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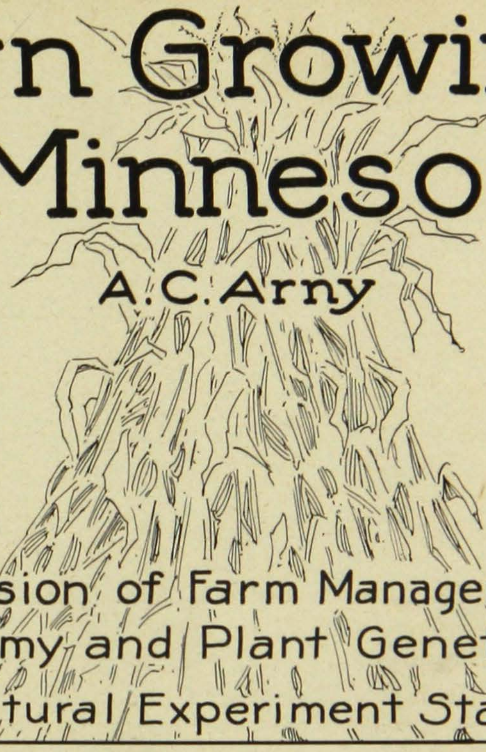
Corn Growing in Minnesota



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FOR the ten-year period, 1911 to 1920 inclusive, the corn acreage in Minnesota averaged in round numbers three and one half millions as compared with an average of one and one half millions for the ten years previous, as shown in Table I.

Table 1. Acreage, Yield per Acre, Price per Bushel and Gross Value per Acre of the Corn Crop in Minnesota, 1901-25

Years	Acreage	Bu. per acre	December farm price per bu.	Gross value per acre at Dec. 1 farm price
1901-10	1,548,224	29.3	$0.43	$12.47
1911-20	3,683,200	34.7	0.73	25.57
1921-25	4,165,000	34.6	0.58	19.25

In addition to the large increase in acreage, there was also an average increase of 5.4 bushels per acre during this period. As an average for the five-year period, 1921-25, there was a still further gain in acreage of nearly half a million but no increase in the yield per acre. Minnesota ranks eighth among the corn states in acreage of this crop. Approximately one-fourth of the cultivated acres in the state produce corn. The acreage of oats exceeds that of corn by a small margin. Wheat is produced on approximately one-eighth and flax and barley on approximately one-sixteenth of the crop acreage. These five crops occupy annually approximately three-fourths of the cultivated acres.

The average yield per acre of 34.5 bushels for the period 1921-26 inclusive, places Minnesota sixth in rank in yield per acre among the corn states. This yield is 4.9 bushels less than the average for Iowa and 1.5 bushels less than the average in Illinois for the period. Many growers in this and other corn states, however, are producing from 50 to 75 bushels per acre—nearly twice the average for the state.

ESSENTIALS FOR HIGHER YIELDS

On the average Minnesota farm the yield of corn can be increased from 30 bushels per acre or less to 50 bushels or more at a very small additional cost. It is largely a matter of looking ahead to get the soil in the best condition; to get the right seed; and to see that all the work in connection with the crop is done well, and at the proper time.

With favorable weather conditions, essentials for yields of between 50 and 100 bushels of corn per acre are: (1) an adapted strain of a high-yielding variety; (2) good seed; (3) highly productive soil; (4) a well-prepared seedbed; (5) a good stand; (6) proper cultivation. Unsatisfactory yields of corn are largely due to the neglect of one or more of these essentials.

The frost-free growing season for corn in four years out of five varies from 110 to 120 days in southeastern Minnesota to less than 90 days in the northern one-fifth of the state.

The mean temperature from May to September, inclusive, is from 4 to 6 degrees higher for places of about the same altitude in southern Minnesota as compared with the northern parts of the state, about 400 miles away. The higher the average temperature during these months, if rainfall is ample, the greater the yield and the better the maturity of the corn crop. In Table II the average temperatures are given for May to September inclusive, for one exceptional, one good, and two poor corn years, together with average yields per acre. Comparing the temperatures for the different months of the good corn year with the long-time averages for the same months, shows that they are similar. For the exceptionally good corn year the average temperatures are higher and for the poor year lower than the average.

Table 2. Relation of Temperature to Yield of Corn

Year	Average temperatures					Yield per acre
	May	June	July	Aug.	Sept.	
	deg.	deg.	deg.	deg.	deg.	bu.
An exceptional corn year, 1921	59.8	73.5	76.7	70.0	65.0	40.7
A good corn year	61.8	63.7	71.8	69.6	57.0	35.1
Poor corn years 1924	49.8	63.6	69.0	67.0	56.7	28.3
Poor corn years 1927	53.5	63.8	68.3	65.8	62.4	30.5
1871-1925	57.6	67.2	71.9	69.5	60.7	...

The frost-free season and the mean temperature are influenced by the altitude of a location as well as the latitude. The high lands along the southwestern border of the state have less favorable conditions for corn than adjoining lands 200 to 300 feet lower. This is true also for the elevated portion centering about Itasca State Park and for the range country in the northeastern part of the state.

Rainfall also has a modifying influence on corn yield. The annual precipitation varies from 30 to 26 inches for the eastern part of the state to from 24 to 22 inches for the western part. A relatively small area in the extreme northwestern part has 20 inches or less. Where temperatures and soils are favorable for corn, because of the higher rainfall of the eastern and southern portions of the state yields are higher per acre than in the central and western parts.

An Adapted Strain of a High-Yielding Variety

Corn is cross-pollinated and hence, where careful selection for one or more stages of maturity has not been practiced for several years, there is a considerable range in time of ripening. Taking advantage of this diversity by selecting seed for several years, distinct strains of a variety may be obtained. This method has been followed in developing strains of varieties adapted to different parts of the state. By carefully selecting ears from the earliest maturing strong plants from

University Farm Minnesota No. 13, the Haney and Moccasin strains have been developed for use in northern Minnesota. They are from ten days to two weeks earlier than the variety from which they were selected. The Minn. No. 13 strain developed at the Morris branch station is 7 to 10 days earlier and the Hanson strain 5 to 6 days later than the Minn. No. 13 grown at University Farm.

Each of these strains of Minn. No. 13, showing as wide differences in days required to mature as entirely distinct varieties, has been developed by selection from Minn. No. 13 grown at University Farm. The Crookston strain of Northwestern Dent is distinctly earlier than other strains of this variety grown in the central part of the state. Strains of Rustler are being grown which show as wide variations in number of days required to mature as the strains of Minn. No. 13. Therefore particular attention must be paid to securing an adapted high yielding strain of the variety desired in order to get the best yields of mature corn. As years favorable and unfavorable to corn can not be known in advance, the use of a variety or strain that is a few days early for the location rather than somewhat late is the conservative and most satisfactory practice.

RECOMMENDED VARIETIES AND STRAINS

The varieties and strains recommended for various sections of the state are listed in Table III, together with some of the characteristics of each. The strains of each variety can not be identified by the appearance of the ears or the kernels. The only way to be sure of obtaining seed of the strain desired is to purchase it from a reliable source.

While the divisions of the state given below are based mainly on a conservative estimate of the frost-free season, the temperatures during the growing months for corn, and the altitude, some use has been made of arbitrary county lines. Farms located north of these lines may be more favorably situated for corn production than some south of the lines.

The southern section includes Dakota County in the east, Scott, Sibley, the southern half of Renville, and Yellow Medicine on the west. The northern portion of Rock County and the other counties bordering on the state line with adjoining parts of Murray and Lyon Counties require somewhat earlier maturing varieties than the rest of the section, owing to the higher altitude. The Morris strain of Minn. No. 13, the Payne strain of Rustler, and other varieties or strains that mature in approximately 110 days can be used to advantage here.

Table 3. Recommended Varieties for Minnesota

Section and variety	Strain	Approximate days planting to maturity	Approximate size of ears		Number of rows of kernels	Color		Character of dent
			Length	Circumference		Grain	Cob	
			inches	inches				
Southern Section								
Silver King		120-125	8-9	6.5-7	16-18	Creamy white	White	Wrinkled
Murdock		120-125	8 9	6.5-7	16-18	Yellow	Red	"
Rustler	University Farm	115-120	8-9	6 -6.5	14-16	White	White	Dimpled
Minn. No. 13	"	115-120	8-9	6 -6.5	14-16	Yellow	Red	"
Central Section								
Rustler	"	115-120	8	6 -6.5	14-16	White	White	Dimpled
Minn. No. 13	"	115-120	8	6 -6.5	14-16	Yellow	Red	"
Minn. No. 13	Morris	110-115	7-8	6 -6.5	14-16	"	"	"
Rustler	Payne	110-115	7-8	6 -6.5	14-16	White	White	"
Northern Section								
Northwestern Dent	Crookston	100-105	6-7	5 -6	12-14	Red with Yellow cap	White	Dimpled
Minn. No. 13	Haney or Moccasin	105-110	6-7	5.5-6.5	12-14	Yellow	Red	"
Minn. No. 23		100-105	6-7	5 -5.5	8-10	Yellow with Yellow cap	Pink	"
Dakota White		95-100	5-7	4 -5	8	White	White	None
Pearl		95-100	5-7	4.5-5.5	10-12	"	"	"
Gehu		95-100	5-7	4.5-5.5	10-12	Yellow	"	"

The central section includes all counties north of the southern section including Wilkin and Ottertail Counties, the southern portions of Wadena, Cass, and Crow Wing, and eastward to the state line. University Farm Minn. No. 13 and Rustler are adapted in the eastern and southern parts of this section. The Morris strain of Minn. No. 13 and Payne Rustler are recommended for the western, northern, and northeastern parts of this section; and on the less productive lands, the Haney and Moccasin strains of Minn. No. 13 can be used to advantage. The Williams strain of Minn. No. 13, developed in Becker County, is similar to the Morris strain.

Conditions favorable for corn production vary more in the northern section than in the other two. The northern part of it, approximately one-sixth of the total area of the state, including the range country on the east and extending northwestward through the Red Lake country to the state line, is better adapted to the growing of small grains, hay, and root crops than corn. Only the very earliest varieties and strains have any chance of producing ear corn. South and east of the range country bordering Lake Superior, the altitude and conservative frost-free season are favorable for corn but the mean temperatures for the growing season are so low because of the modifying influence of the large body of water, that only the earliest varieties need be tried for the production of mature corn. A fair quality of silage can be produced, however, by using early strains of Minn. No. 13 and Northwestern Dent.

Varieties for Silage

In the southern and central parts of the state the same variety can be used for both silage and grain production. Nothing is gained by using so-called "silage varieties," which are tall-growing southern corn. They produce a large tonnage of material high in water content. The ears are poorly developed or lacking and hence the silage is low in nutrients. In the northern part of the state, varieties grown for grain in the central section may be used to provide a somewhat larger tonnage per acre, with ears well developed but not mature.

Varieties for Hogging-Off

In the central and southern sections of the state a considerable acreage of early maturing corn is needed for hogging-off before that in the main fields is mature enough to use. The Crookston strain of Northwestern Dent, Dakota White, and Gehu flint mature approximately two weeks earlier than University Farm Minn. No. 13. Some growers hesitate to use these early varieties for hogging-off, thinking that they will cross-pollinate with the variety grown for the main crop. If one of these early strains or varieties is planted at the same time as the main crop, the pollen from the early corn will be shed largely before the silks of the main crop appear. Therefore the amount of cross-pollination should be very slight.

New Varieties

Some first-generation crosses between distinct varieties of corn have given higher yields than either of the parent varieties, but many others have not. This method of attempting to increase yields has given way largely to a more promising one. The new method has as its basis the self-fertilizing of a large number of plants of desirable varieties or strains, selecting the most vigorous and disease-free lines the following year, and continuing them by self-fertilization. In this way the undesirable characters in a variety or strain are eliminated and the desirable ones retained. The self-pollinated lines are less vigorous and produce comparatively low yields of grain and the kernels are often relatively small. However, when lines that combine well are crossed, greater vigor and higher yields of seed than of the original variety result. Lines coming from one or more than one variety may be combined.

Three methods of combining the lines are being followed:

1. Single crosses made by crossing two selfed lines. The result is the commercial crop. In following this plan it is necessary to make the cross each year. One of the disadvantages of this method is that the self-fertilized lines produce relatively small yields of seed and, in many cases, small kernels.

2. Double crosses are first-generation crosses of two single crosses. They involve three crosses to obtain commercial seed. The seed from each of two single crosses is planted in alternate rows the following year and all the plants from one are detasseled before any of the silk appears. The ears from these detasseled plants provide the seed for the commercial crop. This method provides relatively large amounts of seed, but three crosses are needed to obtain it.

3. Crossing several self-fertilized lines to produce seed for the commercial crop and selecting seed from vigorous plants in subsequent years, is a method of obtaining a new variety and seed can be saved in the ordinary way.

Increased yields of from 20 to 30 per cent have been obtained by following one or more of these methods.

Isolating desirable lines and finding the best combinations of them require considerable skill. Hence this work is being done by experiment station workers and by properly trained men connected with seed firms. After desirable selfed lines are obtained, first-generation crossed seed may be produced by farmers. No hybrid varieties are available for distribution in Minnesota.

Purchase Seed of Acclimated Strains

Seed of the strain desired, produced in approximately the latitude where it is to be grown, is preferable to that grown farther south or north. Corn cross-pollinates to so great an extent that a strain distinct for maturity soon loses its identity and hence its value when grown closer than 40 rods to another strain with which crossing can occur. Woods or hills intervening reduce the distance necessary between fields to prevent cross-pollination.

Seed Supply in Northern Minnesota Often Short

There are more years in the northern section when corn does not mature than in the central and southern sections. When several unfavorable seasons occur in succession, the available supply becomes practically exhausted.

If care is taken to locate fields so that cross-pollination is largely prevented, the early varieties and strains so necessary for successful corn culture in the northern part of the state may be grown farther south for a year or two without decided loss in earliness. If this method is followed, it is necessary that the original seed come from the northern section of the state and in following years northern grown seed of the variety or strain must be used at least every other year. One grower might carry out such a program, but the work can be done to better advantage by an association of growers or by seedhouses that have the organization and equipment to carry it through successfully.

SELECTING SEED CORN

Time to Select Seed

Seed corn is best selected in the field when the ears are ripe but the plants still green. The husks on many of the varieties turn yellow as the ears mature but on others they remain green.

A light frost of only a few hours' duration, which kills the leaves, does not necessarily penetrate the husks and hence does not injure the kernels. Such a frost, however, should be a strong reminder that it is necessary to get the seed ears into a building and dried out before continued cold weather sets in.

Good Seed May Be Obtained from Immature Ears

Work done over a three-year period at University Farm, together with work done at other experiment stations, shows that ears in the roasting stage gathered from the field before severe frosts and properly dried may yield seed corn of good germination. Ears in the roasting stage have fairly well developed kernels filled with thin milk. Therefore, in unfavorable corn years, as soon as the ears have reached the roasting stage and the weather threatens killing frosts or continued cold weather, the number of ears needed to supply seed for planting the next spring should be taken in and dried properly. The kernels shrink badly and do not look as good as those from more mature ears, but they can be used in an emergency. When the ground is wetter and colder than usual at planting time, this immature seed is less likely to grow than mature seed.

The Plant the Basis of Selection

In order to obtain a vigorous variety, it is desirable each year to select seed ears from normal vigorous plants in full-stand hills. This may be done most effectively by selecting in the field plants that appear free from disease and have well matured ears while the plant remains green. Such plants have matured normally. This should result in more even maturity of the plants throughout the field in subsequent years. Diseased plants mature earlier or considerably later than normal healthy plants as a rule, and frequently break over. Shanks on apparently strong plants may be so diseased that the ears hang straight down instead of being held in proper position. When the selection is made at the proper time from standing plants, these diseased plants can usually be recognized and avoided.

Inherently weak plants growing in full-stand hills yield much less than stronger ones, and their undesirability as a source of seed is easily recognized. However, if weak plants grow alone or in hills with less than three or four plants they may appear strong and develop reasonably good ears. Therefore, when selection is made in the field on the basis of the plants, hills with a stand less than normal should always be avoided entirely. On the other hand, when seed ears are selected from the husked corn, there is no way of knowing what kind of plants produced them or what the stand was in the hills. Therefore effective selection of seed ears from husked corn is impossible. This is true of ears that win at shows as well as for the less symmetrical ones left at home.

Kind of Ears to Select

Ears somewhat long and small in circumference and heavy for their size mature earlier and yield better than short, thick ones. Ears with 12 to 16 rows of kernels are preferable to those having from 16 to 20 rows. Large ears are not necessary in order to secure good yields of corn. An average of 3 eight-ounce or 4 six-ounce ears per hill checked 3 feet 6 inches, will amount to 75 bushels per acre.

Amount of Seed to Select

Fifty-six pounds of shelled and graded corn will plant 7 or 8 acres when checked 3 feet 6 inches to 3 feet 8 inches apart with 4 or 5 kernels per hill, or drilled at about that rate; 140 to 150 ears of standard Minn.

No. 13 usually make a bushel of shelled corn. To make allowance for the discarding of some of the undesirable ears and the tip and butt kernels, approximately 200 ears should be brought in and dried for each 7 or 8 acres to be planted next spring. For varieties and strains with smaller ears than Minn. No. 13, more ears will be needed.

Drying Seed Corn

Proper drying of seed corn is essential at all times, but particularly when the ears are immature. Seed ears in the roasting stage average 75 to 80 per cent water as compared with 70 to 75 per cent for ears in the dough, 60 per cent for ears beginning to dent, and 50 per cent for ears with all the kernels dented but without the luster of well ripened ears. When the ears have reached maturity but the plants are still green, the corn usually contains from 40 to 50 per cent water. The larger the percentage of water in the seed ears, the greater the precautions necessary for satisfactory drying.

Drying is much more rapid if artificial heat is supplied than at open-air temperatures. At a room temperature of from 68 to 70 degrees F. with a good circulation of air, corn can be dried to 12 per cent water or less in 4 or 5 weeks. Corn dried to that percentage of water is not injured by continued cold weather unless it takes up moisture again, which it is liable to do if stored in a damp place.

An attic room above the kitchen with an opening over the stove leading into it or connected by a door that can be kept open, is a satisfactory place to dry seed corn provided there are windows or doors so that air movement continues. The heat from a kitchen stove during the fall will be sufficient to dry corn. Putting the ears on some sort of hangers that prevent them from touching each other and suspending these from the rafters allows the air to circulate around them.

Hanging seed corn from the rafters in a well ventilated attic is usually satisfactory even tho it is not possible to supply artificial heat. The attic gets hot during sunny days and if the windows are closed on cold nights the corn will usually be dried out before continued cold weather sets in.

Approximately three-quarters of a million bushels of seed is needed each year to plant the four and a half million acres of corn in the state. Seedhouses and men who make a practice of putting up more seed corn than they need for their own use can supply less than one-fourth of the total amount needed.

The following locations are unsatisfactory for drying seed corn: (1) On plants standing in the field. Shocked corn dries out more rapidly than standing corn. (2) Hung up out of doors exposed to the rapid changes of temperature that occur during the fall as well as to rains. (3) Hung in an unheated though well ventilated building, protected from frost but with no provision for rapid drying.

Final Selection of Seed Ears

Where corn has reached full maturity, and the seed supply is ample, the final selection should retain only the bright looking ears heavy for their size and free from discolorations on the cob.

Germination Test

Selecting seed ears from strong plants and caring for them in the manner outlined should result in corn of relatively high and strong germinating power and reasonably free from disease. However, to make certain that the germinating power is satisfactory, a preliminary test of two or three kernels from a considerable number of ears located in different parts of the storage quarters is always advisable before shelling. If the preliminary test indicates that the germinating power is doubtful, an individual ear test is necessary.

The important conditions for germination are (1) a favorable temperature, (2) the right amount of moisture, and (3) air. A temperature of 70 degrees F. is favorable. Temperatures up to 80 or 85 degrees hasten germination; below 65 degrees germination takes place very slowly. Air is necessary for the germination process. More water than is needed to keep the kernels moist is undesirable, as it keeps the air out.

Modified Rag Doll Germinator

The use of the modified rag doll germinator is a simple and efficient method of testing ears for germinating power and disease infection.

To make a modified rag doll, cut strips of muslin 12 inches wide and 54 inches long and boil thoroly in order to sterilize. Then lay this wet cloth on a strip of very heavy hard-finished paper the same width and 6 inches longer. The heavy glazed paper is to keep the molds that may develop on the kernels from one ear from growing through the cloth and affecting kernels from the other ears when the rag doll is rolled up. When the ears to be tested have been laid in order or numbered, from 8 to 10 kernels are taken from each ear and laid on the wet cloth in straight rows, germ side down and tips pointing toward the operator. A rule is used as a guide in laying the kernels in straight rows. The kernels from 20 ears are placed on the rag doll as shown in Figure 1. Dolls made of strong paper towels instead of cloth have the advantage of being fairly free from molds and they are inexpensive and hence can be discarded when the tests are completed. Two thicknesses of paper towel are laid down after they have been wet. The kernels are placed in the same way as on the cloth doll. One wet paper towel is then placed over the corn and on that one sheet of oiled paper. The doll is then rolled, tied loosely at each end, and labeled at the top. Fresh newspaper folded to about the size of paper towels with four thicknesses beneath and two over the corn may be used with good results. The dolls should be rolled only tight enough to hold the kernels in place.

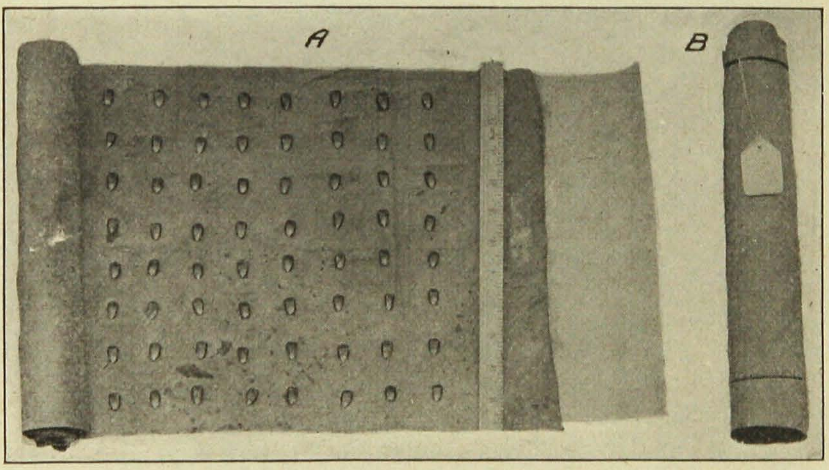

Fig. 1. Improved Rag Doll Germinator

A, Open, showing insulating paper, cloth, and corn kernels in position. B, rolled and labeled. (Note that all the kernels are placed with germs down and tips pointing downward.)

A number of simple methods of caring for the dolls during the week or ten days that it takes for the corn to germinate have been used successfully. A wooden candy pail or a metal pail of that size is deep enough that the dolls may be placed in it in an upright position and covered to retain the moisture. Pieces of wood may be placed on the bottom of the pail so that the lower ends of the dolls will not stand in the water that drains off after they have been moistened. The dolls should be moistened at least every other day by dipping them in warm water. The pail may be placed near the furnace or stove or in any other location where the temperature is favorable. Hanging the pail prevents mice from doing any damage.

Reading the Test

The test may be read when the stems are 2 or 3 inches above the ends of the dolls. To reach this stage the corn requires 7 to 10 days or longer if the temperature goes below 70 degrees F.

Corn selected for seed may be unfit for this purpose owing to injury by frost, improper drying, or faulty storage. Kernels that have been injured either do not germinate or are slow and the seedlings are weak. Vigorous stems with many thick glistening white roots and rootlets indicate strong germination. If stems and roots are weak the ears from which they came should be discarded.

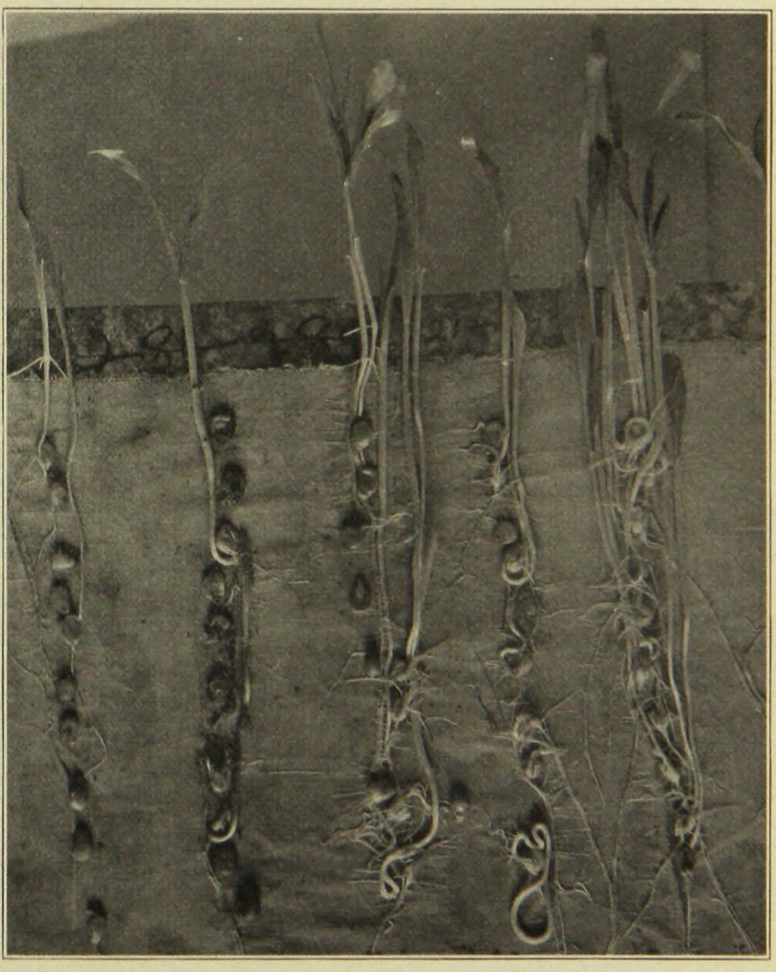

Fig. 2. Examples of Strong and Weak Germination

At the right, strong germination. Ears the kernels from which show strong germination are the only ones that should be saved. In the center, weak germination. Here a few of the kerels germinated strongly but the others weakly or not at all. At the left most of the kernels are dead.

Grading the Seed

In order to drop uniformly from the corn planter, the seed must be carefully graded and the planter set for each size of seed, if more than one size is to be used. The grading of the seed and the regulating of the planter can well be done before spring work begins. If left until planting time they will be done in a hurry or not at all.

Keep a Reserve Supply

High quality seed corn may be stored for two years either on the ear or shelled, in dry, well ventilated, vermin-free quarters, without lowering the percentage or strength of germination. Sacks of shelled corn should not stand over summer on a concrete floor unless the floor is raised well above the general level of the ground. The use of one- or two-year-old seed and the holding over of that gathered and prepared from the current crop is good practice in all parts of the state, but particularly in the northern part where the corn fails to mature oftener than in the two sections farther south.

Highly Productive Soil Best

Corn requires for its best development well drained, deep, mellow soil that holds moisture and contains a generous supply of plant food. Nature has given all these desirable qualities to few fields.

In modifying soils so that they become more suitable for corn production, the importance of organic matter can scarcely be over-emphasized. This may be added in the form of legume or grass plants used as green manure, or the crops may be removed and only the stubble and roots plowed in as crop residues. Organic material may also be in the form of barnyard manure.

Organic Matter Improves Physical Condition of Soil

The beneficial effect of organic material on the physical condition of the soil is very marked. Without a plentiful supply soils become compacted and lack air, rain is not readily absorbed, and the water-holding capacity is somewhat lowered. Tillage implements leave the soil in clods which bake easily. When in this condition, soils can hardly produce well even tho plant nutrients are sufficient. On the other hand, if generously supplied with organic matter, ordinary soils become mellow and well aerated. They absorb water readily, store it in larger amounts than when the supply of organic matter is low, and can be cultivated more easily, earlier in the spring, and sooner after rains.

Organic Matter Helps to Liberate Plant Nutrients

The materials which plants take from the soil in water are usually not soluble in large amounts at any one time, but under proper conditions become available gradually. Ordinary soils, when well supplied with organic material, become the home of large numbers of bacteria and other low forms of living organisms which live on the organic matter and bring about important changes resulting in the liberation of materials which are soluble in water and can be used as nutrients by plants.

Essential Plant Nutrients Need Consideration

Among the materials that plants take from the soil in small amounts dissolved in water, are nitrogen, phosphates, potash, and lime.

Potash usually abundant.—In the mineral soils of Minnesota, potash is usually available in sufficient amounts for the use of corn plants. Therefore until the present supply runs low, no provision need be made for an additional supply. Barnyard manure and other organic matter applied to soils supply potash in small amounts.

Phosphates need consideration.—Soils from which crops and livestock have been sold for a period of years need to be tested to determine the supply of phosphates available for crops, if the manure applied has been from animals to which only small amounts of purchased feeds have been fed. The application of phosphates in commercial forms has given profitable returns in west central Minnesota.[1] Whether the application of phosphate will increase yields of corn and help it to mature earlier can be learned only by actual trial. If, after trial on part of a field, phosphates are found to increase yields enough to pay for the fertilizer and the labor of applying it, giving a margin of profit besides, then its use is warranted.

Lime may aid indirectly.—Corn yields are usually not increased directly by the application of lime. However, lime may have a very beneficial effect on the leguminous crop which precedes corn, and in this way aid materially in an indirect way. The supply of lime in the western half of the state is ample. Whether lime is necessary for leguminous crops on any farm can be ascertained by trial.

Nitrogen must be available.—The supply of nitrogen in the soil is very limited. As it becomes available, it is taken up by plants, washed away by water, or escapes into the air. Consequently, in order to keep the soil productive, the supply of nitrogen must be renewed regularly. Nitrogen in commercial forms is too expensive to use for this purpose, at least for ordinary farm crops. Fortunately, however, there are

[1] McMiller, P. R., Miller, P. E., and Nesom, G. H. "Phosphate demonstrations in Stevens County, 1918." Minn. Agr. Ext. Special Bull. 34, 1919.

ways to maintain the supply of nitrogen in the soil at very small expense and at the same time to benefit the soil in other respects.

Unleached barnyard manure contains nitrogen, phosphates, and potash, and the only expense in its use is the labor of applying it. On most farms, however, the supply of barnyard manure is not large enough to furnish the amount of nitrogen needed for profitable crop production. The deficiency may be made up by growing such leguminous crops as clovers, alfalfa, and soybeans. Leguminous crops use the plant nutrients in the soil as do other crops, but they have a power not possessed by other plants, that of drawing on the unlimited supply of nitrogen in the air. By growing well-inoculated leguminous crops, therefore, feeding the hay to livestock, and returning the manure to the soil, or by plowing under green crops when necessary, the supply of nitrogen in the soil may be not only maintained, but actually increased.

It should be remembered, however, that when leguminous crops are cut for hay and sold there is usually no increase in the nitrogen supply in the soil from which these crops were harvested. Under these circumstances, about as much nitrogen is removed from the soil as is added in the nodules and roots.

A Good Plan of Cropping Aids

Adopting a good plan of cropping suited to the needs of the individual farm aids in maintaining in the soil the necessary supplies of organic material and nitrogen.

The essentials of a good rotation are a leguminous crop to supplement the manure in maintaining or increasing organic matter and nitrogen, and a cultivated crop which provides the opportunity to keep the land free from weeds.

Four rotations are given, any one of which may be modified somewhat to supply needed feeds and cash crops on individual farms.

1. Three-year rotation: Grain, clover, corn
2. Four-year rotation: Grain, clover, corn, corn
3. Four-year rotation: Grain, clover, corn, grain
4. Five-year rotation: Grain, clover and timothy hay, pasture, corn, grain.

These rotations have been in operation at University Farm for a period of years. Manure was applied preceding the corn crop once in each rotation at the rate of 6 tons in the three-year, 8 tons in the four-year, and 10 tons in the five-year rotation. The yields of corn were nearly equal and more than 50 bushels per acre in each rotation.

Well-Prepared Seedbed Helps

Corn usually yields equally well on fall- or early spring-plowed fields. Except on very uneven fields where serious washing is likely to occur, fall plowing is a good practice because: (1) There is usually more time for plowing in the fall, (2) the loosened soil absorbs moisture more readily, (3) weeds and cutworms are more easily controlled, (4) the sods in meadows or pastures and any barnyard manure that may be plowed under have time to decay so that good connection is established between the soil in the furrow slice and that beneath. When sod or manure is plowed under late in spring, the ground prepared in the usual way, and the corn planted soon after, the young plants may not be able to get enough water unless timely rains fall. This is because the roots of the young corn plants can not readily pass through the large air space in the unpacked soil to get down below the furrow slice where the supply of moisture is abundant.

Deep Plowing Desirable

Generally, the heavier the soil the deeper it should be plowed. When the soil is plowed 4 or 5 inches deep and the cultivator run to a depth of 2 or 3 inches, only from 2 to 3 inches of loosened soil is left undisturbed in which the roots of the young plants may spread out easily. Plowing from 6 to 8 inches deep almost doubles this loosened area. The depth of plowing should be increased gradually, so that no large amount of raw soil is brought to the surface in any one year.

Early Spring Disking Important

In the spring, as soon as the small grains are planted, fields plowed for corn in the fall should be thoroly disked. This early disking keeps the moisture in the ground and hastens the warming up of the soil, which in turn causes the weed seeds to germinate and grow. Subsequent harrowings or diskings as needed to keep the weeds from showing green above ground further the cleaning process. Cutworms can not live in fields where all green plants have been destroyed.

Treating fields in this way provides well pulverized clean seedbeds ready for planting as soon as all conditions are favorable. It is much more economical to cultivate corn fields thoroly before the seed is planted than afterward.

Eliminate Gophers

While preparing the soil, all the striped gophers in the vicinity should be poisoned. Dissolve one-eighth ounce of strychnine in a gallon of hot water and allow it to cool. Then add as much corn as the solution will cover. In from eighteen to twenty-four hours the corn will have absorbed enough poison to be effective. If any of the solution is left, more corn may be put in. This corn may be put in gopher holes in the field and along its borders. In pastures it must be put far enough down in the holes to be beyond the reach of domestic animals.

A Good Stand Is Worth While

The work expended in selecting seed and preparing it for planting, and in getting the soil in good condition is partly lost unless the stand is good. Therefore every effort should be made, both before and after planting, to have and maintain as nearly the desired stand as possible. To have an average of four plants per hill, it is necessary to plant five kernels in many of the hills. If the stand is very poor, it is usually advisable to disk the field and replant it rather than attempt to fill in the missing hills.

Early Planting Best

It is highly desirable to plant corn as soon as the soil is warm and the weather favorable in order to give the plants the longest possible growing season. If disking is started early in the spring and continued at frequent intervals, a mellow, warm seedbed, free from weeds, will be ready at any time that the weather is favorable. The usual time for planting in the southern part of the state is from May 1 to 10; in the central part, from May 10 to 20; and in the northern part from May 20 to June 1 or later; but corn should not be planted at the times mentioned unless the seedbed is warm and the weather favorable.

Thickness of Planting

In Minnesota, lack of moisture often limits the yield of corn. Under these circumstances, highly productive soils are able to supply the necessary nutrient materials to a greater number of plants than those low in productivity. Other conditions being about equal, small varieties may be planted somewhat more thickly than tall varieties. For grain production, checking corn 3 feet 6 inches or 3 feet 8 inches with 4 to 5 kernels per hill; or planting in drills with the plants 10 to 12 inches apart is the method usually followed in Minnesota. Checking the corn allows cultivation both ways and gives a better opportunity to keep it free from weeds than drilling.

For silage or for bundle-corn to be fed without husking, an average of a plant every 6 or 8 inches in the row, either checked or drilled, will produce a larger yield and better quality than thinner planting.

No Advantage in Deep Planting

The depth of planting depends on the condition of the seedbed. From one to two inches is a good depth if the soil is moist. If the soil is dry to a depth of three inches, the corn must be planted that deep in order to have the moisture necessary for prompt germination. When the season is late and the soil still somewhat wet and cold, planting not more than an inch or an inch and a half deep is best. With conditions favorable for planting corn from one to two inches deep, nothing will be gained by planting deeper. The corn plants can not be made to root lower in the soil simply by deep planting.

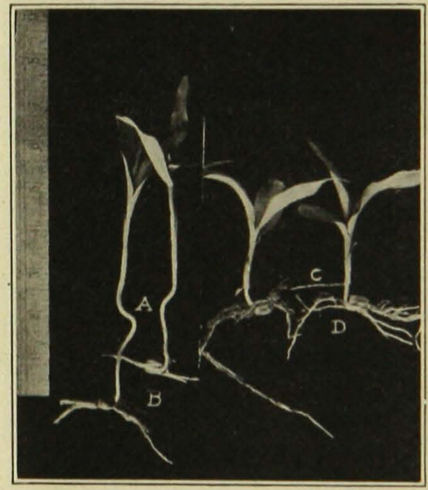

Fig. 4. Young Corn Plants

The kernels of corn producing the two plants on the left were planted 3½ inches deep. Those producing the plants on the right were planted 1½ inches deep. At B are shown the temporary roots which, because of deep planting, are not so well developed as those at D from seeds planted less deeply. At C are shown the permanent roots starting ¾ of an inch below ground. At A are shown the slight enlargements at which places the permanent roots will develop. They will be the same distance below the ground as those on the plants on the right. The plants on the left were longer reaching the surface and are consequently more spindling.

Cultivate for Two Purposes

The purposes of cultivation are (1) to kill weeds and (2) to form a dust mulch to keep the moisture in the ground. This maintains a condition favorable to the rapid growth of the young plants. The amount and kind of cultivation necessary depend on the character and condition of the soil at planting time and during the growing season.

Early Cultivation Kills Weeds

With the seedbed so thoroly prepared that it is firm below, mellow at the surface, and free from weeds, shallow early cultivation is all that is necessary. This kills the weeds as they start and prevents the formation of a crust. Harrowing corn after it is up always reduces the stand somewhat. If there is more than a full stand, the first cultivation may be done in this way at a saving in cost of labor. The harrowing should be done on a bright afternoon when the plants are somewhat wilted and for that reason less easily broken.

If the seedbed has not been thoroly prepared, or if heavy rains have packed a well prepared seedbed after the corn was planted, the first cultivation should remedy this condition as far as possible. Medium deep cultivation, either before the corn is up or as soon as the rows can be seen, is advisable. This should be followed by a deep and close cultivation each way by the time the corn is from 4 to 6 inches high. Preparation of the seedbed is less effective and costs more after the corn is planted than before.

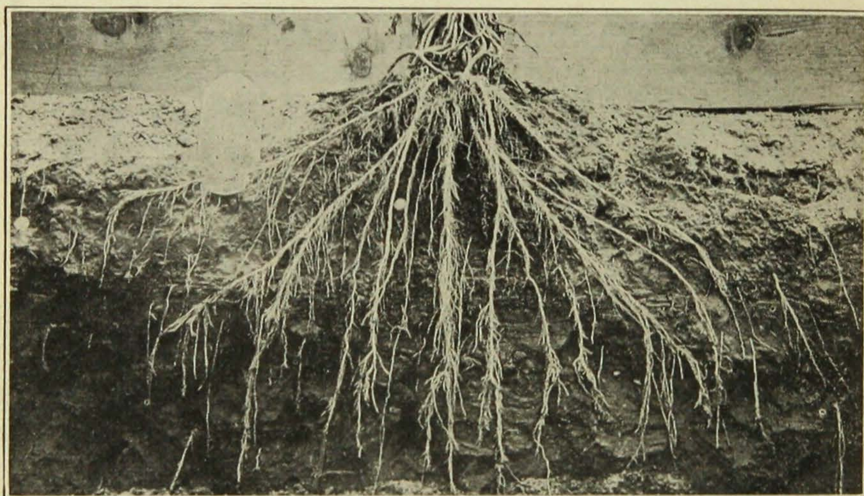

Fig. 5. Roots of Corn Plant (Courtesy of C. P. Hartley, U. S. Dept. of Agr.)
After corn is 6 or 8 inches tall, close and deep cultivation becomes increasingly harmful.

Late Cultivation Should Be Shallow

Late cultivations are mainly for the purpose of killing weeds and retaining moisture. Shallow cultivation will accomplish both.

As the corn develops, its roots spread outward and downward. The roots that spread outward start near the surface and usually grow somewhat deeper toward the middle of the rows, where they cross those of other plants. After the corn is from 6 to 8 inches high, deep or close cultivation becomes increasingly harmful, as the roots growing near the surface are cut by the cultivator and the amount of water supplied to the plants is reduced. When corn plants wilt in the hot sun soon after cultivation, it is a sign that the cultivator is being run too deep.