plant of much fertility, and will cause poor crops where heavy ones might be produced by attention to this one point.

Care of the Field—If for any reason it is impossible to plow early for wheat, and the clover plant has been left on the ground, the clover should be mowed and drawn off the field or burned before plowing. It is then better to make a shallow seed bed, say four or five inches, compacting the soil as thoroughly as possible. Burning the fields before plowing accomplishes two purposes; first, the removal of too great a bulk of vegetable matter; second, the destruction of many insect pests. Experiments have shown that cut-worms are among the pests destroyed in this way.

Many farmers consider the tramping of land by cattle a great factor in compacting the soil. Where fields can be pastured before plowing for wheat, the double benefit is secured of adding fertility in the form of the manure produced, and compacting the soil. On virgin soils the practice is almost universal of pasturing the wheat itself while the plants are young. Experience, however, does not show that pasturing wheat is an unmixed blessing. This is probably owing to the fact that stock is left on the ground when it is too wet, and, under these conditions, both wheat and fields are injured. Taking into account, on the other hand, the fact that this pasture is often worth a dollar an acre to the farmer as food for his stock, the yield of wheat need not be increased to make pasturing profitable. Spring pasturing seems less objectionable than fall, and many think it aids in reducing insect pests. Letters from twenty different Kansas farmers in regard to pasturing wheat, show eighteen out of twenty in favor of it, and they estimate the value at from fifty cents to three dollars an acre.

Plowing for Wheat—In sections of our country where new soils are available and the land has not been cropped, the plowing for wheat should be shallow, only a few inches the first year, and increased from year to year until the desired depth is reached. An interesting fact about seeding on new soil is the length of time profitable crops may be grown without barnyard manure or fertilizers of any kind, and with no rotation of crops. In some instances wheat has followed wheat for ten or twelve years with no decrease in yield. One account tells of wheat



The disk harrow is indispensable in the work of preparing the seed bed

lodging and enough being left on the ground to seed the entire field, and a heavy crop being harvested the following season without the use of any implement until harvest time. Our country is fast approaching the time when such tales will seem incredible. The countries of the old world will have to be our teachers to show us the secret of maximum yields on long cropped soils.

Rotation of Crops—Many farmers follow the practice of seeding after corn where a three-year rotation of wheat, clover, and corn is followed. In any rotation, one great advantage is the fact that different crops make available different elements in the soil. For instance, manure applied to the corn crop is made available for the wheat crop that follows; and clover unlocks hidden treasures of the earth for crops that follow it.

Corn fields that are to be seeded to wheat should be given as near absolutely clean culture as is possible, and laid by as late as the condition of the corn will permit. If this is done, it will not be necessary, in ordinary seasons, to plow the land before seeding to wheat. Whether to seed in the standing corn or after it is shocked has been the subject of a number of experiments, and the conclusions are in favor of shocking the corn; as then the ground can be put in shape with the harrow or cultivator and the roller or drag, making a mellow, well stirred seed bed on the compacted corn ground below.

Proper Tillage—Bearing in mind that the preparation of the seed bed for wheat is the only cultivation that can be given to insure a good crop, it is of the utmost importance that everything that will contribute to this end should be done. The maxim, "Tillage is manure," should also be kept in mind, and where stable manure is not abundant, the fact should be emphasized that too much work cannot be done in preparing the wheat field. If a soil is kept fine for two months or more during the heat of summer, it becomes vitalized and enriched, so the seed truly falls on good ground and sometimes, brings forth if not "a hundred fold," an abundant crop. It is of the utmost importance that all work of preparing the seed bed be done at the best possible time. There are generally two or three days of cool weather after a rain, and this is the time when the teams should be kept busy early and late. The land then works to the best possible advantage, and a team will work for twelve or fourteen hours with less strain than they will for eight hours when the ground is dry and hard and the mercury up in the nineties. Again, when pulverizing the land just before seeding, there are times when one day's work will accomplish more than three a little later. There is a time after each rain when the ground is in ideal condition, and the farmer can harrow a large area in a day and put the land in the best condition to be

benefited in the highest degree by sun and air. Stirring the surface checks evaporation also. A few days' neglect, and all these advantages are lost, moisture is carried off, a crust forms, and the land becomes dry and cloddy.

Drainage—Where land is not well drained, much good may often be accomplished by opening with the plow little outlets, at every low place in the field, to prevent water standing on any part of it. Open furrows are not desirable in a wheat field, as they may be troublesome in the use of machines or cause washing, but they are better than an excess of water. As a farmer prospers, nothing should appeal to him more than the desirability of drainage, and as soon as possible the farm should have a complete system of underdrains.

Many farmers believe that there is no fertilizer so valuable as stable manure. The Ohio experiment station has taken up this question as applied to the wheat crop. They have found that a ton of average farm manure taken from the open barnyard, contains nine pounds of nitrogen, ten pounds of potassium and from three to four of phosphorus, a less proportion of phosphorus than is usually needed on wheat land. Accordingly the experiment was tried of reinforcing the stable manure with phosphorus, the material used being finely ground phosphate rock, known as "floats" and acid phosphates, using forty pounds of each to a ton of stable manure. This manure was spread on clover sod and plowed under for corn, wheat following the corn, and clover following the wheat in a three year rotation, no other fertilizer being used for the three crops. The results fully justified the use of the phosphorus. Lands already brought to a state of average fertility, yielding fifty-seven bushels of corn per acre and eighteen of wheat, were still further improved by this addition of "floats" and phosphoric acid to the stable manure, producing sixty-two bushels of corn and twenty-four bushels of wheat to the acre. Stable manure that has not been exposed to the weather gives still better results when combined with these fertilizers—and applying it with a manure spreader will insure maximum results.

Selection of Seed—The selection of seed wheat is an ever present problem. The long list of old and new varieties is bewildering, and the claims for some of these are so enticing, that the farmer is perplexed to make a selection. A study of local conditions and varieties will often result in finding the best seed wheat near home, as wheat usually suffers more or less deterioration from change of locality. The points to be kept in mind in selecting a new variety are as follows: A full grain of good weight, stiff straw with ability to stand up in adverse weather, a compact head ripening early and not liable to shatter, good bread quality, and power to resist insect enemies. A

variety that tillers freely has greater chances to escape destruction at the hands of its enemies.

The demands of the available market will determine whether to grow hard or soft wheat. In many sections of the country the hard wheat takes the lead, and mills are specially equipped for grinding it. The soil on which wheat is sown has been found to modify the character of the grain. Hard wheat sown from year to year on sandy soil gradually becomes softer, while the soft varieties taken from sandy soil and grown on uplands, become harder. As seasons change, and market demands alter, it may be necessary to modify the type of seed selected. It may take a series of years to establish the desired type, but when obtained, it will repay the effort expended. Where it is desired



The spring tooth harrow can be used to good advantage

to test varieties from a distance, only a small area should be planted, and this, if successful, will furnish seed for a larger area the following year; while if unsuccessful, the smaller the plot the better.

Quantity of Seed to Sow—After the seed wheat has been selected, the question naturally arises, how much seed shall be sown per acre? Individuals and experiment stations have been at work on this question for years. The conclusions are varied. In a series of experiments where eight test plots were seeded with from three to eight pecks per acre, the minimum yield was from three pecks and the maximum from five and a half, the variation in yield being over four bushels per acre. In a series of reports from farmers who operated large wheat farms, the amount of seed used was from three to eight pecks per acre. In a list of reports from twenty of these farmers, one used three

pecks; eleven used four pecks; six used five pecks; one used six pecks; and one eight pecks. The average yield from these sowings was a little more than seventeen bushels per acre, the largest being twenty-eight bushels and the smallest ten. The highest yields were obtained where five pecks of seed were used and the lowest from four pecks. These are average yields for a series of years on good land, and show what farmers have actually done on a large scale. From the many experiments tried to determine what amount of seed to sow per acre to insure the largest yield, it has been found that on most soils five and one-half pecks give the maximum result. Heavier seeding may be necessary on worn-out soil, while four to four and one-half pecks will give an abundant yield on fertile land.



The smoothing harrow adds the final touch of preparation

Time of Seeding—After the preparation of the soil, the selection of seed, and the decision as to how much seed to sow per acre, comes the important question of time of seeding. Shall we sow early and court the ravages of insect pests? Shall we sow late and take the chances that growth will be sufficient to carry the wheat through the perils of winter? No invariable rule can be laid down as to date of seeding, as weather conditions and other factors, over which man has no control, may determine the possibilities at seeding time. Much, however, can often be done to modify adverse conditions. In a time of drought, a thoroughly prepared seed bed with a well pulverized surface is of even more importance than under ordinary conditions; as the mellow soil at the surface acts as a mulch to retain moisture and prevents evaporation from below, and even a slight shower will put the soil in condition to receive the seed. If the land,

under such conditions, is only half prepared and seeded before sufficient rain has fallen, almost certain failure is courted.

Long years of experience and observation seem to point to early seeding rather than late, as most often successful. Many of the experiment stations have prepared tables for their own states and made suggestions for exceptional seasons, giving approximate dates for sowing in each section of the state. In southeastern Ohio, from the 10th to the 20th of September usually gives the best results, though later dates are suggested in some seasons.

Advantages of Using the Drill—Whether to sow our grain broadcast or with a drill is hardly a debatable question in recent years, the advantages in favor of the use of a good drill are now so well recognized. By means of the drill the seed is put in evenly, at a uniform depth; the fertilizer is placed just where it will be soonest available for the growth of the plant; and the ground is left in small ridges between the rows. These ridges hold the snow so that often a light covering will protect the plant in the furrows. Another advantage from these ridges comes when the freezing and thawing of mild days causes the earth to crumble on the ridges and fall into the furrows around the roots of the wheat. Farmers who drag or roll their fields after drilling the wheat lose these advantages. All work of that kind should be done before seeding.

Depth to Set Drill—The depth at which the drill should be set for wheat has been much discussed. If weather conditions could be foreseen, it would be the part of wisdom to seed deeply in dry weather, and nearer the surface in wet weather. Experiments in deep and shallow seeding show the best results from seed covered from one and a half to three inches. The following table shows the result of experiments conducted by the agricultural college at Lansing, Michigan, and emphasizes the advantages of shallow covering:

Depth	Time in coming up	Proportion of seed that grew
$\frac{1}{2}$ -inch	11 days	$\frac{7}{8}$
1 "	12 "	all
2 inches	18 "	$\frac{7}{8}$
3 "	20 "	$\frac{3}{4}$
4 "	21 "	$\frac{1}{2}$
5 "	22 "	$\frac{1}{8}$
6 "	23 "	$\frac{1}{8}$

The report showed that the plants from deep sown wheat were weak. They had rooted deeply, and later put out a new set of roots near the surface and the stem below rotted off, leaving the plants to start a new growth from the second set of roots, which, of course, made them later and weakened them. This would not have been the case with wheat drilled at the proper depth.

Yield per Acre—Another table, taken from the report of the Kansas experiment station, not only shows the time of germination and proportion of seed that grew, but follows the crop to time of harvest and gives the yield per acre on six experimental plots.

Plot No.	Depth	Stand	Wt. per bu.	Yield per acre, bus.
1	1 inch	Fair	60½ lbs.	29.69
2	1½ to 2 in.	Fairly good	60 lbs.	30.64
3	2¼ in.	Good	59¼ lbs.	31.55
4	3 in.	"	60 lbs.	30.45
5	3¾ in.	"	60¼ lbs.	30.51
6	4 to 4½ in.	"	60 lbs.	29.91

The agricultural department calls especial attention to the importance of drilling the rows of wheat east and west, in seeding wheat in semi-arid regions, as the prevailing winds will then drive the snow and dirt into and around the drills instead of out of them. From practical experiments this has been found to be a point of importance in other sections. Another reason for this practice is that rows running north and south receive the direct rays of the sun between the ridges, while in rows running east and west the ridges tend to shade the plants. It is not so much freezing that injures the wheat, but freezing and thawing to such a depth that the roots of the plant are disturbed, and anything that will check frequent thawing is beneficial.

Enemies of Wheat—The story of the wheat plant would be incomplete without some reference to the enemies that attack the wheat from the time the seed is cast into the ground until the day it is used commercially. The wheat midge, Hessian fly, chinch bug, wheat plant louse, wheat straw worm, wheat bulb worm, army worm, and sawflies lie in wait for the growing plant, while smut and rust get in their deadly work and weevil invades the storage bins.

How shall this host be combated? Anything that can be done to start a vigorous growth in the fall will aid in keeping down these insect pests and protect the plant from ravages by fungus enemies. It is even better to ignore the possible ravages of the Hessian fly, and get an early vigorous growth on the wheat fields in the fall than to allow late sown plants to go into the winter with a sickly growth unable to withstand the vicissitudes of winter. By making the best possible seed bed, by the judicious use of stable manure and commercial fertilizers, by drilling the seed, by underdraining and a wise rotation of crops, the best conditions possible are secured for a vigorous growth of the wheat plant and consequent strength to resist its many enemies.

Some enemies of the wheat crop have not been mentioned—in fact their name is legion—but many so seldom harm the crop

that time and space need not be given them. When hail and wind destroy the crops there is no remedy, unless insurance of crops should come to include these forms of destruction. And for insect enemies the best remedy after all is a thrifty plant. He who farms well will often escape injury, while his careless neighbor loses his crop. Intelligent farming is good farming, and only good farming is profitable farming.

The Hessian Fly — Yet there are exceptional years when some enemy threatens the complete destruction of the wheat crop, and prompt measures must be taken to save it. In the case of attacks by the Hessian fly the plan has been suggested by the Ohio experiment station of making several sowings of wheat, the first one large enough to attract the full force of the Hessian fly, and thus save the later sowings from its ravages. The



Drilling in the seed

portion of the wheat that has been invaded by the fly and on which its eggs have been deposited, should then be plowed under. Others recommend sowing strips of rye around the wheat fields about the same date. They claim the fly will deposit its eggs on the rye, and the rye can then be turned under. In either case, whether plowing under wheat or rye, the plowing should be so thoroughly done that no ends of wheat or rye blades or of weeds can be seen, as these would form an avenue of escape for the buried insects. After plowing, the ground should be harrowed, and if necessary compacted with a roller, so that no larvae thus buried may survive as flies. Burning of stubble is strongly advised by the experiment stations, where clover does not follow wheat, as in this way the fly will be destroyed in the "flax seed" stage.

The fact that a season that is favorable for one pest is unfavorable for another is fortunate. In times of drought the

chinch bug gets in its injurious work; but let wet weather follow when a field is badly infested with these pests and various deadly fungus diseases appear and exterminate them for that season. Under certain conditions the Hessian fly also has its parasitic enemies which quietly and quickly reduce their numbers, thus doing swiftly and silently, the task man labors more clumsily to accomplish.

Co-operation Among Farmers—Growing the same crop continuously over large areas tends to increase the insect pests. There should be co-operation among farmers in their efforts to subdue these enemies. The care and forethought of one farmer may be entirely undone by carelessness on adjoining farms. As intensive farming becomes more and more a necessity, more attention will be given to the extermination of insect enemies, and committees will unite in their warfare against them.

Rust in Wheat—Rust is sometimes more injurious to wheat than its insect enemies. Years ago it was learned that certain plants were largely responsible for the spread of rust on wheat. The year book of the Department of Agriculture for 1904 gives an account of the discovery that the spores of barberry rust will spread to adjoining wheat fields; and so destructive is this rust that laws were passed in some states requiring the destruction of barberry hedges. By this measure that particular form of rust was greatly reduced. A good many years before this was published by the Department of Agriculture, this fact came under my observation, and barberry bushes that were highly prized were sacrificed. These bushes had been brought from the old home in the east and were not only ornamental, but a tie between the old home and the new. Continued outbreaks of rust in wheat fields near these bushes led to the discovery that they were the cause of the trouble. Several years later the same rust appeared in a neighbor's fields and search brought to light the fact that birds had carried seed to a woodlot some distance from the original shrub, and these had grown into bushes that were again spreading this destructive rust. A peculiar fact about this rust on the barberry is that it does not injure the barberry plant, but does greatly injure the wheat plant, producing first a red rust on the blades and later a black rust. The great epidemics appear as red rust. If the season is moist the plants are overwhelmed by the rapid spread of this disease. In climates where the red rust on the wheat plants cannot withstand the winters but must be carried over on its host, the barberry bush, it is only necessary to get rid of the barberry bushes in order to eliminate its ravages, but where it lives over winter in the fields, the wheat is more or less infected each season.

Fungicidal treatment for rusts has so far proved of little value. The best work being done is the effort to produce rust resisting varieties through selection and hybridization.

Treatment for Smut—Smut is more easily combated than some other pests that wheat is heir to. The infection is caused by the use of smutty seed, and not by smut spores in the soil. The smut makes its attack when the young wheat plant first pushes through the soil, as the spores are sown with the wheat and germinate at the same time. They live in the tissues of the plant and take enough nourishment from the parent plant to keep themselves alive, but they never entirely kill the wheat plant as the rusts do. They live with the wheat until maturity and deposit their spores on the ripened grain or replace the grain in the head of wheat according to the variety of smut that has attacked the plant. If smutty wheat can be treated with some chemical that will kill the spores and not injure the vitality of the wheat, the trouble may be easily met. One of the cheapest and surest remedies for smut is the application of a solution of formaldehyde, also known as formalin. This should be a forty per cent solution, and a pound used with forty-five gallons of water will treat one hundred bushels of wheat. The wheat should be spread out thin on a tight floor in barn or granary; after being well sprinkled, it should be covered with sacks to prevent too rapid drying. In a few hours it may be uncovered and stirred to assist in drying. The solution should come in contact with every grain.

Many use the copper sulphate solution with success. One pound of copper sulphate dissolved in two and a half gallons of water is sufficient for ten bushels of wheat. If the wheat is shoveled over and over, the solution will reach each grain, and by keeping it moist for half an hour, the smut germs will be killed. When it is desirable to sow the wheat immediately after treating, lime or dust may be sprinkled on it half an hour after applying the solution, and it may be sown at once. It must be taken into account, however, that soaking swells the grains, and the drill should be set accordingly, and a few quarts more of seed should be allowed per acre.

The hot water treatment for smut is also successful. The wheat is placed in half filled gunny sacks and immersed in tubs of water of 120 degrees Fahr. When the wheat has been thoroughly warmed, it is taken out and drained for a few seconds, then immersed in another tub of water at a temperature of from 130 to 135 degrees Fahr. It is a good plan to dip the wheat at once in cold water, as it will cool more quickly and the grains will not swell so much. The wheat should then be spread where it will dry quickly. The general use of these well tested remedies would make the existence of smutty wheat a rare occurrence.



Harvesting the crop

Experiment Plots— Much has been done by the Department of Agriculture and the state experiment stations to aid the farmer. By long continued experiments and by spreading the information thus gained, many have reaped large benefit, but it is to be hoped that the time is not far distant when each community will have experiment plots of its own, and these centers will become nuclei of both scientific and intensive farming.

Harvesting Wheat— In the story of the wheat field we have come to the time when the sound of the binder is heard in the land. Most farmers are well prepared for this part of the work and modern machines are keeping up with the demands of the progressive farmer. Many farmers cut their wheat when it is too ripe and much loss results. It may be cut while the grain is still soft, so that it can be crushed between the thumb and



Wheat in the shock

finger, and while there is considerable sap in the straw. Early cutting adds also to the value of the straw and reduces the risk from storms. The sheaves bind together better and there is less opportunity for water to gain admittance. Another advantage is the fact that a larger amount of wheat can be stored in a given space if cut moderately green. The best hands for this work should attend to the shocking, as much damage may follow carelessness in this part of the work. If the cap sheaves are put on with the heads in the direction of the prevailing winds, they will be less apt to be blown off. If barn space is not sufficient to store wheat, it pays to erect sheds for this purpose. Much wheat has been damaged by being threshed too soon; and leaving it out in the field is always a risk.

Storing under Shelter— It is not only from the standpoint of safety for the wheat crop that it is best to store under shelter,

but it makes threshing less of a problem, as it may be done later in the season when weather conditions are more endurable, while the straw can be stacked in or near the barn and utilized with less labor and trouble. When threshing is done in the field, and the straw left on the ground it must be burned or it becomes a nuisance by occupying valuable ground until decayed; or if spread on the fields is of comparatively little value. The waste of such by-products as this often materially reduces the income of the farmer.

An estimate of the weight of the chaff and straw from a field of wheat can be made when the number of bushels of wheat is known, as for one hundred bushels of wheat there will be about six tons of straw and chaff. Of course, this proportion varies somewhat, but this is a general average.



It pays to build good stacks

Wheat Straw — Wheat straw has several values to the farmer. In the early days cattle were often wintered on straw alone, to which they helped themselves from the stack. Needless to say that by spring they were in a forlorn condition, and many of them died from starvation. Farmers do not try such experiments now, as they know animals must have foods that will make a balanced ration. Straw, however, can be made an important part of such a ration. By sprinkling it daily with brine when placed before the stock, it will be readily eaten; but in connection with the straw some highly nitrogenous food, such as oil meal or bran must be given, and the animals will do almost as well as if fed on good hay. As this plan would be adopted as a matter of economy, it will be a question to settle mathematically whether it will pay better to sell hay and buy oil meal and mill stuff in

order to feed the straw, or to feed the hay and put the straw to other uses. The relative prices of hay and feed will determine this. The manure product becomes more valuable when animals are fed on bran, and this may have some weight in deciding on the winter ration.

No farmer can afford to waste his straw, whether used as roughage for stock or not. It makes the cheapest and best bedding in the stable, both as an absorbent and to keep the stables clean. By using it liberally and removing it daily, both animals and stables will be clean and comfortable.

In a berry growing section there is nothing better than straw for mulching the berry fields. Baled straw always commands the highest price, but that price is not always high enough to justify the farmer in selling this valuable by-product and removing it from the farm.

Bran and Middlings—Two other important by-products of the wheat crop are bran and middlings. Bran contains a considerable amount of crude fibre, somewhat resembling that contained in straw. It thus furnishes a bulky food and is, at the same time, rich in protein, making it excellent to combine with a corn ration. The high price charged for bran has led the dealers to offer mixtures instead of the pure bran, but in our experience the stock quickly detect the difference, and sometimes refuse altogether to eat it. As in most states there are laws requiring the dealer to state the contents of any mixtures he offers, it ought to be possible to get the pure article by insisting on having it. Middlings are especially valuable in building up healthy and muscular bodies in the case of hogs and horses, but perhaps bran ranks ahead of it for cattle. Middlings, so called, are also offered the farmer, being reground bran with something added to give weight. But in this case, too, the farmer should look for a pure food when buying.

A Fascinating Story—The story of any crop from the seed back to the seed is fascinating. Every step is important from the preparation of the seed bed, its fertilization and culture, and the implements used, to the time when storing, marketing, and seeding again, have completed the circle.

Success with haphazard methods will soon be a thing of the past. The American farmer has entered upon a scientific era in which he will use, in so far as they meet his needs, all the discoveries of the laboratory, all the helps of the experiment stations and the Department of Agriculture, and all the improved methods and machines demanded by his farm operations. When this is done, the oft expressed fear that increasing populations will outstrip the supply of food will be seen to be groundless.

Ample Food Supply Assured—This hopeful view is founded on investigations made by the Department of Agriculture and

published in its year book for 1909. Statistics of the yield per acre of wheat for periods of ten years each since 1866 showed a steady, though small increase of yield per acre. Using this as a basis of calculation, and ignoring the probable factors that will accelerate this rate, it showed that the bread supply will not only keep pace with the increase of population, but that in the year 1950 there will be a surplus of 200,000,000 bushels of wheat in the United States. That a large increase in the yield of wheat from one acre of land is possible, no one doubts; and the future surely promises also an increase over large areas in the yield from each acre of wheat, and an end to the low averages now so generally reported from all the wheat growing sections of our country.



Farm Power

BY L. W. CHASE

Professor of Agricultural Engineering, University of Nebraska



In the Hilly and Mountainous States,

water which can be used for power is going to waste. In the prairie states, wind which might be used as a power is abundant, in fact, to those who visit the regions only occasionally it is entirely too plentiful. The water for power is being wasted because it is not in the proper locality. It is confined to streams which are so far from the homes where the power should be utilized that only a few are fortunate enough to use it. Wind

for power is scattered all over the prairies, but it is irregular in its velocities and it takes such large quantities to develop only a small amount of power that the cost of the plant is great. Either water or wind are the cheapest powers possible, but in either case, the cost of a plant great enough to furnish power is sufficiently large to make them prohibitive to the farmer. Steam power can be used for everything on a farm, but the time required to start the outfit and the care it needs when once started prohibits its use on the farm for anything but very large units, so the most feasible automatic power left for the farmers is the internal combustion engine, the gasoline engine being the most common type.

If the first salesmen of gasoline engines had known as much about their stock in trade when they introduced the new motor power, and if the public to whom they were endeavoring to sell their goods had known as much about them at that time as they do now, gasoline engine manufacturing would not have received such a cool reception as the general public gave it after only a few engines had been tried. It is a failing of human nature that wherever there is a wheel to turn, everybody must try to turn it. Likewise everybody is desirous of having a motive power to do his work which runs of its own accord and needs no feeding, no currying, no harnessing, no cleaning, no firing, and in short, practically no care. When the gasoline engine first came into the market the dealers came out with just such extravagant claims; they had just what everybody wanted, an engine

always sure to run; you had simply to throw in the switch, open the throttle, give the wheels a half turn, and it was off. But if it was off, it was usually for a few times only, and then the trouble began. And why the trouble? For no other reason than that the operator didn't know the principles of his machine. He hadn't been told that the charge of gasoline had to be diffused into a very weak gas, that this gas had to be compressed to about 60 pounds per square inch before it would ignite, that if the gas contained too much gasoline it would not explode, and a number of other little things which are necessary to make an automatic motor.



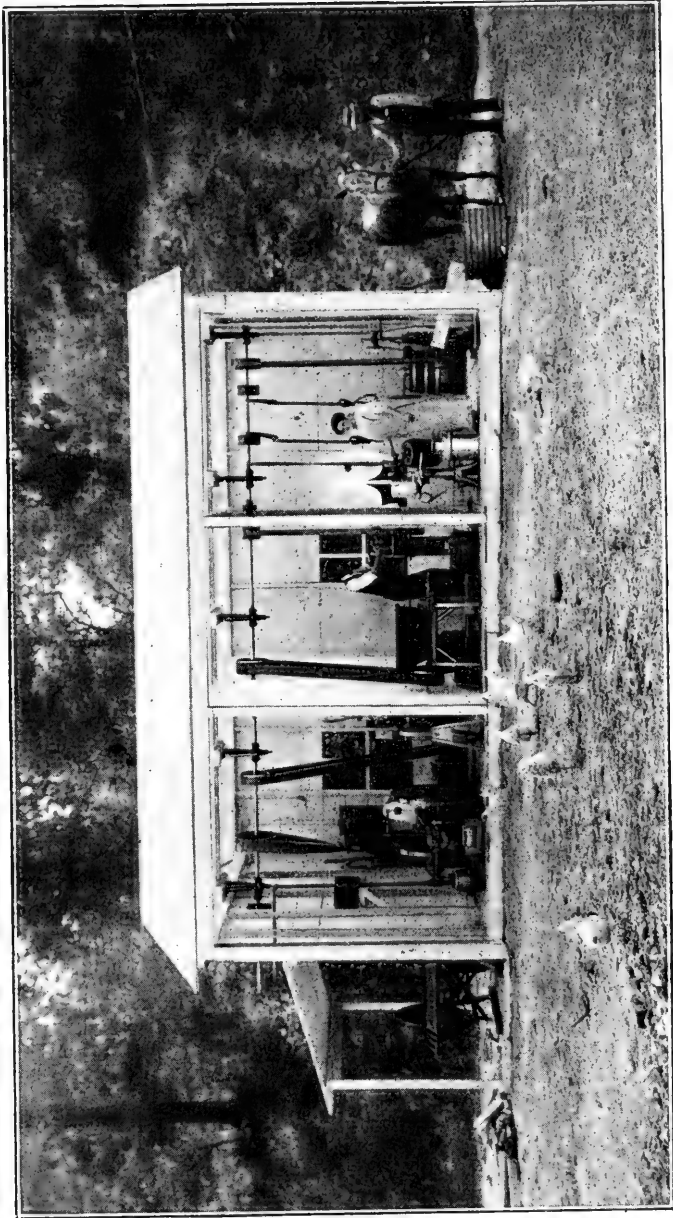
Spraying fruit trees

But Long Before This Time the dealer has learned that he must know his machine by heart, must know the internal as well as external workings. Not only must he know his own machine, but he must also know his competitors'. But what of all this knowledge on the part of the dealer? Does it help the farmer? It certainly does, for because of this information which the dealer has thrown out, the farmer takes a much broader view of an engine. He knows it is a success if properly handled and in many instances he knows the principles of the machine. And if he does not know the principles, he admits his ignorance

and sets to learning them. The gasoline engine has come to be looked upon as a necessity, and all men are now desirous of learning, along with the fundamental principles of the machine, the more intricate details.

Today most farmers have learned that a gasoline engine is an automatic machine when properly handled, but that if it is not handled very carefully, it will behave worse than the proverbial mule. If the farmer himself does not know that a four cycle engine requires a suction stroke, a compression stroke, an expansion stroke, and an exhaust or clearance stroke, before the cycle of gases is complete, his son is quite apt to, so what is the difference—it is all in the family. This same son knows that the charge which is drawn into the engine must be of the proper mixture, he knows that the charge must be compressed to the proper number of pounds per square inch or it will not explode. He knows that ignition must take place a certain distance before the piston reaches dead center in order to get the proper power from the charge, and he knows that the burnt charge must be removed from the cylinder before a new charge is taken in. These four fundamentals of a gasoline engine he knows, and he also knows that if any one of these is off, the engine will not run.

Not Dangerous—Some say that gasoline engines are dangerous because they will explode. This is an erroneous idea. Gasoline engines do explode, or at least should explode about 150-300 times per minute, and there has been far more trouble caused because they do not explode than because they do explode. Gasoline itself will not explode. If you do not believe it, fill a bottle full of the liquid and hold a match to it. You do not need to scringe or blink; it will do nothing but slowly burn, throwing off a yellowish blue flame. It is not the gasoline which explodes and does harm, but it is the gasoline vapors which have escaped into the open air that explode. Take a pint fruit jar and drop about ten drops of gasoline into it. Stir the air up within the jar, then turn the jar over and hold a match to the mouth. A small explosion occurs—and this is what happens every time a charge of gas explodes in the engine, and also every time gasoline vapors are ignited in a room. Roughly it takes 1,700 to 2,000 times its own volume of air mixed with gasoline to make it explode. Try exploding the charge of gasoline vapor in the fruit jar once more, but this time put in about twenty-five drops of gasoline instead of ten. Some men act upon the principle that if a little is a good thing, more is better. If we got a small explosion with ten drops of gasoline, we ought to get a large explosion with twenty-five drops. Ignite the charge and see. It doesn't explode—simply burns with a slow flame as long as the jar is turned over. Set the jar up



The power house on the farm

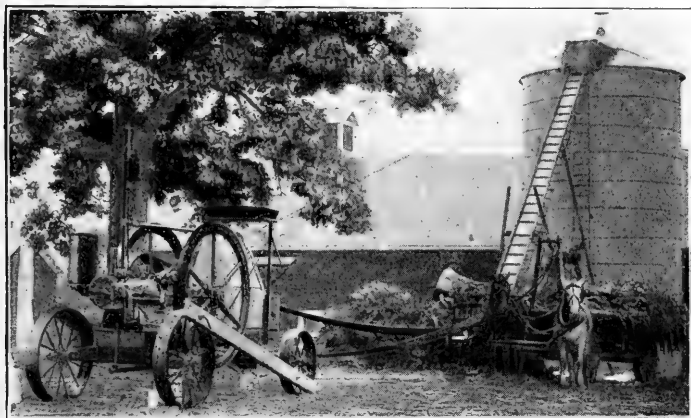
straight and the flame dies out. This is an instance where a little is good, and where more is not so good, and too much is worse than none. The second charge did not explode because there was too much gasoline in the jar to unite with the air in a proportion which would make an explosion. It only made an inflammable gas, which is entirely too slow for a gasoline engine.

Apply the above principle to a gasoline engine and you will have the cause of fifty per cent of the troubles of the amateur. He unconsciously floods his engine, and after working over it for an hour or so trying to start it, goes away in disgust. Perhaps in an hour or so, some one comes along who gives it a try and it starts right off. The reason for this is that the first man flooded the engine with gasoline, and as it would not start, he kept on flooding it. But when he left the engine the vapors within the cylinder deteriorated or passed off in some way, so when the next man came along the mixture of gasoline and air were of such consistency that the engine started at once.

It is always better to have the needle valve open too small a distance than too large a distance, then if the engine does not start the first time the wheel is thrown over, close the needle valve, hold open the inlet valve, and turn the wheels around a time or two. This will clear the cylinder of the previous unburnt charge so that the try can be made again without danger of flooding.

Ignition — The ignitor of a gasoline engine is a simple affair when one understands its principle. Batteries will generate current only when there is a complete circuit. Set a cell out by itself and nothing goes on within it until some metallic substance is placed across the binding posts. If you hold one end of a wire on the zinc binding post and then snap the other end across the carbon, a few sparks and smoke will be thrown off. This shows that a circuit has been made and that a current was set up in the system. A series of cells connected together, zinc to carbon, zinc to carbon, and so on until the last cell is connected to the first, form one big cell, or as it is commonly called, a battery. Instead of connecting the last cell to the first, connect it to some bright spot in the engine, and from another bright spot on the engine connect a wire to the first cell. It will be noticed that a circuit is again made, the engine acting as a part of the wire. Now cut one of the wires leading from the battery to the engine and connect the ends of the severed wire to the binding posts of the spark coil and again snap the wire across the cell. A much more brilliant spark is made than before. The coil acts as a booster, and is essential in all igniting systems. Take one of the wires connected to the engine and connect it to the binding post of the ignitor, then snap the wire in the battery

and it is found that no spark is made. This is because the binding post in the ignitor is insulated from the engine. Swing the trip on the ignitor around until you feel it strike something on the inside of the engine, then snap the wire across the battery, and again the spark is made. This is because the movable part of the ignitor has come in contact within the engine with the insulated binding post, and a circuit is made through the inside of the engine. Leave both wires connected to the battery and snap the trigger on the ignitor, and you make a spark within the engine the same as you did on the battery when you held the trigger around so that contact was made through the inside of the engine. If you do not believe this, take the ignitor out and lay it on some bright part of the engine and try it. While you have the ignitor out put some water between the



Filling the silo

points and then snap it and see if you get a spark. You do not, because the water bridges the gap between the points, and being a conductor of electricity, the circuit is not broken. Put some oil between the points and try it. No spark is made in this case because the oil is a non-conductor of electricity, and the circuit was not made, hence could not be broken.

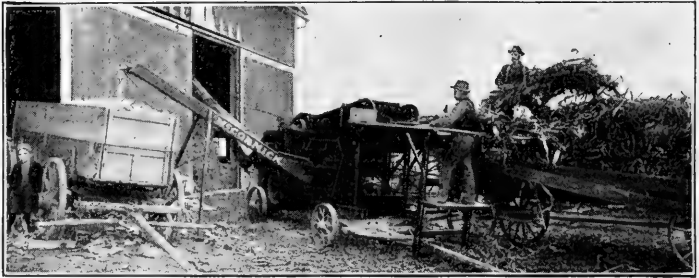
These illustrations show that if a non-conductor gets between the points of the ignitor a spark is not made, and if a conductor gets across the points a spark is also not made, hence it is absolutely essential that the ignitor and all binding posts be kept clean, and the latter must be kept tight.

Since gasoline gas does not burn instantly, ignition should take place some time before the piston reaches dead center. This point is generally determined by the position of the crank and the speed of the engine. A slow speed engine should ignite

when the crank is about 10 degrees below center, while some extremely high speed engines should ignite about 70 degrees below or before dead center. This latter applies more especially to automobile engines.

The farmer who knows the principle of the action of the gases in his engine and understands his ignitor, will have no troubles other than those which come up because of wear and poor adjustment or lack of care, and these troubles he must learn to adjust as they come about.

A Comparison—Men who are driven will sulk, will complain, and finally strike, but few will ever overwork. A horse will work on, no matter how much he is required to do and no matter how badly he is crippled up. A steam engine is like a horse—it can be overworked to its detriment—and if it gets out of order it will run on just the same until it is practically ruined. A gasoline engine is like a man—if it is overtaxed it quits, and if it



Husking and shredding fodder

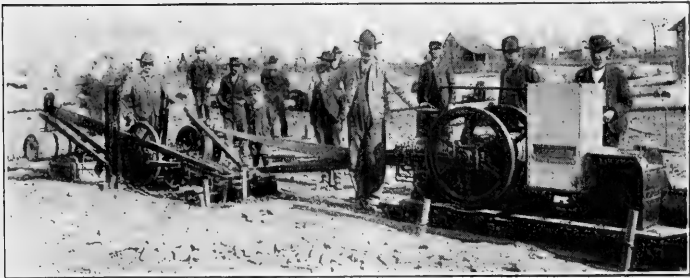
is out of order it will not run. It is like a man in another respect. It is always ready to start, does not have to be driven from the pasture; neither does an hour's time need to be wasted to get its motive power in the proper condition to use. Furthermore, it is not dangerous when handled either by experts or novices. It will not run away, it will not kick, nor will it explode its boiler.

Men have been known to say that horse labor is cheap, and some men believe it is. But can they prove it? Transfer companies in the prairie states make the claim that it costs \$125 per year to feed a horse. Of course these horses are all work horses, and most of the time they work. The Minnesota experiment station has proven that it costs approximately \$80 to maintain a farm horse for a year, and the horse only returns about three hours' work per day for this, which makes the cost of his services to the farmer amount to about eight cents per hour. In addition to this must be counted the depreciation, interest, and taxes.

With gasoline at 20 cents per gallon, and with a very extravagant engine, it should not cost more than two and a half cents per hour for each horse power used. The interest, taxes, and depreciation would be about the same as for a horse when in use, but when not in use the engine does not depreciate and the horse does. Again, when not in use, the engine does not eat anything, while the horse eats nearly as much as when in use.

It is quite difficult to compare the cost of using the horse with the use of gasoline engines, as neither one is ever used all the time, but it may be of interest to make an attempt at the exact figures.

What the Tests Show—The department of agricultural engineering at the University of Nebraska has made tests of pumping with a 3-horse power gasoline engine and found that it takes one gallon of gasoline to pump 2,454.5 gallons of water from a well 43 feet to water, and that one gallon of gasoline will pump



Sawing wood

1,720 gallons of water from a well 159 feet to water. A gallon of gasoline should pump sufficient water from a well 43 feet deep to supply 300 head of cattle 24 hours, and it should pump sufficient water from a well 160 feet deep to supply 215 head of cattle 24 hours. The same engine referred to above shelled 28 bushels of corn in 26 minutes and used .105 part of a gallon of gasoline. This shows that one gallon of gasoline will shell 264 bushels of corn.

The men, in making this test, did not stop with shelling the corn, but kept on and ran the corn through a feed grinder at the rate of 29½ bushels an hour, and found that a gallon of gasoline would grind 48.6 bushels of corn sufficiently fine for good feed.

These same men found that it took .0893 gallons of gasoline to run the engine empty for one hour, or .001489 of a gallon to run the engine one minute. It takes about one minute to separate one cow's milk, and requires about ¼-horse power to run

the separator. Small gasoline engines use about a gallon of gasoline plus the amount used by the engine to do one horse power's work for ten hours. Computing from this it is found that it takes about .00011 part of a gallon of gasoline to do the work separating one cow's milk. Add this to the amount of gasoline used (.001489) to run the engine one minute, and the sum is the amount used (.001589 galls.) separating the milk of one cow with a 3-horse engine and a 740 pound separator.

Strange as it may seem, it should take only about .32 of a gallon of gasoline to separate the milk from 100 cows for 24 hours, which at 20 cents per gallon would cost only 6.4 cents.



Grinding feed

It takes about $\frac{1}{5}$ -horse power to run a common hand grindstone, which means that it takes .958 part of a cent to grind a sickle. If it takes 30 minutes to grind a sickle, and farm help now costs approximately 25 cents per hour, it costs 12.5 cents for a man to turn the grindstone while the sickle is being ground.

Other Work for the Engine—Saving a woman's labor on a farm is an item which should not be overlooked when considering a farm power plant, and this is especially true of the weekly washing. When the washing machine is run by hand it takes about five minutes of turning for each washer full of clothes,

and there are generally about six washers full. This means that the machine is run about 30 minutes for a washing, and takes about .0478 part of a gallon of gasoline. This is not the amount which is generally used, for the washing machines are run about twice as long when they are motor driven as when hand driven, and get the clothes correspondingly cleaner.

In short, the following table shows about the gasoline used for the various purposes about the farm with a 3-horse power gasoline engine. Some of the figures are from actual tests and some are computations :

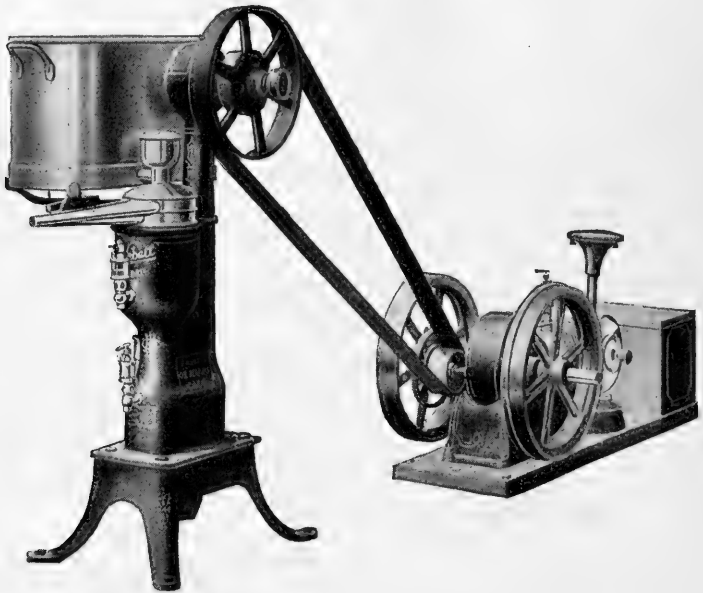
One gallon of gasoline will pump
 2,454 gallons of water from well 43 feet deep.
 1,720 gallons of water from well 159 feet deep.
 Will shell
 264 bushels of corn.
 Will grind
 48.6 bushels of corn.
 Will separate the milk from
 300 cows.
 Will do about
 20 weekly washings without wringing.
 Will grind about
 20 sickles and
 If harvester is pulled by horses, will cut about
 4 acres of grain.

The limit of usefulness of a gasoline engine on a farm depends upon the ingenuity of the farmer. Besides the subjects mentioned, it should be made to cut the ice, put it in the ice house, put the hay in the barn, the corn in the crib, cut the alfalfa, the ensilage, do the threshing, sharpen the plows and the disks, sweep the floors of the house, saw the wood, light the buildings, and do many other kinds of work.

Size of Engine—What size of engine to purchase depends entirely upon the farm and farmer. On the whole, it seems that most farmers are purchasing too small an engine, and overlooking the medium sizes. A good 4 or 5-horse power engine will do anything on the farm, except thresh or fill the silo, and do it as economically as a large engine which would require a large force to keep it supplied with work. This same engine will do all the small work about the farm, and requires only a trifle more gasoline for the work than a 1 or 2-horse power engine.

With modern machines and a good gasoline engine a farmer should use his mental ability in such a way that he and his farm hand can do all his work, and then thereby drop the old time shelling bee and threshing day. By stacking the grain

and using a small separator, a farmer can choose his own time to thresh, and by that means keep a good hand who would otherwise be lost. This method of doing the work will also take a burden from his wife's shoulders, because she will not need to cook for such a large number of extra men as is usual at threshing time. Whenever a farmer gets a gasoline engine he should arrange to do without an equivalent value of horse flesh or man labor.



. Operating the cream separator

The Gasoline Tractor—The matter of substituting a traction engine for horses now depends upon three things to make it a success.

First: The size, arrangement, and topography of the farm.

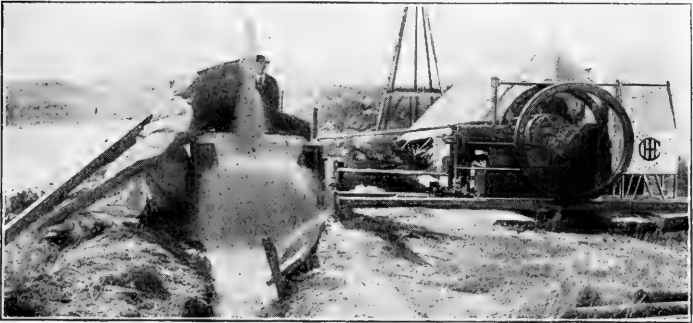
Second: The conditions of roads and bridges leading to town, and,

Third: A man's ability to handle his work so that he can substitute oil and steel for man and horse.

The farmer who has a farm which is fairly level and laid out in long fields can plow the fields and seed them with a traction engine cheaper than with horses.

With large wagons, good roads and bridges, a man can deliver his produce in town with a traction engine as cheap and probably cheaper than with horses.

A modern farmer must not only be able to select good seed, sow it scientifically, and feed the harvested crop scientifically, but he must be able to sow, till, harvest, and handle the crops economically. To do this he must be an engineer as well as an agriculturist in every sense of the word. One



Pumping water

of the greatest losses on the modern farm today is through poor handling of labor, machines, horses, and improper arrangement of buildings. A great part of these losses is the feeding of several horses for ten months in the year to do a few weeks work, and the farmer must learn to arrange his work to utilize the services of his horses all the year around, or he must arrange his work for the efficient use of a gasoline engine. The latter appeals to the writer as a more feasible plan and one which the best farm management is slowly but surely adopting.

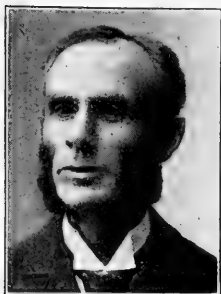


Profitable Hay Making

THE SEEDING—THE GROWING CROP—BEST METHODS OF CURING HAY

BY PROFESSOR THOMAS SHAW

Formerly of the Minnesota Experiment Station, St. Anthony Park, Minn.



The Corn Crop—The United States stands first in the popular estimate. This estimate is based on the fact that the corn crop far exceeds, in direct cash value, any other single crop grown in the United States. In 1910 the farm value of the corn crop was \$1,523,968,000. The hay crop is second, with a farm value of \$747,769,000. Wheat ranks third, with a farm value of \$621,443,000.

That corn is king among farm crops, to use a popular phrase, would be apparent from the above figures. But it is only apparent. The grass crop is the most important crop that the United States produces, and may continue to be so through all time. That such is the fact may readily be shown. Let it be observed:

1. That the estimated value of the grass crop included only hay, while it is undoubtedly true that the pasture crop is more valuable by a large margin than the hay crop, because of the immense area in pasture. Add these values, and the cash value of the grass crop will exceed that of the corn.

2. The corn crop has cost much more to produce than the hay crop, hence the net profit from growing the hay would approximate much more nearly the net profit from growing corn than the maximum value of the former does that of the latter.

3. The full value of the hay to the farmer is not shown by its commercial value in the matured form. While the grasses have been growing into arable farms where rotation is practiced, they have been storing the ground with their roots, which, along with the stubbles, when the meadows are broken up, furnish humus for the growing of other crops. Those leguminous in character always in addition leave the ground richer than they found it in nitrogen, and nitrogen is the costly element of fertility.

The indirect value of the hay crop to the farmer can not be stated in figures. But it would not be extravagant to say, that

all things considered, it would not be much less than the market value of the hay.

In the absence of grass, the humus supply in the land can not so well be maintained in any other way, which means that without it, land can not be kept for a considerable term of years in a proper mechanical condition. Without the grass crop, weeds can not be so readily kept under control, nor can the diseases that affect grain crops be so readily kept at bay. In its absence, some soils blow and others are carried away by the action of water, which may fall in the form of rain or snow. In its absence, live stock can not be maintained on the farm without undue expense, and consequently, in its absence mixed farming will be impossible. Beyond all question, grass is king among the crops of the farm in the United States and so it will continue to be.

Meadow in the Rotation.—In the absence of the grass crop, true rotation in the sense of resting and renovating land, is not possible without undue expense. To change from one cereal crop to another in the rotation does not rest or renovate land unless the cereal grown is a legume. Growing these crops in alternation has some advantages over growing only one in unchanging succession, especially when one of these, as corn for instance, is made a cleaning crop, but all of these, except the pea crop, draw upon practically the same elements of fertility in the land.

The frequency with which the hay crop should be introduced into the rotation depends upon conditions such as relate to soil, climate, the character of the hay crop grown, and the object for which it is grown.

Where the soil conditions are such that in conjunction with the climatic conditions, a stand of grass can be reckoned on with much certainty, the introduction of the grass crop should be quite frequent in the rotation. The aim should be, as a rule, to grow not more than three crops of grain between the grass crops. In this way the land may be adequately supplied with humus. With great propriety the grass crop may precede such crops as corn and potatoes, and if the sod has been manured with farmyard manure before plowing it, the conditions are just to that extent improved. Under the conditions named, the plan is good which cuts two crops of mixed hay, followed by one season of pasturing. This in time is followed by a cultivated crop, and after the cultivated crop, two crops of cereals.

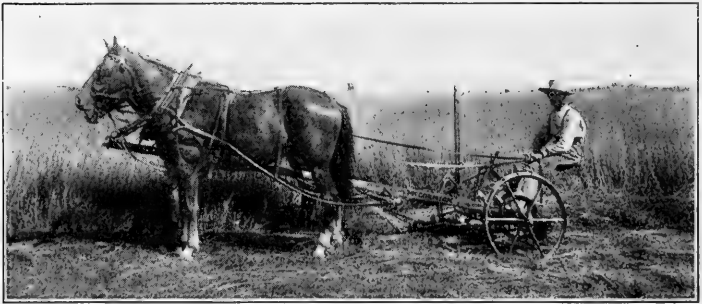
Wherever the rainfall is large and the temperature warm, it would be better to aim to grow only two crops of cereals between the grass crops, because of the quick decay of humus. But where the rainfall is light, and the atmosphere of a character which retards the decay of humus, as in the northwestern states, in

many instances four crops of grain may come between the grass crops without too quickly depleting the land of the humus supply.

If the hay crop grown should be a legume, as for instance red clover, then the most profitable rotation is clover cut twice in one season, a cultivated crop as corn or potatoes next season, and a cereal crop seeded to clover the third season. Such a rotation is unrivaled for the maintenance of maximum production in crops.

But there may be instances when it is not desirable to rotate hay crops. Certain soils have special adaptation to growing hay, and they may be so situated that hay crops grown upon them are more remunerative than other crops; such are reclaimed tide lands by the sea, and in some instances river bottom lands subject or not subject to overflow.

In some cases hay is so dear relatively that it is more profit-



Harvesting the hay crop

able to keep the land growing hay for successive years when once a good stand has been obtained. The production in the crop is then maintained by applying artificial fertilizers. In other instances good crops may be grown for a long term of years without fertilizers, as when certain marsh lands have been reclaimed, and yet in other instances a certain hay crop may have so high an adaptation to certain soils, that it may produce many successive crops of hay without injury to the land, such as the alfalfa crop.

Mixed Grasses for Hay—Some grasses grow best alone. This may arise from inability to cope with other grasses, as in the case of alfalfa; hence, except under peculiarly favorable conditions, the aim is to grow alfalfa alone. Or, it may arise from the greatly aggressive character of these grasses, which enables them soon to crowd out other grasses. Such are Johnson grass, grown in the south, Bermuda grass also grown there, Kentucky blue grass, which grows over almost the entire United States

save in the semi-arid west, quack grass which is widely scattered over farms in the northern central and eastern states, and which persists in growing where it is not desired. Johnson grass and quack grass yield well, but both are so persistent in their growth that they should never be sown. Bermuda and Kentucky blue grass have far higher relative adaptation for pasture than for hay, hence they should only be sown or planted for pasture.

The three grasses, timothy, Russian brome, and western rye grass or slender wheat grass, as it is sometimes called, may be grown with other grasses, but for certain reasons, are very frequently sown alone.

Timothy is the most valuable of all grasses. It stands shipping best. It has highest adaption to the needs of horses, partly on account of its composition, and partly because of its freedom from dust. For these reasons it is very frequently grown alone.



The side delivery rake makes neat windrows

Russian brome grass is frequently grown alone in the Dakotas and the northwestern provinces of Canada, because of its high relative adaption to the conditions found there. For a similar reason western rye grass is sown alone in the same areas, and more particularly where the conditions are driest in the same.

More commonly, however, hay is sown in mixtures. The following are among the chief reasons for sowing it thus:

1. Larger yields are obtained.
2. Usually such hay has a wider adaption for feeding than is possessed by any one variety.
3. It is frequently more easily cured than if grown alone. Experience has shown that in growing plants in certain combinations, larger yields may be obtained than when they are grown singly. This is owing to the fact, doubtless, that in mixtures they more completely occupy the soil, and to the further fact, that each draws most heavily on its own proper food elements in the soil, hence more plant food is appropriated by the

combination than could be appropriated by any single plant. Because of the difference in the analysis of plants thus grown together, they have a wider adaptation than if grown alone. Timothy, for instance, has high adaptation for horses, but low adaptation for sheep. Clover has high adaptation for sheep and unless when entirely free from dust, low adaptation for horses; whereas, a mixture of clover and timothy answers well for almost every kind of feeding to the domestic animals of the farm.

The prejudice to a limited amount of bright, well cured clover in timothy fed to horses, is not well founded. When clover is grown alone it is sometimes difficult to cure. When grown along with such grasses as timothy or orchard grass, it cures more quickly and easily, since the curing, or rather the keeping qualities of the clover is favorably influenced by admixture with grasses which cure thus quickly.



A typical Western hay field

The most common mixture of grasses is medium red clover and timothy. These are peculiarly adapted to produce hay most desired on the farm. They grow well together on the same land. The timothy helps to sustain the clover and the clover improves the character of the hay for feeding, and when it dies the dead roots nourish the timothy. In such a mixture clover will predominate the first season of harvesting the crop for hay, and timothy the next year.

This mixture has high adaption for all the northern states and several of the provinces of Canada, also for certain areas west of the Rocky Mountains and in the irrigated valleys of the Rockies. In these areas the yields may be improved upon by sowing timothy, medium, mammoth, and alsike clover in combination.

In the central states, with Kansas as a center, orchard grass,

meadow fescue, and Russian brome grass may figure largely in the grasses of the meadow.

In the upland areas of the northern plateaus of the western mountains, orchard grass, meadow fescue, Russian brome, and tall oat grass have given satisfaction. In the south, one of the best combinations is orchard grass, tall oat grass, and in some instances timothy.

The Legumes as Hay Crops—Leguminous crops are those that produce their seeds in sacs or pods. They are all possessed of the power to draw nitrogen from the air in the process of growth and to store it in the soil, where it is accessible to crops that immediately follow. This power to appropriate nitrogen not in the soil is doubtless one reason why legumes are so rich in protein. Protein is the element in foods which is chiefly used in making muscle and milk, for other than legumes are largely used



The work of stacking made easy

in the production of heat and energy. Unless these foods are fed in due balance, animals can not be so cheaply grown, so perfectly grown, or so well maintained.

Three reasons will always exist for the growing of legumes. The first is that they must be grown if foods are to be fed in balance. The second is that nature unaided does not furnish them in anything like the same abundance as it furnishes many of the grasses proper. The third is because of the great service they render in the enrichment of the land. Of so much account are they in the animal and vegetable world that it behooves the farmer to give special attention to their abundant growth in the rotation.

Young animals, especially, must be abundantly supplied with muscle-making material. This explains why the clovers furnish more suitable food for them than the grasses proper. Likewise

cows and other animals which provide milk can not do so in the absence of liberal supplies of protein. This explains why good clover hay is better adapted for milk production than good corn stover. There is, of course, some protein in grasses and coarse fodder, but there is not enough to supply the needs of the classes of animals named. It must be supplied from some other source, and there is no source of supply so cheap ordinarily as that which furnishes protein by growing it on the farm.

Nature does not furnish foods, nitrogenous in character, with anything like the same abundance that it does foods that are carbonaceous. All the grasses, many of which take possession of the soil unaided as it were, are relatively low in protein as compared with legumes. Nature covered the original prairies with grasses, not legumes. When the forest is cut away, blue grass



Following the mower

comes in and possesses the soil. Nature never covers the land with legumes. The nearest approach to such a covering is found in the more or less abundant growth of wild pea vines scattered amid the native grasses, and particularly on lands more or less covered with brush in the American and Canadian northwest.

All the grains which grow in the north are non-leguminous, except peas, vetches, and beans, and the same is true of those of the south except cow peas, soy beans, and velvet beans.

The only leguminous root crop, strictly speaking, that furnishes food for live stock, is the peanut. All the coarse fodders, as corn, sorghum, and the non-saccharine sorghums are non-leguminous. True, flax in the north and cotton-seed meal in the south are relatively rich in protein. So are the by-products of wheat, as bran and shorts, but none of these is a legume. Where live stock is to be kept, therefore, the need is imperative for growing a sufficiency of protein, and in no way can it be more cheaply

furnished than by growing legumes, and more especially in the form of hay.

But the great service that legumes render to the soil furnishes an important reason for growing them freely. Red clover grown on soil will furnish a crop of hay and also of seed in one season, and will leave the ground richer in nitrogen than when the crop was sown. Peas, vetches, cow peas, and soy beans may be allowed to mature and the vines and seed may both be removed and yet the land will be richer in nitrogen than it was previously. Should alfalfa, clovers, and the other legumes mentioned be fed on the land, it will be apparent that the process will exert a favorable influence in building up the soil. Of course, when these crops are sold, it may be necessary to supply the soil with additional phosphoric acid and potash.



The hay tedder

Climatic Adaptation for Legumes— While legumes of one species or another may be grown in all the states of the Union, these differ greatly in their adaptation to the climatic conditions.

Alfalfa has more general adaptation than any other legume grown on this continent. It can be grown with more or less success in portions of every state in the Union where the soil conditions are right. Although, by far, the most abundant yields are obtained from it when grown under irrigation, nevertheless it is well adapted to areas that have but little humidity. It may be grown on suitable soils where the rainfall is not less than 10 inches per annum, and where the precipitation averages 15 inches, good crops may be grown. Without any irrigation, these should yield on an average not much less than two tons per acre per year. This means that alfalfa will be the principal hay crop through all time for all the region west of the Mississippi river, and east of the Cascade mountains.

The three leading varieties of clover; *iz.* the common red, the mammoth, and the alsike, all grow relatively better under humid conditions than under those that are dry. It would seem safe to say that clover cannot be grown at its best when the annual precipitation is much less than 20 inches. This means that in the absence of irrigation these clovers will not give returns equal to those obtained from alfalfa in all the area which lies west of the meridian 100°, and east of the meridian 120°. Crimson clover which is an annual, has highest adaptation for the Atlantic and southern states. Japan clover is frequently grown for hay in the southern states, but the yields obtained from it are relatively small.

Vetches have highest adaptation for climates that are moist. The best climatic conditions, therefore, for vetches are found on the Pacific slope west of the Cascades, in proximity to the great lakes, and in the Atlantic and southern states. No better hay crops can be obtained along the Pacific coast than those obtained from vetches. The sand vetch, however, will grow relatively better with but moderately humid climatic conditions.

The cow pea and the soy bean cannot be grown at their best much farther north than the parallel 40°. They call for a longer and a warmer season than is usually found north of the parallel named, but they can be grown for hay much farther to the north than for the grain. Where the climatic conditions become less favorable for the growth of these plants, they become more favorable for the growth of the Canada field pea, which grows at its best north of the parallel named.

Soils for Producing Hay Crops—The question of soil adaption in growing hay is one of great significance. A grass or clover that may flourish well on one kind of soil may utterly fail on another. Climate adaption is also important, but that has already been touched upon.

The highest adaption for alfalfa is found in the volcanic ash soils of the west. These are more or less sandy in character, and if they are underlaid with sheet water within a few feet of the surface, the adaption is further increased. Next to these come clay loam soils of mild texture and underlaid with clay not dense in character. Wet and marshy lands are quite unsuitable. On many soils alfalfa will not succeed well until inoculated with the bacteria essential to its growth. This is most easily done by sowing 200 to 300 pounds of earth over the land that has been obtained from a field in which alfalfa is growing vigorously.

Medium red clover has soil adaption a good deal similar to that of alfalfa, but it will flourish in a shallower soil, as it feeds less deeply, and also in a soil with watery saturation which

comes nearer to the surface. Red clover is almost certain to grow well on soils that will produce hard wood timber, and usually without inoculation. It generally grows well also on the average prairie soil where climatic conditions are suitable, but these may in some instances require inoculation with soil taken from a field in which red clover has recently been grown, or is growing when the soil is obtained for such a use.

Alsike clover has high adaption for humus soils. It will succeed well in situations that would be entirely too low for red clover of either variety, for mammoth clover has much the same adaption as medium red clover. It is because of this adaption for humus soils that alsike clover is so well adapted for being grown with timothy, as well as because the two mature at the



Cutting a heavy stand of timothy

same time. But alsike clover will also grow well on soils with much less clay in them, although the yields from these will not equal the yields from humus soils.

Timothy, like alsike clover, has highest adaption for humus soils, providing these are possessed of a considerable clay content and more particularly when they are underlaid with clay. Timothy will also grow well on sandy and clay loams, particularly the latter, when an ample supply of moisture is present. But neither timothy nor alsike clover is well adapted to light lands low in fertility, and especially in regions where the rainfall is light.

Red top grows naturally in low lands, that is, it grows at its best in these, even when composed of peaty muck. In such marshes as have grown wire grass before they were drained, red top will usually possess the soils when the waters have been

removed. But red top will also grow well on uplands reasonably moist, as shown by its behavior in New England when grown in conjunction with timothy, and in several of the states of the south, in which it is a factor of considerable importance in growing hay.

Orchard grass will grow in a fairly wide range of soil. It has been mostly grown on certain of the loamy clays of New England, the stiffer soils of Indiana, the reddish clays of Tennessee and other states of the south, and in the sandy loam soil of Idaho and the adjoining states. Orchard grass calls for soils naturally moist, but not wet.

Russian brome grass will grow in soils that would be too dry for timothy or orchard grass, but it does not grow nearly as well relatively on dry as on moist soils. It has high adaption for the soils of western and especially northwestern prairies, and in many localities it gives yields considerably ahead of those obtained



The mowing machine in operation

from timothy, and produces hay of equal feeding value, ton for ton, but not nearly so well adapted for selling in the open market.

Western rye grass grows well on average prairie soils. It will grow better on sandy soils under dry conditions than almost any other kind of grass. It will flourish under conditions that would be too dry even for Russian brome, but of course it will give better yields where the soils are not so open and the land is more moist. The hay is more woody than that of timothy and brome grass.

Tall oat grass is adapted to a considerable variety of soils, ranging from light sandy loams to clays of considerable density, but it finds most congenial conditions in loam soils. This grass has higher adaption to the central and far western states, and to areas south rather than north from these.

Meadow fescue would seem to have nearly the same adaption

as tall oat grass, but it is slower in taking a firm hold upon the soil and is correspondingly more enduring. It has been grown with much satisfaction for hay and for seed in Nebraska and Idaho. Peas and vetches require a moist but not a wet soil. It should also be more or less clayey in texture. The conditions suitable for medium red clover are also usually suitable, at least in a fair degree, for growing Canada field peas and common vetches. The cow pea and sand vetch will grow well under conditions less favorable to growth, as where the soil is sandy and relatively low in fertility.

The soils adapted to growing grains for hay are virtually the same as those for growing them for the grain, but with the difference that when grown for hay, grain production is not so important relatively as when grain is the principal object sought, and straw or rather hay production; that is, the production of



Sweep rake in operation

stem and leaves is relatively more important. Because of this, these crops may be sown on lower soils and richer in vegetable matter than would be suitable for growing them at their best for grain production.

Sorghum and kaffir corn may be successfully grown for hay on any kind of soil that will produce Indian corn in good form; that is, they may be successfully grown on any good sandy or clay loam soil where the climate is suitable. In almost every state in the Union the climate is suitable for growing some variety of sorghum into hay, but kaffir corn requires conditions somewhat warmer. The central Mississippi states have highest adaptation to growing such hay.

Sowing Grasses and Grains for Hay — No matter what the grass or grain may be that is sown, it should always be the aim to sow on soil clean, mellow on and near the surface, moist, and

firm. These conditions may usually be attained by the proper preparation of the land previously. They are most readily secured when crops for hay are sown after those that have been cultivated the previous season, as for instance crops of corn, sorghum grown for syrup, kaffir corn grown for grain, or potatoes, or field roots. The cultivation given to those crops where such cultivation has been ample furnishes all the requisite conditions named above. Usually the preparation that should follow such crops consists of disking and harrowing rather than plowing and harrowing, but of course to this there are some exceptions.

The best time for sowing many of the grasses is the early autumn, but they also may be sown in the early spring. When thus sown they are not so well able to endure dry weather the summer following. In all northern areas they may be sown in the spring, and the same is true of alfalfa. But in all southern areas these may be sown in the autumn.

Alfalfa, as a rule, is best sown in the early autumn, south of parallel 40 degrees. When sown northward in the spring, it should not be sown so early as the clovers. As these are more hardy than alfalfa, the aim should be to sow them very early.

In moist climates, grasses and clovers may be sown any time from early spring to early autumn. The aim should be not to sow such grains as early sorghum and kaffir corn, until the arrival of settled, warm weather, and the same is true of cow peas and millet.

Millet in several varieties is frequently grown for hay. It yields abundantly on prairie and slough soils, because of their richness in vegetable matter, and since it will mature a crop in 60 to 80 days from the time of sowing, it is often sown to provide hay when there is likely to be a shortage. But the hay though palatable and nutritious, for certain reasons should be fed in connection with other fodder.

All of the hay plants except alfalfa should be sown broadcast or on the broadcast plan. It is usually better to sow alfalfa with the grain drill. They may be sown by hand or by machinery. Both the grasses and clover may be sown by hand-machines, strapped to the body and turned with a crank, by a distributor wheeled over the ground like a barrow, or by an attachment to the grain drill. Usually when mixtures of grass seed are sown they are mixed and sown together. But this way may not always be possible, as when large or small seeds are sown together. They do not feed out evenly in such instances, hence it may be necessary to sow them separately. Timothy, all the clover seeds, and alfalfa grow well together. All grains or grain mixtures may be best sown with the grain drill. The same is true of sorghum, kaffir corn, and even millet, though all these may also be broadcast.

Whether the grasses and clovers should be sown with or without a nurse crop will depend largely on climatic conditions. A nurse crop is of course a crop along with which these crops are sown; in many instances at the same time. Usually the grass and clover seed thus sown grow without doing any harm or any serious harm to the grain crop along with which they are sown until the latter is harvested. In some instances, however, the nurse crops overshadow the ground to the extent of smothering the young grass or clover plants. In other instances, they smother them by lodging, and in yet other instances, they so weaken them by drawing on the moisture in the soil, that the young plants perish after the nurse crop has been harvested. But usually the plan is good which sows them with a nurse crop.

Alfalfa is oftener sown alone than the other grass and clover seeds, as under some conditions the plants are benefited by



The hay rake

being cut off two or three times with the mower during the first summer.

The best nurse crop is probably barley, as it does not grow so tall as other grains and occupies the ground for a shorter period. Next to barley probably is speltz, for similar reasons. Then comes rye, which does not stool so much as other grains and is harvested earlier, thus letting in sunlight and ceasing at an early period to draw moisture from the soil. After rye is wheat, of both the winter and spring varieties. After wheat comes oats, lowest in adaptation because of the abundance of the stooling and the large amount of the leaf growth. But oats answer well for a nurse crop when they are grown thinly and cut for hay at the heading out stage.

In some instances grass and clover crops are sown along with certain cereals which are pastured off rather than reaped. Where soils are over porous, and the climate is dry, the plan

works well, as in western areas which border on the semi-arid region. The treading of animals helps to make the land firm. The grazing removes shade too dense and leaves more moisture for the young plants. Such grazing may consist of any of the small cereals, or better, of two or more of them combined. Grass seeds may thus be sown with rape grazed down, or with the flax which is to be harvested.

The depth for sowing grass and clover seed will depend much on soil and climatic conditions. On loam soils where the weather is moist much of the season, grass and clover seed will not of necessity require other covering than that given to them by allowing them to fall before the grain drill tubes, or rolling the ground when they are sown by hand.

In other instances, as where the conditions are dry, they will be benefited by a stroke of the harrow in addition. This should always be given when they are sown in the spring along with winter rye or wheat, but under some conditions it may not be practicable to do this. Where soils are so light and spongy as to sink much beneath the tread, it may be wise sometimes to sow the grass seeds along with the nurse crop and to feed them along with it through the grain tubes.

Sorghum and kaffir corn and also millet should be buried from one or two inches deep according to the soil and its condition at the time of sowing.

The amounts of seed to sow will vary with soil and climatic conditions and the character of the hay sought. Thick sowing increases fineness, and thin sowing coarseness. In some instances the conditions are so dry that thin sowing is imperative to give each plant enough moisture.

Should the clovers be sown alone, the amounts suited to average conditions would be: alfalfa, fifteen pounds per acre, and in the semi-arid country not more than eight pounds; medium red or mammoth clover, twelve pounds; and alsike clover five or six pounds. The average amount of timothy or red top to sow alone would be nine pounds. When timothy is sown with one or more clovers, the average amounts may be fixed at—timothy, six pounds, and clover or the clovers, six pounds in all. This last is the great standard hay crop.

Should orchard grass, meadow fescue, tall oat grass, Russian brome, or western rye grass be sown alone, the average amount of seed may be fixed at fifteen pounds an acre, and when two or three of them are sown together, proportionate amounts are sown. It is of course to be understood that in all instances these amounts relate to the growing of hay. For pasture it may be necessary to sow more seed.

When timothy, red top, and alsike clover are sown to provide permanent meadow, the respective average amounts of seed may be set down at six, six, and three pounds of each, respectively.

When oats are sown for hay, the average amount of seed sown may be fixed at three bushels per acre in humid climates, but the quantities should be reduced with decrease in humidity. Wheat and barley, if grown without irrigation, should not be sown in greater quantity than say one and one-half to two bushels an acre. Cow peas are usually sown alone for hay at the rate of about one bushel per acre. Oats and peas are commonly sown at the rate of two and one-half bushels per acre, of which the proportion of peas will vary from one to one and a half bushels according to the soil adaption. When vetches are sown with other grain, the whole amount sown may be put at two and one-half bushels, of which one bushel or more is vetches. Except where the conditions are very dry, about eight bushels of seed is sown per acre in order to make the hay fine, along with



The hay loader in the field

about one bushel of millet seed. When grains are sown in mixtures and pastured, from two to three bushels are sown and the usual amount of grass and clover seeds.

Harvesting Hay—It is exceedingly important that hay should be harvested at the proper season. If cut too early, there is a great loss of nutrients through loss in bulk and weight. If cut at too advanced a stage, there is serious loss in palatability, and also in digestible nutrients. The loss from undue delay in cutting is least from crops that produce only one cutting in the season, and greatest from those that produce more than one. Alfalfa and medium red clover are of the last named class, hence delay in cutting one crop is followed by serious shrinkage in the next crop in addition to the loss in feeding value in the crop thus cut at too advanced a period.

The best stage at which to cut alfalfa is when it is coming into bloom, when probably not more than one third of the blooms are opened. All the clovers are at their best for cutting when approaching or at full bloom. They will then have some heads, not many, beginning to tint brown. If cut sooner than the period named, alfalfa and red clover will be hard to cure; if cut later, there is likely to be a serious loss of leaves in the curing process, and leaves are the most nutritious and palatable portion of these foods.

Timothy is at its best for cutting when in the later stage of bloom, that is, when the bloom still lingers upon say one third or one fourth of the top of the head. If cut when in full bloom, the adherent blossoms make the hay somewhat dusty when cured. Red top should be cut when in bloom, and the same is true of Russian brome. The orchard grass, meadow fescue, tall oat grass, and western rye grass are better cut in the early stage of bloom than later, as they quickly become woody and so lose rapidly in palatability. This is particularly true of orchard grass and western rye grass.

When hay crops are grown in combination; that is, when clovers and grasses are grown together, there will be no difficulty in determining the time at which they should be cut when they mature at the same time. Happily this is true of mammoth and alsike clover, timothy, and red top. The best time for cutting these clovers will also be the best time for cutting timothy and red top which grows with them. But should medium red clover and timothy be grown together, the difference in the time of maturing is from two to three weeks, according to the season. The safe rule to follow is to cut at the best time for making clover hay, when the clover hay predominates, as it usually does the first year, and the best time for making timothy hay when timothy predominates — as it usually does the second year.

The best stage at which to cut wheat, oats, and barley for hay, is when the grain is in the dough stage, or a little earlier with wheat and barley; as, when it has reached the milk stage. This will be indicated by yellow appearance in the stems for a few inches up from the ground. In the case of oats there will appear a slight tint of yellow on some of the heads when ready to harvest.

When grains are sown in combination, as in the case of peas, vetches, and other grains, they should be cut when the bulk of the grain in the dominant crop is reaching the dough stage.

Cow peas are ready to harvest for hay when a considerable sprinkling of the pods have begun to mature. Sorghum and kaffir corn should be allowed to reach maturity, or nearly so, as then they contain a much larger amount of food nutrients than at an earlier period. But they should in all instances be cut before frost. Millet is at its best for hay when the crop begins

to assume a yellow tint. Cut earlier it will be lacking in bulk; later, it will shed seeds freely.

The implements for cutting hay are the mower and the binder. The implements for curing are the tedder and the horse-rake. The implements for storing are the wagon, hay loader, hay sweep or bull rake, the horse fork, the sling, and the stacker. The binder is only used for cutting grains for hay alone or mixed sorghum, kaffir corn, and millet. But in some instances these are also cut with the mower. When cut with the binder, the sheaves should be small and rather loosely bound to prevent them from moulding underneath the band in the airing process.

Alfalfa and clover are cured by the same method in climates possessed of normal rainfall. When cut with the mower, the



Baling hay

hay lies on the ground until it is ready for being raked. This can be told by the ease with which it can be raked clean into windrows. When too green for being drawn together, bunches of the hay will fall back from the ends of the rake and it will draw heavily. The drying will be greatly facilitated by running the tedder over the field once or twice within a few hours of the cutting of the crop, or at least the same day when the hay is cut early in the day. The side delivery rake aids in the quick drying of the crop. If kept unraked until browned with the sun, the loss of leaves and of palatability is considerable, especially in the case of alfalfa.

As soon as raked, the hay should be put up in cocks, not wide, but reasonably high to complete the curing. In the cocks the hay sweats, and usually requires two days to complete the

curing. It is then drawn and stored. In showery weather it is a great advantage to have the cocks covered with caps of rain-proof cloth, weighted at the corners. These are kept over from year to year. In such weather it may be necessary to open out the cocks a few hours before drawing the hay.

This method of curing makes excellent hay, but is costly when hay is made on a larger scale. Because of this, clover is sometimes cured in the swath and windrow, and the same is the common method of curing alfalfa in dry areas. The plan answers well with clover well sprinkled with timothy when the weather is good. It can then be loaded with the hay loader. Cow peas are cured in much the same way as clover, but they are even more difficult to cure in good form.

The grasses proper are more commonly cured in the swath and windrow than in the cock. They cure much more quickly than the clovers and alfalfa, and are much less injured by rain. When put up in cock they also turn or shed rain much better than the clovers. With the aid of the tedder it has been found possible to cut some of these in the morning and to store them the same day. Usually in good weather they may be cut one day and stored the next.

When grains grown alone or in mixtures are cut with the mower, they are harvested in the same way, substantially as grasses, but may take somewhat longer to cure. The tedder should also be used on these with more caution lest the hay should be soiled with earth. In locations where they are not liable to be thrown down by the winds when cut with the binder they are most quickly cured in long shocks in which the sheaves are set up in pairs.

When sorghum and kaffir corn are cut with the binder, after the sheaves have lain a day or two to dry the butts, they are stood up in round shocks, as these frequently stand for weeks and even months. These shocks are tied near the head with a band. When cut with the mower the crop may lie where it fell from two to four or five days. It is then raked and put up into large cocks and fed from these as desired. It does not readily mould in these, nor does it take injury easily from rain. Millet is cured in best form like clover, but is more commonly cured like the grasses.

Feeding Hay on the Farm—Of course, the question as to whether hay should be fed to live stock on the farm, or sold, must be determined by the conditions. These are such as touch the relative market value of hay and meat, the needs of the live stock on the farm, and its condition as to fertility. There are instances when it is justifiable and commendable to sell hay. The revenue of some farms is in great part or entirely from the sale of hay and this is not incompatible with the maintenance

of fertility. Everything depends upon the way in which the work is done.

Whether hay should be fed on the farm will depend almost entirely on the conditions. It may pay better to sell timothy than to feed it, because of the very high price which it brings in the market. Usually, however, it will pay better to feed hay from legumes on the farm. It does not bring so high a price relatively as timothy in the market, and yet it is more valuable than timothy for home feeding, except in the case of horses. Alfalfa in the range country is now frequently sold in the stack to ranchmen, who feed it in winter to the cattle and sheep which they run on the open range in summer. Such hay may usually be made to bring a much higher return to the grower who will judiciously turn the same into beef, mutton, wool, or pork on the ranch which produced it. But of course there are conditions under which it is legitimate to sell it.

This much is clear, it never pays the farmer to let his stock go backward for the sake of selling hay at a high price. The policy is also mistaken which sells hay from a farm much in need of fertility, unless the price is such that it will justify selling the hay and buying the needed fertility in the form of commercial fertilizers.

When hay is fed to live stock, the resultant product in meat, wool, milk, or labor, is only a part of the farmer's return. He has also the fertility obtained from feeding it. It is common to estimate that the fertility offsets the cost of labor from feeding the hay. Usually it is worth much more than such labor.

It should be observed also that hay composed of legumes is usually much more valuable for feeding than non-leguminous hay, and the resultant fertility is also much greater. On the other hand, non-leguminous hay, as timothy and red top, is most in demand in the markets and brings the highest price. If, therefore, hay is to be sold from the farm, let it be hay that is non-leguminous in character. Such hay ships much better than the other, since it breaks less while being handled. For some kinds of hay there is virtually no market off the farm and probably it is well that it is so, as they can be utilized so well on the farm. Such are sorghum and kaffir corn hay.

Usually it pays better to feed hay on the farm than to sell it. Where it does, the farmer should aim so to stock his farm that the animals on the same will consume it all. The great truth, that should ever be remembered, is that the relation between abundant stock-keeping and high values of land and profits from it, is of the closest possible kind.

The Care and Protection of Farm Equipment

BY M. R. D. OWINGS

Advertising Manager, International Harvester Company of America



Since the arrival of dollar wheat, seventy-five cent corn, and fifty cent oats, editors, college professors, and economists have taken a great deal of pleasure in speaking of the present day farmer as a "business man." They do not always define the term and on close scrutiny it looks as if the so-called "business" farmer is such sometimes largely because high prices of his products have made him prosperous, rather than because of his adoption of more business-like methods.

It has been well demonstrated that a real business man is successful as a manufacturer in so far as he is able to make mechanical labor take the place of less productive hand labor, and that a real business man as a farmer is similarly successful in so far as he can do the same thing.

But here, very often, is where the resemblance ceases.

The manufacturer invests so much money in labor-saving machinery, he allows so much for depreciation, and then proceeds to see that his machine is well housed, well cared for, and kept going. He figures that it must pay so much interest on the original investment plus a profit sufficiently large to equal, ultimately, the original investment. The longer the machine can fulfill the duties for which it was intended, the greater the money returns on the first outlay.

When a farmer figures on the same basis in caring for his equipment, the economic term of "business man" fits him, and generally you can call him an automobile owner as well. But when he invests his capital in expensive machines—and many of them—such as a modern farm nowadays necessitates, and then leaves his plow in the fence corner, his binder in the field, and his new wagon under the eaves of his cow shed, he falls short of exercising the right kind of business methods.

Perhaps he makes enough to be able to do all this without noticing the drain upon his gross income. Some farmers figure that way, but it is not good commercial doctrine.

The money which a farmer puts into a binder, mower, or manure spreader, is capital invested just as much as the money another man puts into a machine for making shoes or spinning cotton. It deserves an annual interest and an ultimate profit equally as much, and it is entitled to as thorough care and protection. Furthermore, the laws governing continuity of service apply exactly the same to a cream separator and a wagon as to a planer or grinder. Of course, owing to the seasonal use of farm machines, there are lapses of time when certain machines must remain idle. It is at this period that they should be best protected. Scientists say that the muscles of an arm wither quicker from inactivity than from over-activity. The same thing is true of equipment, whether on the farm or in the factory. More plows have been worn away by the weather than were ever worn away by service.

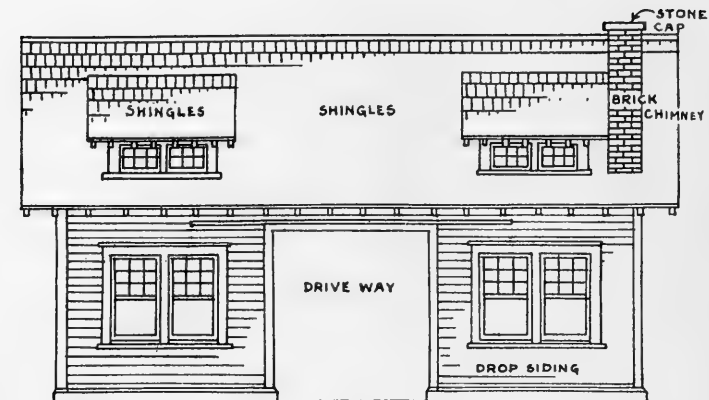
True as this is, very little attention has been paid to the science of machine care. Experimental stations will work for years to show how to grow forty bushels of wheat where only thirty bushels grew before. No one questions the usefulness of this work, but it takes the difference of a good many acres to pile up enough dollars to buy a new binder. And yet, very little time is spent in showing how to increase the life of a binder from six to fifteen years. Perhaps they leave it to the common sense of the farmer. If they do, all right, for common sense is really the thing that is needed.

College instruction, ancestral advice, and original research in the care of farm machines can all be simmered down to these three elementary necessities—good roofs, good paint, and good lubricants. These three determine whether the days of a machine shall be long in the land or whether it shall soon return to the dust whence it came and another order go to the firm who made it.

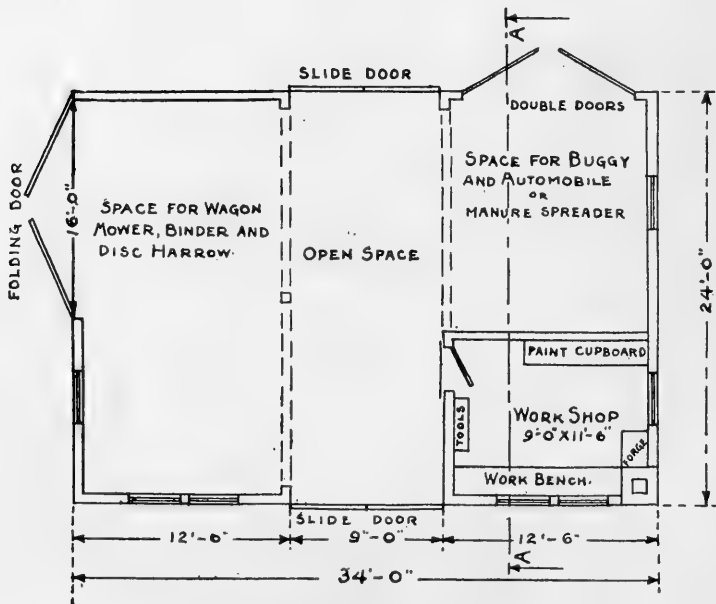
Let every farmer attend to this trio. How and when are questions which each must answer for himself—not very profound questions—but very important.

Few people realize how simple and yet how essential such care is, and for those who have overlooked this phase of agricultural life, we give the experience of one successful Kentucky farmer which may contain helpful suggestions.

This man ran a big farm in that state and in spite of inefficient help and long used soil, made money. He was a firm believer in the above mentioned triumvirate, and he practiced what he believed. Back of his barn he had erected a long, low shed, not particularly showy nor expensive, but dry, and under this shed he kept everything in the equipment line—from grindstone to wagons. In one end he built a homemade improvised paint shop. Although his reputation as a family man in that country was good, it is said of him that he would just as



FRONT ELEVATION

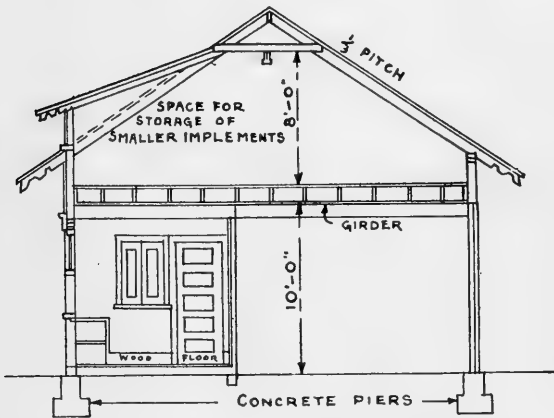


GROUND FLOOR PLAN

Plan for building the machine shed



SIDE ELEVATION



SECTION ON LINE A-A

SCALE $\frac{1}{8}'' = 1$ FOOT

SKETCH OF FARM MACHINE SHED
 IHC SERVICE BUREAU
 INTERNATIONAL HARVESTER © OF AMERICA.

soon leave a member of his family outside all winter as his mower or his drill.

When he finished his plowing, he saw to it that his men brought the plow back to the shed. He then went over it thoroughly with a coat of white lead, and it was left that way all winter. In the spring a little kerosene or turpentine was applied which loosened the paint so that with the first contact with the ground the share came out smooth and shiny like a mirror.

"That plow," said the Kentuckian, "cost me \$35.00. The paint cost 35 cents, and it made the plow last several years longer.

"That is just an illustration," continued he, "of my procedure with every machine I own. Every two years I make it a point to go over the binders, mowers, and all the machines I have on the place with a good metal base paint. I take off the binder canvases, roll them up, and put them out of the way of the mice. I grease the sickles of the mowers and binders, wrap them up, and put them away in a dry place. Then when I have occasion to use these machines I put the sickles back in place, and before the first circuit of the field is completed they are as bright and shiny as when new.

"Perhaps also the question of pride helps a little, because I always like to have everything about the farm clean and bright. I generally use red paint because I like that color, and because red lead is better than white lead for outside work. I keep even the tongues and whiffletrees of my wagons as good as new. They are mostly made of locust in our country and, when properly painted, last a century.

"This painting is not just a hobby; I have found that it pays. One time I sold a binder which I had used steadily for six years, for over two-thirds of what it cost me, and I didn't cheat the fellow, either. It was practically as good as new.

"I am a paint advocate alright, and it seems to me that hired men may come and hired men may go, but my wagons, mowers, and drills go on forever.

"I don't use up all of this paint because I feel more friendly toward the Sherwin-Williams people than I do toward the International Harvester Company of America. It is merely a matter of economy with me because paint is cheaper than new machines.

"I am even more cranky on the lubricants. You know the parts of a binder, for instance, that are subject to wear are the chains, the gears, the boxes, and knotter. Painting won't help these, but plenty of oil will. When I first started farming the most important bit of barn furniture was the oil can. Many a time since then, when I have seen my neighbors tied up in the middle of a work day with an overheated part, I have

'praised John from whom oil blessings flow,' as the University of Chicago boys say. I make it a rule, after each long trip, to grease my wagons, with the result that they are always ready and always ship-shape. I invent patent dust protectors of my own when none come with a machine, and where this is not possible I keep the exposed parts well cleaned.

"Now all of this may seem rather unimportant to some farmers, or they may think it a great deal of trouble for nothing, but I never notice the trouble and, in the long run, I find that it is a good form of economy. I farmed for many years, at a time when prices were much lower than they are now, and I made my farm pay. I do not claim that it was all due to my caring for my equipment, but the fact that I have made every cent of capital invested in machines return one hundred cents on the dollar, and then some, has had a great deal to do with my prosperity."



*Farm Machines and Progress

BY J. E. BUCK

Of the I H C Service Bureau



The Staff of Life—The origin of wheat is unknown. It is at least as old as civilization, and was probably used as food by our primitive ancestors long before they emerged from the obscurity of the ages. For more than forty centuries the golden cereal has been the staff of life of civilized nations. In the advancement of human welfare, no cereal has been more instrumental than wheat. It has developed the mechanical ingenuity and other intellectual faculties of man.

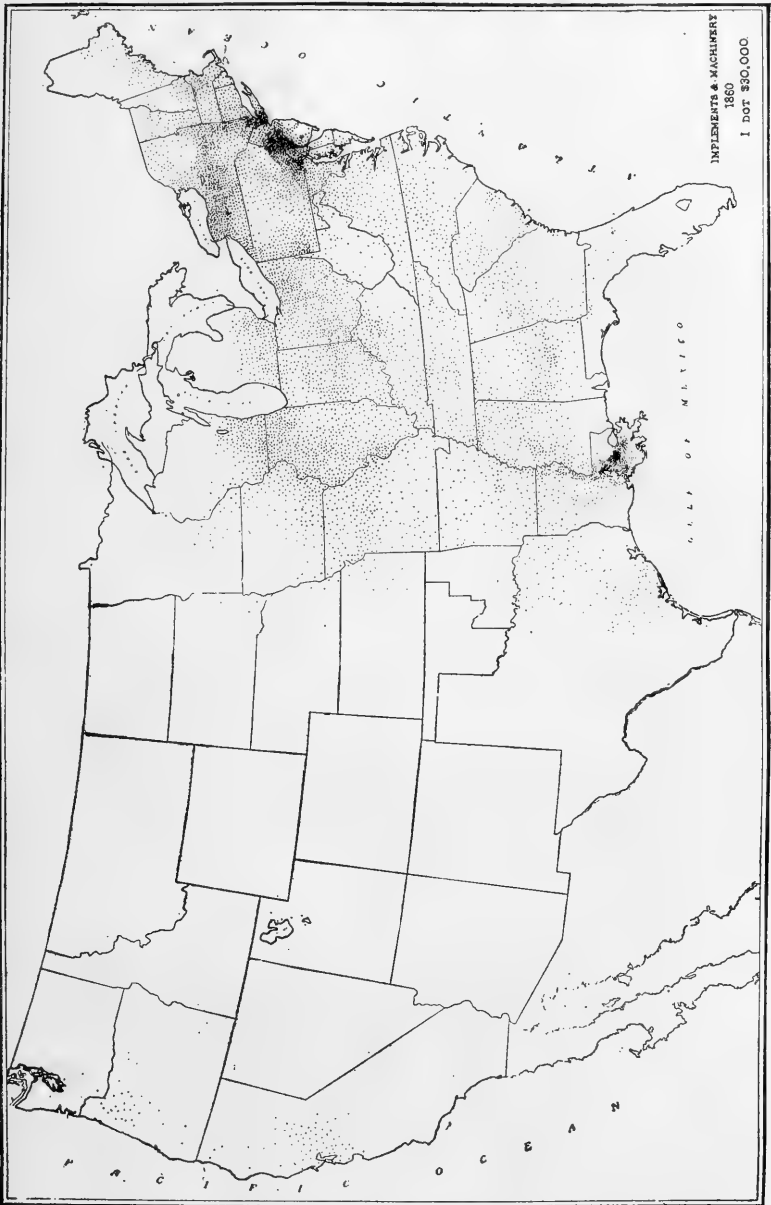
Without wheat, farms would be abandoned, cities would crumble into ruin, and civilization would perish.

From a bulletin compiled by Miss Helen W. Atwater for the Department of Agriculture, we learn that probably no food, unless it is milk, is more generally used than bread, nor is there any food that constitutes a larger part of the diet of the average person. In the earliest historical records it is spoken of, and wild tribes which today inhabit South Africa know something of its use. Of course, the bread made by the Kafir to-day, or by the American Indian three hundred years ago, is very different from that with which we are familiar. The Kafir simply grinds his grain between two stones, makes a paste of this meal and water, and bakes it in the ashes of his camp fire. Israel, in Egypt, ate leavened bread; the ancient Greeks cultivated the yeast plant; in Pompeii an oven was found containing loaves of bread not unlike that of the present day; many European peasants still bake their weekly loaves in the village oven, and so on, to the mammoth bakeries and innumerable fancy breads of modern times. The reason for this importance of bread is very simple. Ever since the far-off days when the wild cereals were first found or cultivated, men have known that food prepared

*Maps Nos. 1 and 2 show the value of agricultural machines in use in 1860 and in 1900, and maps Nos. 3 to 9 inclusive show the production of wheat in the United States by decades, beginning with 1840.

The number of farms increased from 1,500,000 in 1850, to 6,000,000 in 1900, and the total area under cultivation increased during the same period from 293,000,000 acres to 700,000,000 acres. The population of the United States has increased from 4,000,000 in 1790, to 90,000,000 in 1910.

Implements and Farm Machines in 1860
Each Dot Represents \$30,000 Worth of Farm Machines



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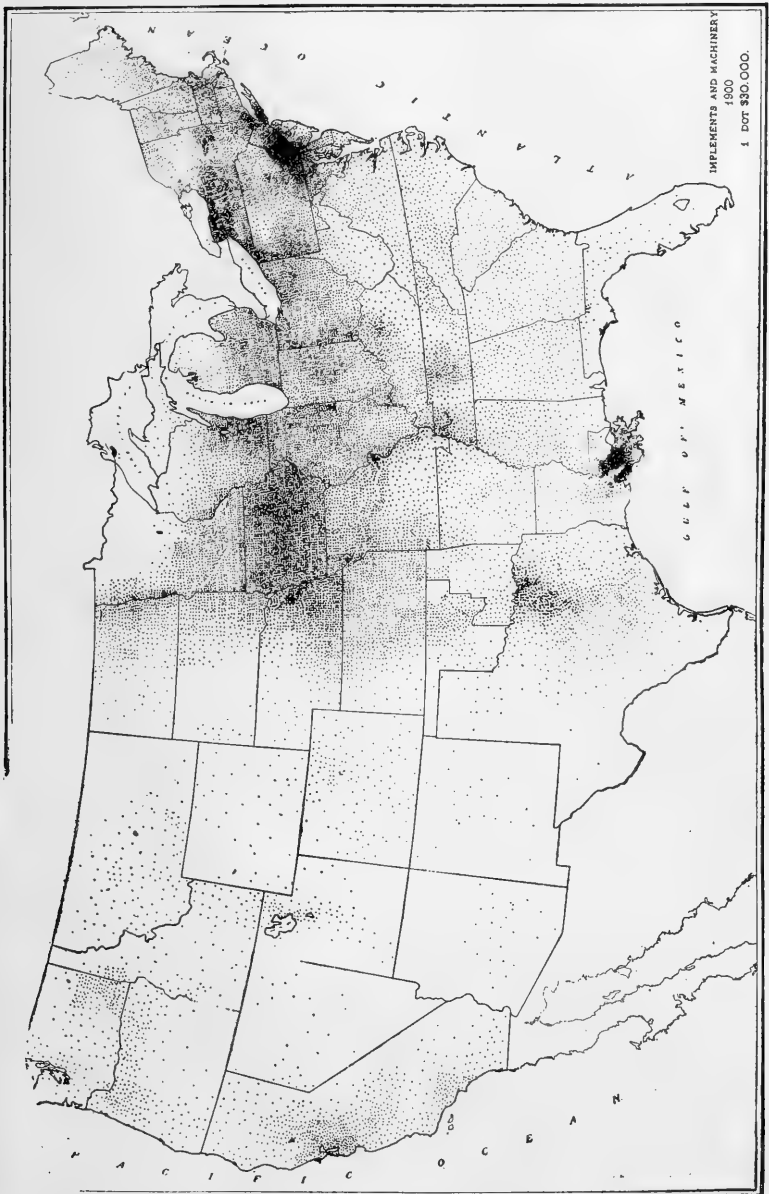
from them would support life and strength better than any other single food except milk. Although in this country the ease with which other foods can be obtained makes bread seem less important, there are many districts of Europe and Asia where it is still the "staff of life," and where when people pray for their daily bread, they mean it literally.

Even in the United States bread plays a more important part than many realize. Statistical investigations which have been conducted by the government indicate that at present the annual per capita consumption of wheat in the United States is about $4\frac{1}{2}$ bushels, which represents not far from a barrel of flour, and there are reasons to suppose that this amount is increasing.

The Early Struggle for Bread—During the first seventy years of our national life, our abundant resources failed to bring us any great increase in commerce or in the products of agriculture, trades, and industries. Notwithstanding the fact that the virgin soil was practically free to the settler, our production of wheat was insufficient to supply our people with bread, and the little that was imported was taken from the mouths of the poor. In the beginning of the century just past, but three per cent of the people of America lived in cities; the remainder lived on the farms and in small towns, and were dependent upon agriculture for food; there was little manufacturing—the people were dependent upon the mother-country for almost everything except the products of the soil. It, therefore, will seem a surprising statement when it is said that the people in the United States as late as 1845 did not raise enough wheat for their bread. In that year only $4\frac{1}{2}$ bushels per person were raised in the United States, while in the year 1800, $5\frac{1}{2}$ bushels per person were raised. We had during the first half of the century no factories such as employ thousands of hands to-day, and our cities were mere villages; therefore, it is no wonder that, with a population in the United States that had quadrupled since 1800, economists were alarmed at the failure of the food supply to keep pace with our rapid increase in population. It is not too much to say that the limit of food production with the sickle had been reached.

Increase in Production of Food—About the middle of the last century there appears to have been a remarkable change in the food-producing power of the American people. From a low rank among nations, we have advanced to the highest position, with a producing power in agriculture and manufacture that almost equals that of all Europe. The source of this remarkable augmentation in our economic power is the result of invention—invention of agricultural machines. Our food supply increased decade by decade from 4.33 bushels of wheat per person in 1849,

Implements and Farm Machines in 1900
Each Dot Represents \$30,000 Worth of Farm Machines.



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to 5.50 bushels in 1859, to 7.45 bushels in 1869, and to 10 bushels per person in 1891. In 1900 the per capita production of wheat decreased to seven bushels, but increased to nine bushels in 1909.

Surprising as these statements are, they tell only half the story. From the 97 per cent of people on the farm in 1800, the number decreased to 80 per cent in 1859, and in 1900 to 33 per cent; the farms to-day, therefore, with less than one-third of the labor of the country, are producing sufficient not only to feed the people upon them, but also the 67 per cent that live in the cities, and export a considerable tonnage of food supplies. This showing is most marvelous, and has been made possible only by the genius of the American inventor, and the intelligence and energy of the American farmer. In all the history of the world this achievement stands out beyond comparison. Much, of course, has been due to the fertile soil of the great plains and valleys in which we live; much to the beneficent government that has given security to property and by its patent system has encouraged invention; much to the great railroads which have transported our products across the continent; but more is due to that body of inventors who recognized the necessity of improved methods on the farm, and who have provided that intelligent, progressive, and energetic body—the farmers of America—with machines which have enabled them to produce food-stuffs more cheaply than in any other land under the sun, thereby enabling them to sell their products in the markets of the world in competition with the penny-a-day laborers of India and China.

Advancement in Agricultural Methods—Wonderful as has been the progress made in other fields of effort during the last half century, the greatest forward strides have been made in agriculture—and this unprecedented development is due almost wholly to the numerous ingenious improvements made in agricultural implements and machines since the middle of the nineteenth century. We all know how important a part modern farm machines played in the industrial progress of the United States, but many are prone to accept it in too much of a matter-of-fact way—prone to forget the many years of unremitting toil required to build the foundation upon which we now rest so securely.

Industrial Emancipation—The nineteenth century was as conspicuous for its industrial as for its political emancipation. Its history cannot be adequately written without taking note of its industrial progress, the abolishment of many of the more burdensome forms of toil, and the multiplication of the effectiveness of labor by supplying mechanical servants to replace human bondsmen.

The struggle for deliverance from the tyranny of despotic

government, and the struggle for deliverance from the tyranny of despotic nature, are manifestations of the same craving after independence and individual sovereignty. There is a close kinship between the spirit which combats the arbitrary authority of man over man, and the spirit which seeks to establish the mastery of man over material agents. Free institutions do not quench man's intuitive ambition for power; they rather tend to substitute a different object for that ambition — power to serve the race instead of power to oppress it — power to invent mechanical agents instead of power to enthrall human agents — conquest over nature rather than conquest over mankind.

When it began to be recognized that the authority which kings had for centuries exercised under the solemn awe of "divine right" rested rather upon the ignorance and subservience of their subjects, it was natural to inquire whether the fetters which nature seemed to have placed on primitive man might not yield to his intelligence, whether he might not dominate each and make its force responsive to his commands through the instruments which his will should summon into action and direct to his service. The complete realization of man's independence required that inanimate substitutes should supplant the liberated slave or serf in the irksome and menial tasks. So long as food and raiment and whatever contributes to sustenance, cultivation, and development, are procurable only through the unaided toil of the individual, each is limited to the most meager necessities of life. Facilities for education and refinement, and the leisure which they require, were in centuries past possible only through the forced servitude of the many to the few. The inventor of machines prepared the way for political emancipation and deserves to share the honor which is freely accorded political liberators. He has multiplied artificial servants until the average citizen to-day enjoys the service of a corps of mechanical slaves more efficient, more capable, and more subservient to the will of the master, than the gangs of human chattels which served the planters of the South fifty years ago, or the retinue of vassals that ministered to the barons of medieval Europe.

We little realize the extent to which we are served by mechanical servants, the extent to which they relieve man from the more burdensome forms of physical toil, and promote him to a sphere where his mental faculties rather than his physical strength measure his earning capacity. If we were to banish the labor-saving machines which invention has provided, we would abandon civilization and reduce ourselves to a condition far more intolerable than that of the primitive savage, for we should have his limitations imposed upon the craving and aspiration to which he was a stranger. An invention, such as the reaping machine, which blazed the trail to higher achievement,

is more important than many of the dynasties which have been conspicuous in history. Some inventors whose names the world seldom mentions have left a more potent and enduring impress upon subsequent history than the famous heroes of battle or statecraft.

The Ever-Present Problem—The opinion that the wonderful wealth and commerce of the United States have sprung entirely from our natural resources has found a too common acceptance among our people. As we think of the increasing population and the higher cost of living, we realize that the ever-present problem of mankind has been to obtain food. The massacre of tribes and the marching of armies have had the obtaining of food as their inspiration. There has been no great progress in the world where food was not plenty. The importance, therefore, of the food producer in the world is manifest, and the honor due to those who have done most to assist in securing a bounteous food supply is too often forgotten.

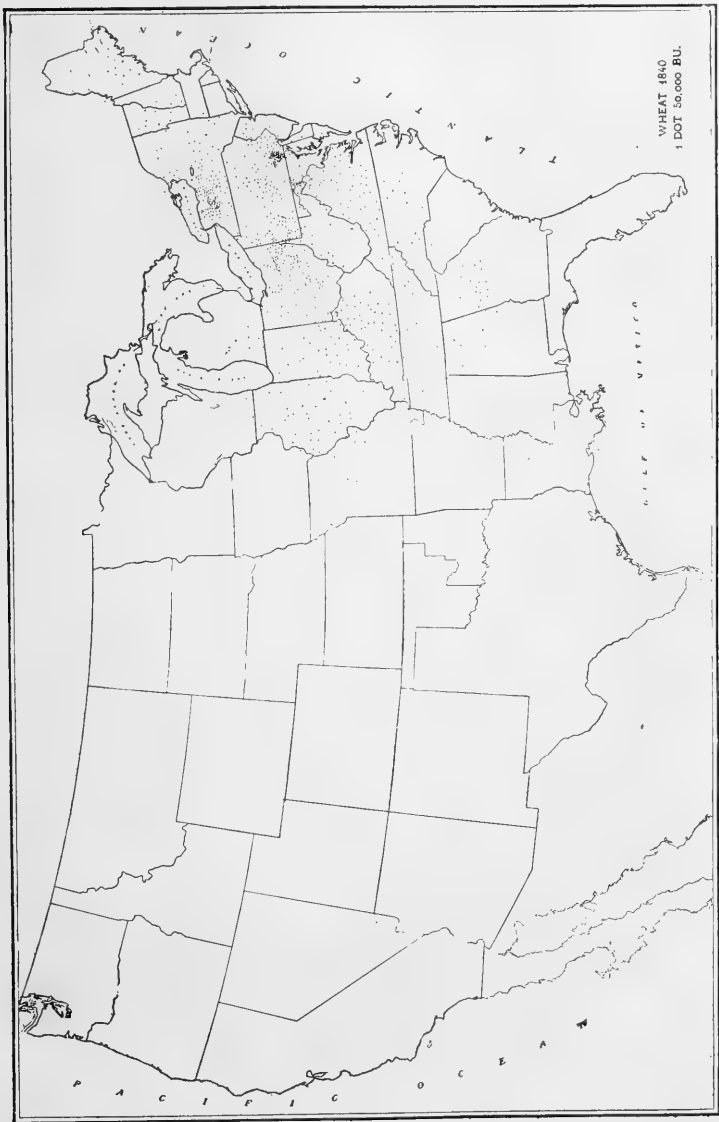
Wheat Production in the United States, 1866—1909

The following figures show the production of wheat in the United States by years beginning with 1866 and ending with 1909, as compiled by the Bureau of Statistics of the United States Department of Agriculture:

YEAR	BUSHEL	YEAR	BUSHEL	YEAR	BUSHEL
1866	151,999,906	1881	388,280,090	1896	427,684,340
1867	212,441,400	1882	504,185,470	1897	530,149,168
1868	224,036,600	1883	421,086,160	1898	675,148,705
1869	260,146,900	1884	512,765,000	1899	547,303,846
1870	235,884,700	1885	357,112,000	1900	522,229,505
1871	230,722,400	1886	457,218,000	1901	748,460,218
1872	249,997,100	1887	456,329,000	1902	670,065,008
1873	281,254,700	1888	415,865,000	1903	637,821,835
1874	308,102,700	1889	490,560,000	1904	552,399,517
1875	292,136,000	1890	399,262,000	1905	692,979,489
1876	289,356,500	1891	611,780,000	1906	745,260,970
1877	364,194,146	1892	515,949,000	1907	634,087,000
1878	420,122,400	1893	396,131,725	1908	664,602,000
1879	448,756,630	1894	460,267,416	1909	735,000,000
1880	498,549,868	1895	467,102,947	1910	691,769,000

Wheat Production in 1840

Each Dot Represents 50,000 Bushels. Of the total crop of 84,000,823, the four states Ohio, Pennsylvania, New York, and Virginia grew more than one-half



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Wheat Production in 1850

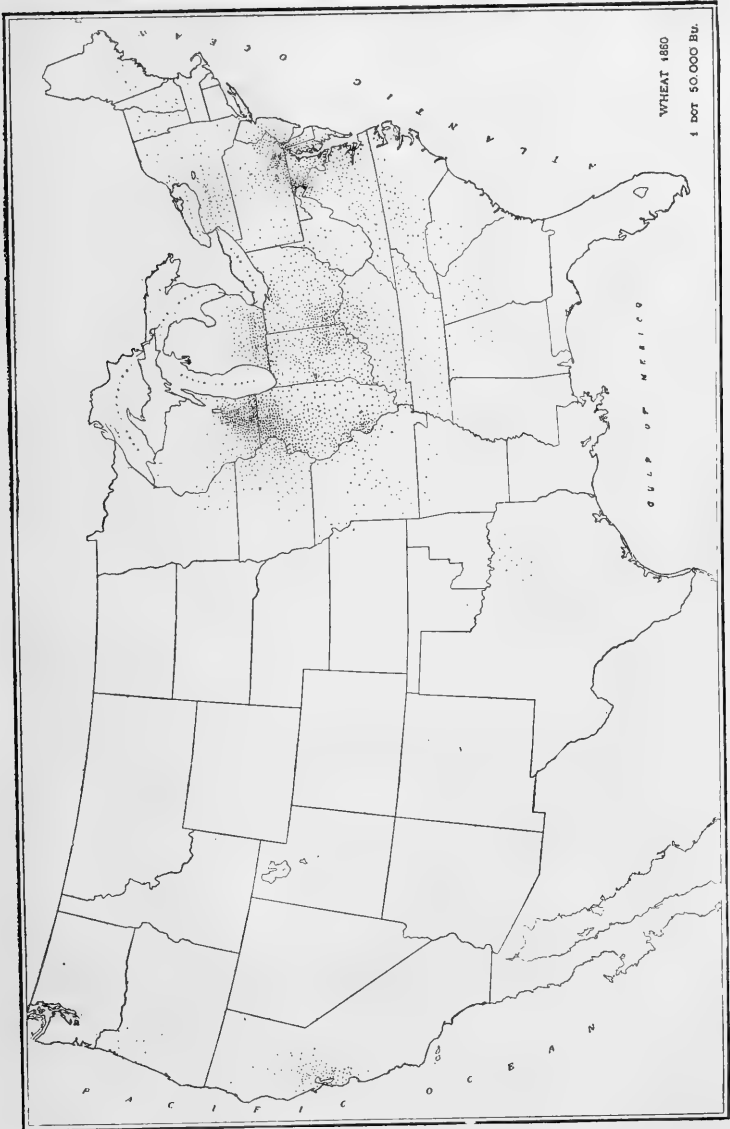
Note that the Wheat Belt is moving westward into Michigan, Illinois, and Wisconsin



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Wheat Production in 1860

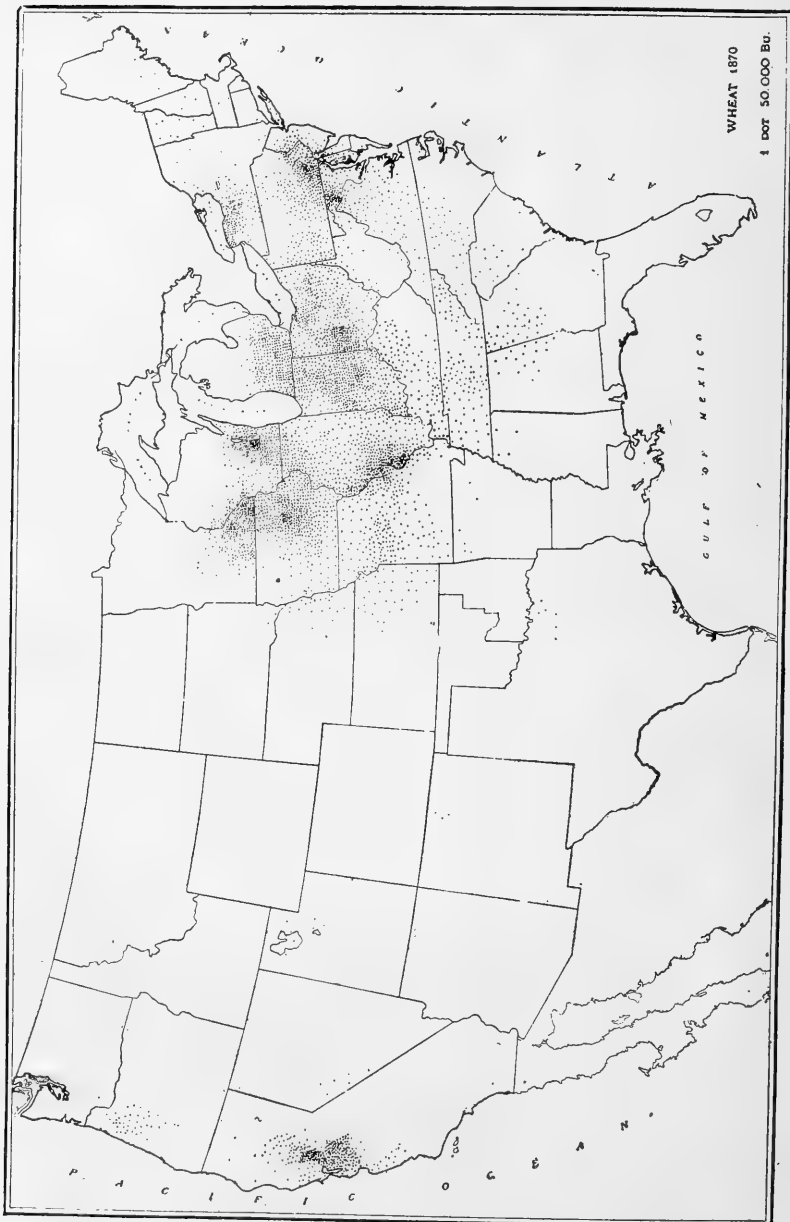
The Central States, Illinois, Indiana, and Wisconsin, were leading in Wheat Production. The total crop of the country was 173,105,000 bushels, or more than twice as much as that of 1840



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Wheat Production in 1870

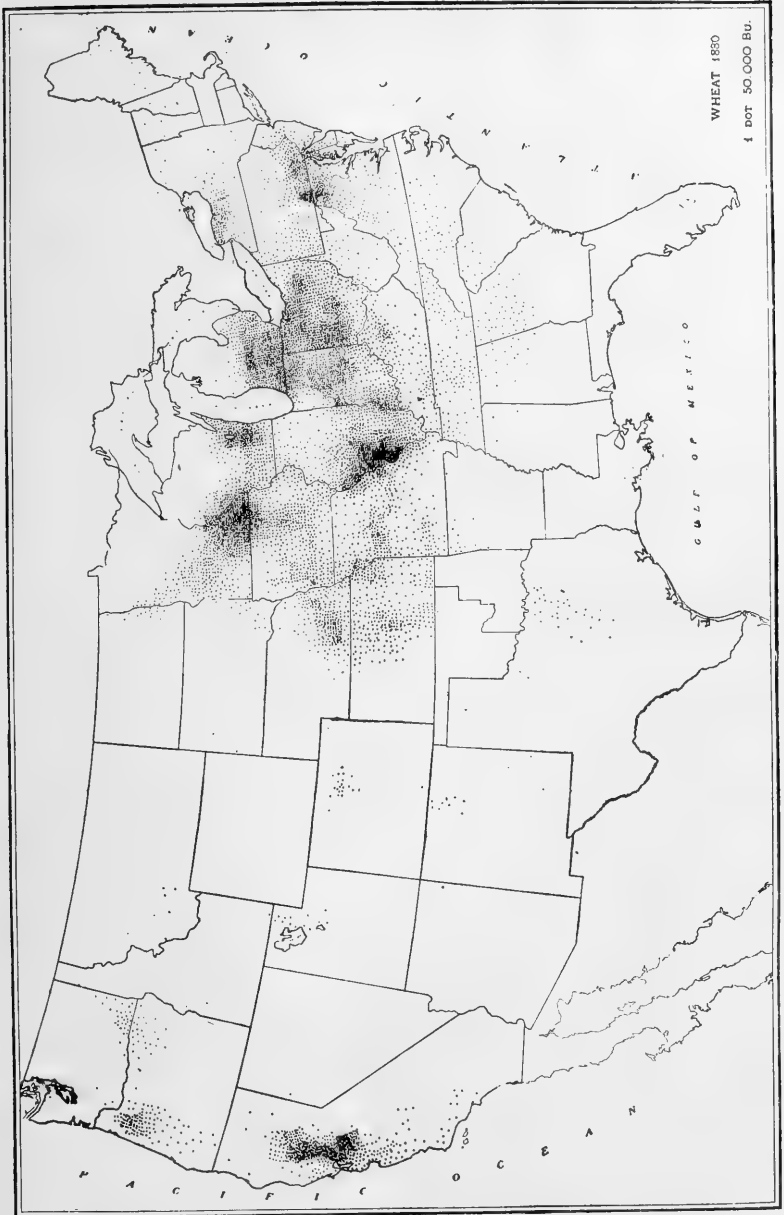
Whereas the Eastern States are growing about the same amount that they grew in 1840, the Central and the Western States have largely increased their wheat crops. The average yield per acre in 1870 was 13.6 bushels.



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Wheat Production in 1880

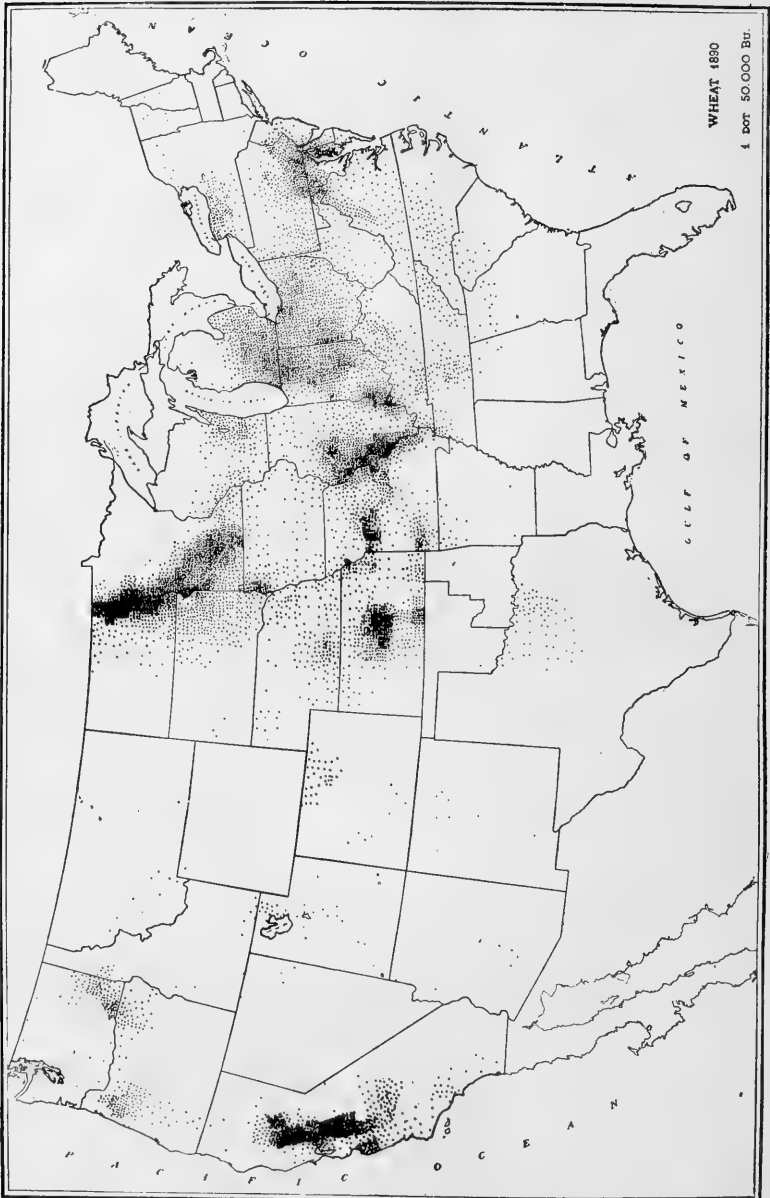
Wheat Growing is moving westward into Kansas and Nebraska



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Wheat Production in 1890

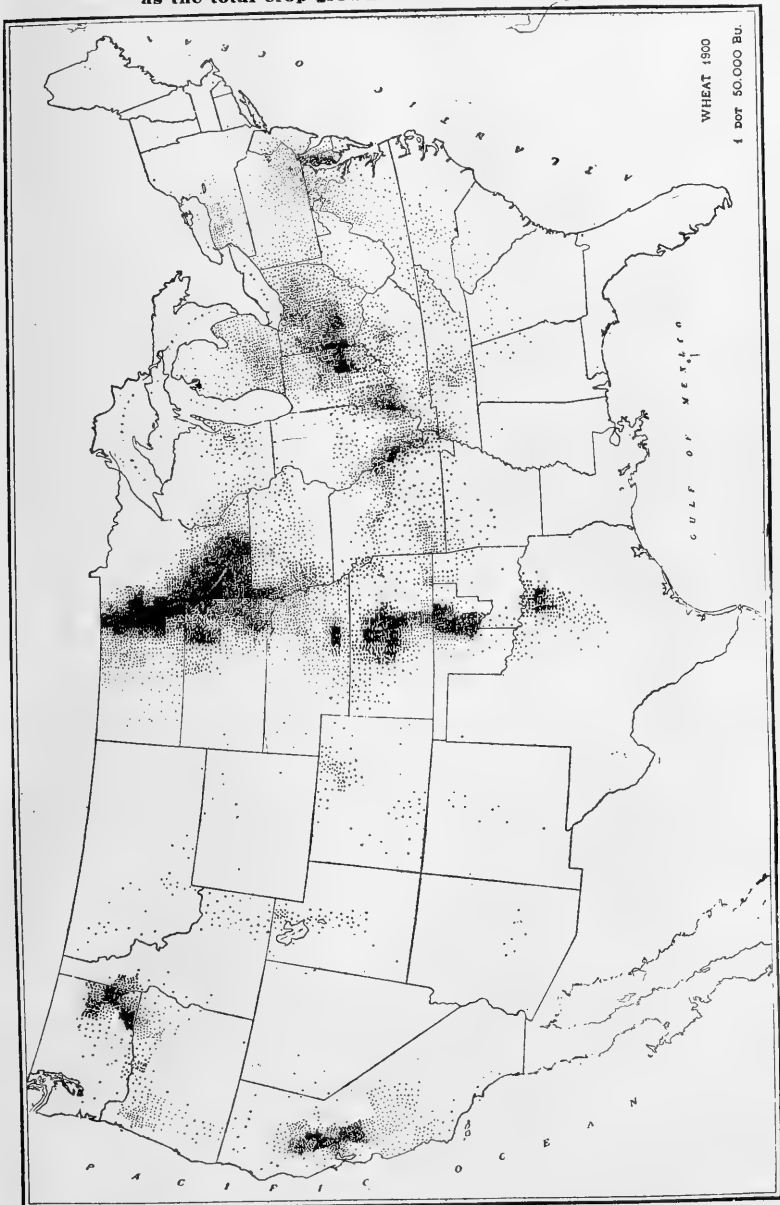
Minnesota and the Dakotas are now the leading Wheat States;
California also is growing large crops



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Wheat Production in 1900

Minnesota and North Dakota have become the leading Wheat Growing States. These two states alone produced nearly twice as much as the total crop grown in this country in 1840

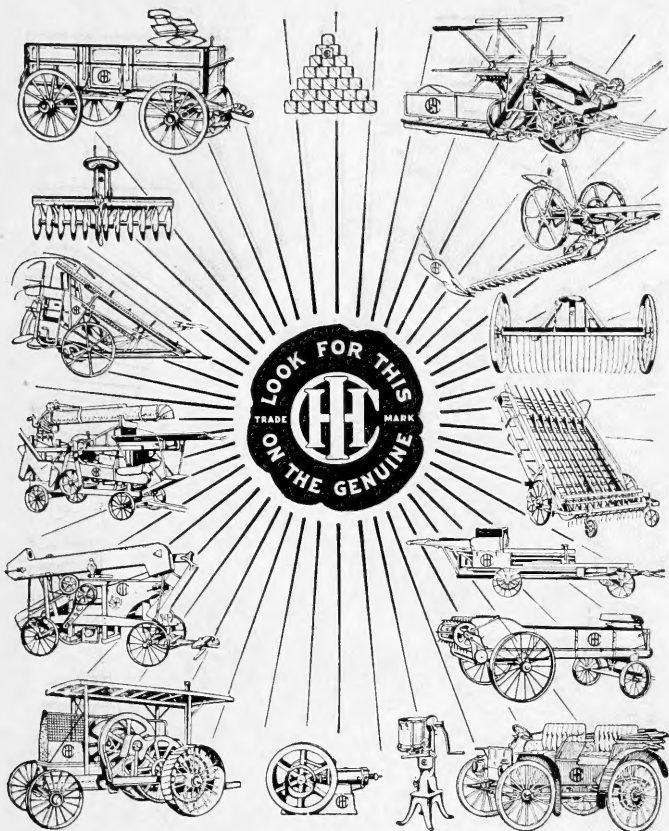


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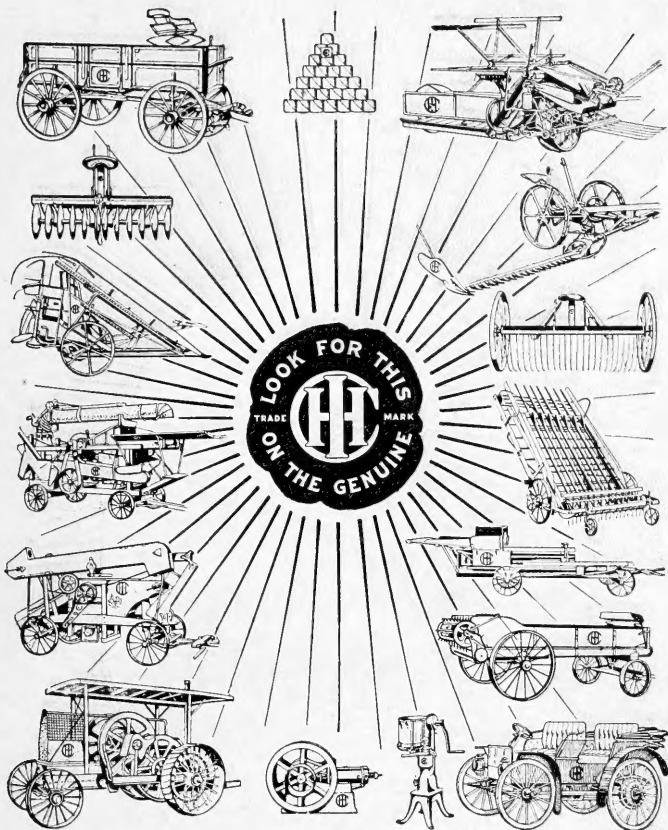
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 SPREADERS,
 ETTENDORF
 BUCKEYE
 RUCKS,
 TWINE

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