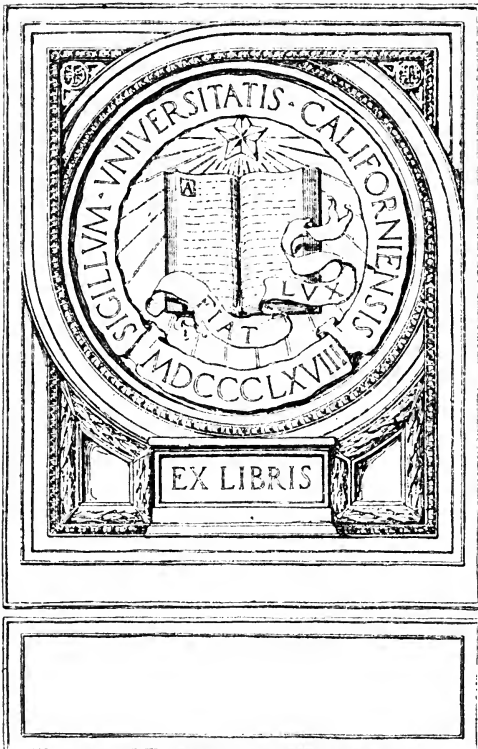
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"No richer gift hath Autumn poured
From out her lavish horn."

The Corn Song—Whittier.

FIELD AND LABORATORY
STUDIES OF CROPS

AN ELEMENTARY MANUAL FOR STUDENTS OF AGRICULTURE

BY

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SUGGESTIONS TO TEACHERS

There is a growing tendency in the schools toward educating children in the common things of life. In some States laws have been passed requiring the teaching of elementary agriculture in the village and rural schools. The object of this work is to interest the pupils in the practical things of country life and to give them some conception of the opportunities which surround them. A majority of the children who attend the village and rural schools will remain in the country, and it is right and proper that they should be educated in the things with which they will have to deal every day of their lives.

The success of the work will depend very largely upon the teacher. Pupils are naturally interested in those things with which they are constantly in contact, and need only the encouragement of the teacher to direct their enthusiasm. In this manual a few exercises are given to illustrate some of the fundamental principles of plant growth, but the central idea throughout is the practical application of these principles to crop production and improvement. Some of the exercises are original, but many of them have been adapted from the publications of the United States Department of Agriculture and from the bulletins of the Extension Department of the Ohio State University. The writer wishes to acknowledge his deep indebtedness to his wife, Hattie F. McCall, for helpful criticisms and suggestions.

No expensive equipment is required, but every effort should be made to induce the pupils to make use of materials on the home farm or in the school gardens. Each pupil should have at home or in the school garden a small plot of ground on which to grow some crops for which he shall be entirely responsible.

The book is expected to furnish material for two periods per week for a half year or one period per week if the work is extended over the entire school term. In order to give the teacher some choice of subjects, fifty exercises have been included. They are arranged in logical order, but it is expected that this arrangement will need to be modified in order to adapt the studies to the season.

In addition to the standard books on elementary agriculture, the school library should have the publications of the State Experiment Station, the Agricultural College, and the United States Department of Agriculture. The former can usually be obtained by direct application to the Station and College, while the latter can be secured by writing to your Senator or Representative in Congress. The Yearbook and the Farmers' Bulletins are the most useful publications put out by the federal government.

At the conclusion of each exercise the pupils should be assigned reference readings bearing upon the work of the period and be required to make a written report. As far as possible, the class-room recitations and discussions should center about the field and laboratory exercises.

Department of Agronomy,
Ohio State University,
August, 1915.

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APPENDIX

FIELD AND LABORATORY STUDIES OF CROPS

EXERCISE 1. HOW PLANTS GROW

Equipment: Shallow tray, 2×6×8 inches; two panes of glass about 5×8 inches; a spool of black thread; a strip of muslin about 3×10 inches.

Method: Sprout some corn kernels in a germinator or

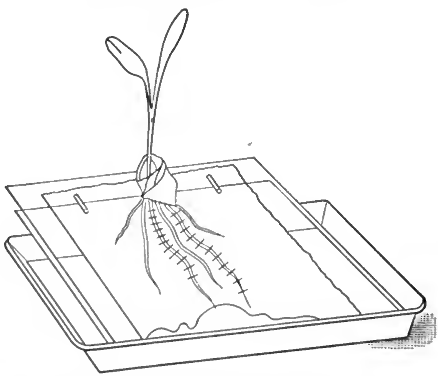


Fig. 1.—Arrangement of Tray and Glass Plates for the Study of Root Growth. (U. S. Dept. of Agr.)

between the folds of a wet cloth until the roots are about two to three inches long. Lay one piece of glass in the tray, letting one end rest on the bottom and the other on the opposite edge of the tray as shown in Fig. 1. Wet the strip of cloth and spread it on the pane of glass, allowing the cloth to project two inches beyond the upper edge of the pane. Lay one of the sprouted grains on the cloth and tie pieces of thread around the roots at intervals of one-fourth inch, or, if waterproof ink is available, mark the roots with a fine pen instead of using the thread. Now place the second pane of glass over the roots, with the upper edge just below the seed, placing a slender piece of wood between the panes to prevent crushing the plant. Fold the corners of the cloth about the seed, put water into the pan to a depth of half an inch, and set aside. After a day or two examine the roots and note where the lengthening has occurred.

The growth of the stems or branches of plants can be studied in a similar manner by tying pieces of thread around them at intervals of one-fourth inch, or by marking them with ink. Measure carefully from time to time the distance between the top mark and the tip of the plant, to determine whether the entire stem elongates or the plant makes its growth mainly at the tip.

Discussion: This exercise shows the manner in which the root elongates and pushes the soft, tender tip through the soil. Is it not much easier for the roots to make their way through a fine, mellow seed bed than through a hard soil? How necessary it is, therefore, to have the soil well pulverized and a deep, mellow seed bed prepared before the crop is planted!

Roots follow the line of least resistance, and if the subsoil is open and mellow the roots will penetrate deeper than they otherwise would, thus increasing their feeding zone. If the soil is mellow to the full depth, such crops as beets and carrots will develop smooth, well-shaped roots.

EXERCISE 2. WHERE THE PLANT OBTAINS ITS FIRST FOOD

Equipment: Two small tin cans filled with sandy soil; a few beans; some grains of corn.

Method: (1) Plant two beans in the can of sandy soil and keep the soil warm and moist. As soon as the leaves appear above the surface of the soil, carefully remove the two half beans, or *cotyledons*, from *one* of the plants with a sharp knife. Compare for a week the development of the two plants and note the more rapid growth of the plant from which the cotyledons have not been removed.

(2) Select four grains of corn and pare off from two of them the starchy outer part (*endosperm*), with a sharp knife, leaving only the *germ*. Plant these germs and the two entire grains in a can of sandy soil and compare the growth and development of the plants.

Discussion: The young plant gets its first food from the supply of material which is stored in the seed, tuber, or other part which is planted. This stored material should be sufficient in amount to supply the young plant until it can send roots out into the soil to secure water, which carries food materials in solution, and its leaves have forced their way to the surface where they may absorb carbon dioxide from the air.

Fig. 2.—Beans Planted the Same Day, but the Plant to the Left was Deprived of its Food Supply by the Removal of the two Half Beans or Cotyledons. (After Graham.)

EXERCISE 3. TO SHOW THAT PLANTS GET FOOD MATERIAL FROM THE SOIL

Equipment: Two quarts of clean sand; two flower pots or quart cans; a few beans.

Method: Heat the sand to redness on a shovel or in an iron pan until all the organic matter is burned out. Fill the two pots with this ignited sand. Select ten large, plump beans and, after soaking them over night, plant five in each pot. Water both pots with rain- or distilled water and set them in a warm place until the beans begin to grow. After this, treat both pots alike, except that one is watered with rain-water and the other is supplied with a soil solution.* As soon as the beans are about two inches high, thin out, leaving three uniform plants in each pot.

Continue the watering until the plants are four of five weeks old, by which time the beans that have received the soil solution should be much larger and stronger than those that have received only rain-water. To what is this difference in growth rate due? Why not use spring-water instead of rain-water?

Discussion: Plant food in the soil is dissolved by water and by weak acids given off by the root hairs much in the

* To make this soil solution fill a large pail half full with rich soil from beneath or near the edge of a manure heap and add enough rain-water to fill the pail. Stir and set aside to settle, then strain off some of the liquid through a piece of cheesecloth.

same way that sugar and salt are dissolved. In this condition plant food can be taken in by the roots as easily as pure

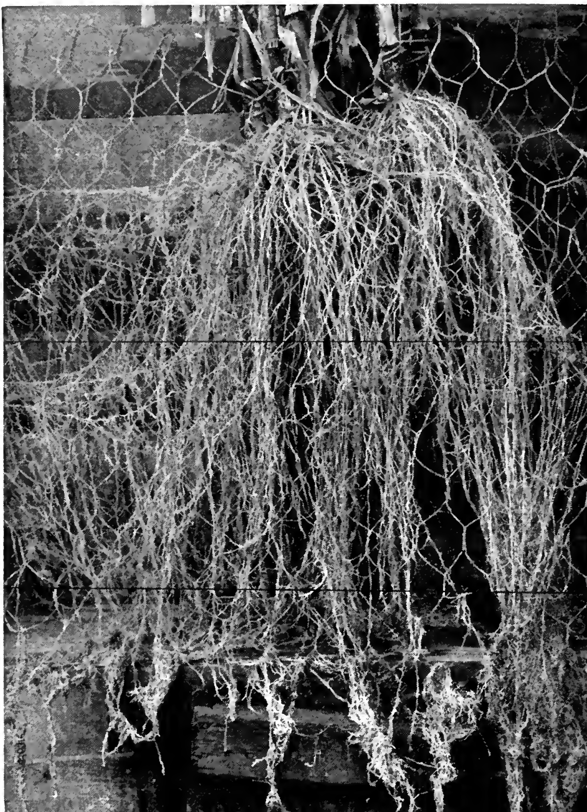


Fig. 3.—The Roots of the Corn Plant Absorb Food Materials from the the Soil to the Depth of Three Feet or More.

water. We think of the " clear-as-crystal " well-water that we drink as being pure water, but we know that often it contains so much lime that every few weeks we have to chip off the scale of lime on the inside of the teakettle.

Well-water may also contain other substances in solution. Suppose you try an experiment to show this by fastening sprouted kernels of wheat on thin slices of floating cork in such manner that the roots will hang over the edges of the cork down into the water. Put some of the seedlings thus arranged into a tumbler of clean rain-water and others into a tumbler of clean well-water and watch their development.

A study of the chemical composition of plants reveals the fact that the greater part of the dry matter of the plant is derived from the air. But before it can utilize the elements from the air, the plant must be able to take up certain mineral substances from the soil.

In ten pounds of mature corn plant there will be found approximately eight pounds of water and two pounds of dry material, of which two ounces have been taken up from the soil, the remainder coming from the air.

EXERCISE 4. TO SHOW HOW PLANTS TAKE UP FOOD MATERIAL FROM THE SOIL

Equipment: Small glass tube or funnel with a long stem; a piece of bladder or parchment paper; some sugar or molasses; a glass can, or wide-mouthed bottle.

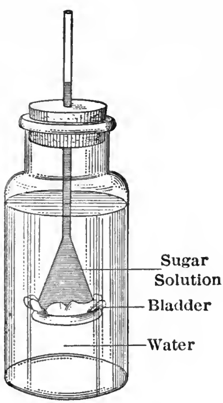


Fig. 4.—Arrangement of a Bladder Membrane to Show How Plants Take up Food Material.

Method: Soak the bladder or parchment in water until soft, stretch the membrane over the end of the funnel and hold it securely by wrapping tightly with waxed thread. Now fill the funnel with a strong sugar solution or with molasses, until the liquid stands about one inch in the stem. Partly fill the jar with water and insert the funnel until the water on the outside is at the same level as the molasses or sugar solution on the inside of the funnel. In a short time the solution in the funnel will be seen to rise above the level of the water in the jar and after a time overflow at the top if the stem of the funnel is not too long.

Discussion: This increase in the volume of moiasses or sugar solution is due to the entrance of water through the bladder or parchment membrane. There is a slow movement in the opposite direction, but since the water moves through the membrane much more rapidly than the molasses or sugar, there is a rapid increase in the volume of liquid on the inside of the funnel. This movement through the membrane will continue until the solution on the inside has the same strength or concentration as that on the outside. The exchange of liquids through membranes is called *osmosis*. By this process the fine root hairs of the plant are able to secure a large amount of water from the moist soil. The thin wall of the root hair corresponds to the bladder or parchment membrane, the cell sap to the sugar solution, and the soil moisture to the water in the jar. The sap is more concentrated than the soil solution on the outside of the hair, hence the water in the soil moves through the cell wall just as the water in the jar moved through the membrane and into the sugar solution.

Sprout some grains of corn and wheat between layers of dark flannel and note the very fine hairs which develop just back of the growing root tip. The moisture which enters the plant through the root hairs carries in solution certain food materials which are essential for the development of the plant. The moisture passes up through the plant and much of it is evaporated from the leaves after having performed its functions as a carrier of food materials from the soil through the plant to the leaf. The food materials carried by the water are left behind in the leaf where they are combined with substances from the air to form the tissue of the plant, including roots, stems, leaves, and seeds.

EXERCISE 5. TO SHOW THAT SUNLIGHT IS NECESSARY FOR PLANT GROWTH

Equipment: Two flower pots; some grains of wheat and corn.

Method: Fill the two pots with moist soil and plant to wheat or corn. Place one of the pots in the window and cover the other with a black paper cone or a box through which the light cannot penetrate. Give both pots the same temperature and the same moisture supply. Observe the contrast in the appearance of the two sets of plants. After the plants under the cone or box have reached a height of three or four inches, remove the covering and note what takes place.

Discussion: The leaves are the workshop of the plant. It is here, under the influence of sunshine, that the plant takes the food materials from the air and combines them with the nutrients gathered from the soil by the roots. The process which goes on in the leaf results in the production of the starches, sugars, fats and proteid substances which are stored in the body and seeds of the plant. The details of the process are not understood, but we know that sunlight is a necessary factor.

The work of the green leaves of the plant is, therefore, to manufacture sugar and starches, which are sometimes called *carbohydrates.* This is an extremely important process, for all life on the earth is dependent upon it for support.

Plants must manufacture carbohydrates not only for their own use, but also for the use of animals. This process cannot go on unless the leaves are exposed to the light. The name *photosynthesis*, which is given to this process, means that the work is done in the presence of light. In the manufacture of carbohydrates the leaves use as raw materials two substances which are very common in nature and easily obtained by the plant. One of these substances is water, which the plant roots absorb from the soil while the other is *carbon dioxide*, a gas which is present in small quantities in the air but which is constantly being renewed, so that there is always an abundance. Water is made up of one part of oxygen and two parts of hydrogen, while carbon dioxide consists of one part of carbon and two parts of oxygen. These are the elements that enter into the composition of a carbohydrate. In this photosynthetic process the elements of the water and the carbon dioxide are separated and in the presence of light are recombined to form carbohydrates. During this process oxygen is given off from the leaf as a waste product. Therefore, in the sunlight the leaf is constantly taking in carbon dioxide and giving off oxygen. If an actively growing water-plant is submerged in a glass of water and exposed to bright light, bubbles of oxygen may be seen coming from the plant and rising to the surface. Shading the glass diminishes the rate at which the bubbles appear.

EXERCISE 6. TO SHOW THAT AIR IS NECESSARY FOR THE GERMINATION OF SEEDS AND THE GROWTH OF PLANTS

Equipment: Two tumblers or quart cans; several grains of corn.

Method: Fill two tumblers within a half inch of the top with rich soil. Plant in each three kernels of corn.

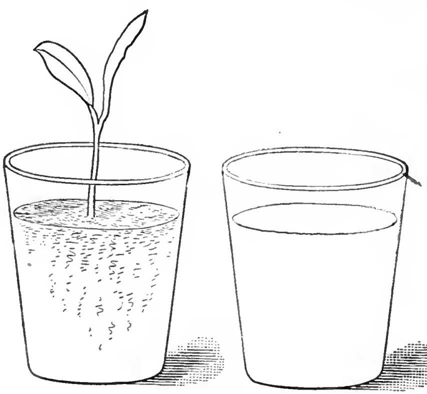


Fig. 5.—The Seed Planted in the Tumbler to the right, Rotted because it was Deprived of Air by the Excess of Moisture in the Soil.

Water tumbler No. 1 only enough each day to keep the soil moist. Keep water in the second tumbler so that it stands a little above the surface of the soil. The seeds in the first tumbler will undoubtedly germinate in a short time, while the seeds in the other tumbler will require a longer time to germinate, and, if the temperature of the room in which the two glasses are kept is low, the seeds will rot. The tumbler which contains an excessive amount of moisture prevents the access of air that is necessary to the germination of the seed, while the one which is kept only moderately moist allows a sufficient amount of air to come in contact with the seeds to insure germination.

Discussion: For the best growth of crops the space not occupied by soil particles should be divided equally between air and water. If this space becomes entirely filled with water, crops will not thrive, since their roots will not be able to get the air necessary for plant growth. Some plants, such as the cypress and the water lily, have special structures which enable them to obtain air from the water while their roots are entirely submerged, but our common field plants do not have this ability.

Of the various means employed to improve land that is naturally unfit for cultivation, there is none which exceeds in importance the operation of tile drainage. A large part of the United States is well drained naturally because of the open structure of the subsoil, which permits the surplus water to pass away rapidly into the underground channels and from thence into the small streams and rivers. In many cases, however, the subsoil is too tight and compact to allow free percolation of the water and artificial drainage is needed.

EXERCISE 7. TO SHOW THAT HEAT IS NECESSARY FOR PLANT GROWTH

Equipment: Two flower pots or tin cans and a few grains of corn or wheat.

Method: Fill the pots with soil and plant the same number of seeds in each. The pots should be watered and treated exactly alike except that one is kept at room temperature (65° to 85° F.), while the other pot is kept in a cool place at a temperature of 40° to 50° F. Note the time necessary for the plants to appear above the surface of the soil and the rate at which growth takes place.

	Date of Planting.	Date up	Average Height of Plants.		
			2d day.	4th day.	6th day.
Room temperature					
Low temperature........					

Discussion: Some seeds will germinate at a temperature only slightly above freezing, while others require a much higher temperature. Oats, clover and other crops that are seeded early in the spring have seeds that germinate at a comparatively low temperature, while corn and melons must not be planted until the soil has attained a much higher temperature.

TEMPERATURES FOR GERMINATION

Crop.	Lowest Temperature, Deg. F.	Best Temperature, Deg. F.
Wheat	32–40	77–88
Oats	32–40	77–88
Corn	45–50	90–92
Melons	60–65	88–99

A low temperature frequently retards germination to such an extent that the seed rots without producing a plant. Thorough drainage and proper cultural methods help the soil to warm up promptly and afford conditions favorable for quick germination and rapid growth of the young plants.

EXERCISE 8. TO SHOW THAT PLANTS TAKE UP MOISTURE FROM THE SOIL AND GIVE IT OFF THROUGH THEIR LEAVES

Equipment: Small potted plant; wide-mouthed jar; piece of cardboard, 6×6 inches; wax.

Fig. 6.—When this Plant is Placed in a Sunny Window, Drops of Water soon Collect on the Inside of the Glass Can.

Method: Use a plant which is at least three or four inches high and growing in a flower pot or tomato can. Cut a slit in the cardboard from the middle of one side to the center and place it around the plant. Seal up the slit in the cardboard with any soft wax. In place of the cardboard, the surface of the soil may be sealed over with melted paraffin or with modeling clay. The object of the seal is to prevent the water from evaporating directly from the surface of the soil and condensing on the inside of the jar. Now invert the glass jar over the plant and place in a sunny window. How do the drops of water get into the glass jar?

Discussion: Plants are constantly giving off water from their leaves. The largest amount is evaporated in the hot sun and when an abundance of water is supplied to the roots. Sometimes in a drouth more water is evaporated from the leaves than is being taken in by the roots. If this is continued for some time, the plant wilts. This reminds us that the water in plants gives the soft stems and leaves their stiffness. All the food which the plant takes from the soil must first be dissolved in water. It is estimated that 900 tons of water are evaporated by each acre of corn plants during the growing season.

In many seasons water is undoubtedly the limiting factor in corn production. It has been found that the total yields of corn for the corn belt may be predicted from the rainfall during the month of July. It has been found that in an average season an additional inch of rainfall retained in the soil during July means an increase of $5,000,000 in the value of the corn crop in a single state.

Unfortunately, rain does not always fall when it is most needed, but by proper tillage and cultivation, large quantities of moisture may be conserved until July.

EXERCISE 9. TO SHOW THE AMOUNT OF MOISTURE RETAINED BY PLANTS

Equipment: A pair of scales and a drying oven.

Method: Dig up enough clover or corn plants from the field to weigh about five pounds. (If accurate balances are available a single plant will be sufficient.) Weigh carefully and record the weight. Place the material in a shallow tray or pan, set the pan in bright sunlight until the contents are thoroughly dry and again weigh. Subtract this weight from the original weight and calculate the per cent of moisture lost.

How many pounds of green clover are necessary to make a ton of cured hay? How much dry corn fodder in a ton of green corn plants?

Place the dried plants in a drying oven and see if more water can be driven off.

Kind of Plant.	Green Weight.	Sun-dried.	Oven-dried.	Per cent of Moisture in the Green Plants.

Discussion: We have already found that a large part of the water taken up by the roots is evaporated from the leaves of the plant, leaving behind the food material which it carried in solution from the soil. We now see that a sufficient amount of water is retained to make up a large percentage of the total green weight of the plant. This moisture gives rigidity to the plant. When the loss by evaporation from the leaf surface is more rapid than the water can be supplied from the soil, the plant soon wilts and ceases to grow. It has been found that our ordinary plants take up from 300 to 500 pounds of water for every pound of dry matter produced by them.

From an experiment in New York State it was found that a field of oats used 522 pounds of water for each pound of dry matter produced; corn 234 pounds; and potatoes 423 pounds.

The evaporation of the water from the surface of the leaf is known as *transpiration.*

In addition to the large amount of water which leaves the soil through the plant, there is a constant loss of water by direct evaporation from the surface of the soil.

EXERCISE 10. TO STUDY THE GROWTH RATE OF PLANTS

Equipment: A home-made measuring device similar to the one shown in Fig. 7; a corn or bean seedling growing in a pot or tumbler.

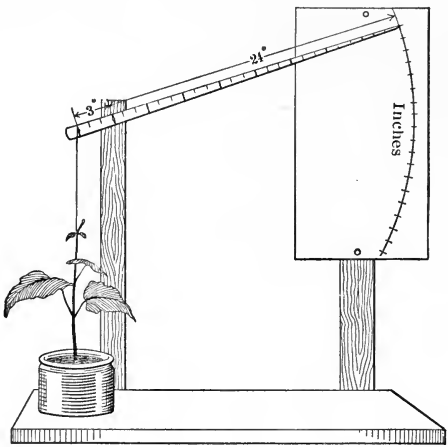


FIG. 7.—A Simple Device for Measuring the Growth Rate of Plants.

Method: By means of a light cord attach the tip of the leaf or the end of a growing stem to the short end of the light lever arm as shown in the drawing. Since the lever arm to the right is eight times as long as the end attached to the plant, an elongation of one inch in the plant will permit the long end of the pointer to drop a distance of eight inches on the scale. Remove the plant from a warm to a cold room and compare the growth rates. Compare the growth rate at night with that of the same plant in sunlight.

Water the plants in one pot with liquid manure, and those in another with water to which has been added a spoonful of ammonia. For a third pot use water to which has been added a spoonful of commercial fertilizer. Compare the growth rates of the plants under the different treatments.

Discussion: Some plants make very rapid growth and mature a crop in a few weeks or months, while others require a long growing period. The growth rate of plants in the field or garden depends not only upon the kind of plant, but also upon the temperature of the soil, the sunshine, and the abundance of plant nutrients in the soil.

Soils that have a sandy texture warm up more promptly in the spring than heavy clay soils because they contain less moisture. For this reason soils of a sandy nature should be chosen for the growing of early truck crops and garden vegetables.

Manures and fertilizers applied to field and garden crops increase their growth rate by furnishing food materials for the immediate use of the plants.

EXERCISE 11. TO SHOW THE PROPER DEPTH FOR PLANTING

Equipment: A case consisting of two panes of glass placed about one-half inch apart and held in position by means of a wooden frame.

Method: Put an inch or two of soil in the bottom of the glass case and then place a kernel of corn on top of the soil close up to the glass. At the other end of the case a bean may be planted in the same manner. Now put in an inch of soil and again plant a kernel of corn and a bean, continuing the operation until the case is full of soil to within an inch of the top. Water the soil thoroughly, cover the glass sides with black cloth or paper to exclude the light and set the case aside until the seeds have germinated. Other seeds than corn and beans may be included in the exercise.

Discussion: Seeds which are small and fine must not be deeply covered with earth, for, if they are, the weak germ which they contain will not be strong enough to reach the light and air. Large seeds, however, which contain a considerable quantity of stored material, as in the case of peas and beans, may be planted quite deeply. In fact, peas, which do not force the seed leaves out of the ground, should, for best results, be planted from three to five inches in depth, while beans, which have a different method of germination, forcing their seed leaves out of the ground, should not be planted too deeply, for, as in the case of soils which are clayey and compact in nature, there will not be sufficient power in the growing stem of the bean to force the seed leaf from

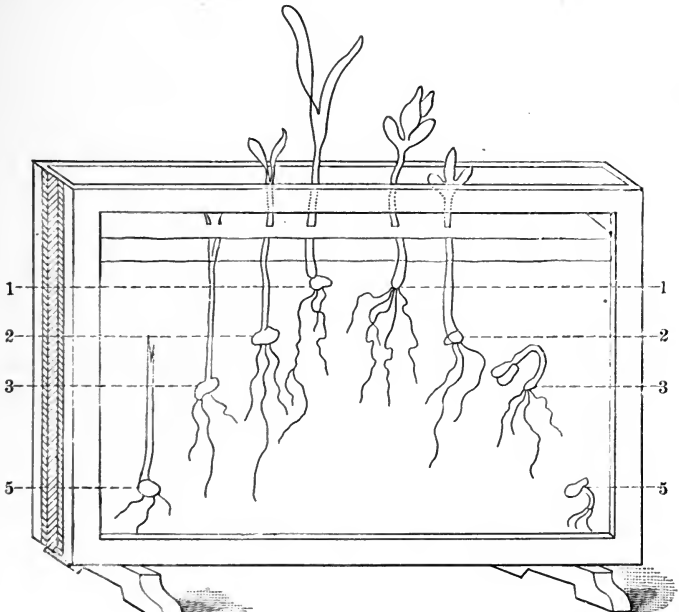


FIG. 8.—A Glass Case to Show the Results of Deep and Shallow Planting. (U. S. Dept. of Agriculture.)

the soil and out into the light. The depth of planting, therefore, must be regulated by the habit of growth of the plant.

EXERCISE 12. A STUDY OF CORN

Equipment: Samples of dent, flint, pop and sweet corn and a copy of the last census report or the Yearbook of the United States Department of Agriculture.

Method: Study the points of difference between these different types of corn by examining their exterior and by cutting the grains in sections. What is each kind used for? What kind is grown in your district? From the census reports, find the states which produce the greatest amount of corn. How does the value of the corn crop in your state compare with that of wheat and oats? Where is flint corn grown? By inquiry find out how many acres of corn are grown on four different farms in your neighborhood and also the yield per acre. Compute the value per acre at the regular market price and fill out the following table:

	Total	Yield per acre	Total production	Value per acre
First farm...........				
Second farm.........				
Third farm..........				
Fourth farm.........				

Have the pupils each bring ten ears of the best corn they can find at home, for use in the exercise on corn judging.

Discussion: On some of the farms of your neighborhood the yields are low because the soil needs drainage, while on others the soil is in need of manures and fertilizers. But rich, well-drained soil sometimes fails to produce good crops because poor seed is used or the seed bed is improperly prepared.

Both the dent and the flint types of corn are grown extensively in the United States. Flint corn is confined principally to the New England States, New York, Canada and regions of similar climatic conditions. Further south, throughout the central part of the United States, the dent type is grown almost exclusively; it has a longer growing period than the flint corn and produces larger yields.

For the best results corn should be planted in rich, mellow, well-drained loam soil and given thorough and frequent shallow cultivation throughout the growing season.

EXERCISE 13. THE CORN KERNEL

Equipment: Samples of white, yellow and red corn; a shallow pan.

Method: Soak the kernels from white, yellow and red ears over night in water. Supply each student with a num-

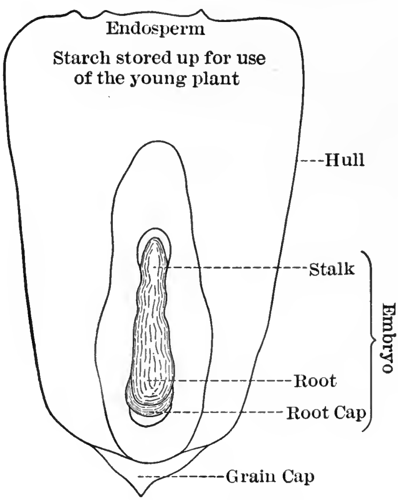


FIG. 9.—Diagram Showing the Parts of a Grain of Corn.

ber of grains of each different color, both soaked and dry. After drawing an exterior view showing the groove side, the grains should be cut in sections, and drawings made of cross- and longitudinal sections. The drawings should show the difference in structure of the different parts of the grain.

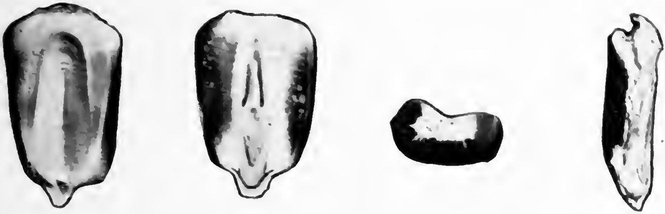


FIG. 10.—External and Sectional Views of a Grain of Corn.

FIG. 11.—Enlarged Photograph of Sprouting Grains. The Stem above and the Roots Growing downward. (Extension Department.)

Remove the outer covering from some of the soaked grains and observe the location of the color. Where is the white color located in the white grains? What is the color of the hull of the yellow grain? The color of the *endosperm?* What is the color of the red grains after the hull has been removed?

Discussion: The corn kernel is composed of four distinct parts: (1) *the hull,* which is the thin, outer layer which covers the entire grain, (2) *the aleurone layer,* which is very thin and located just under the hull, (3) *the endosperm,* which occupies about three-fourths of the entire grain and (4) *the embryo,* or germ, which is the living part of the grain.

The endosperm is composed very largely of starch, and furnishes the food for the young plant after germination and until it has gotten its roots into contact with the soil and its leaves exposed to the air. The endosperm is made up of two kinds of material, one white and starchy and the other hard and horny. The embryo is embedded in the endosperm just under the groove which occupies one side of the grain. The little plant which is snugly folded into the cavity can be seen with the naked eye after the surface of the grain is cut away with a sharp knife. When the grain is planted in the soil, it absorbs moisture and, if temperature conditions are favorable, the little plant pushes its roots out into the soil, and extends its leaves up into the air.

EXERCISE 14. THE STUDY OF AN EAR OF CORN

Equipment: Ten-ear samples of different varieties of corn; tape line; a pair of postal scales or a torsion balance.

Method: Having supplied each student with a ten-ear sample, the work should proceed as follows: (1) Number the individual ears of each sample on a small tab attached to the butt of the ear by means of a small nail.

Ear No.	Length.	Circumference.	Weight.	Number of rows.	Number of kernels per row.	Number of kernels per ear.
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Average						

(2) Weigh and measure each ear, recording the weight in ounces or grams and the length and circumference in inches and fractions of an inch.

(3) Record the number or rows of kernels and the number of kernels per row and the total number of kernels per ear.

(4) Select two representative ears from each sample, shell, and determine the per cent of shelled corn.

Ear Number.	Total Weight of ear.	Weight Shelled corn.	Per cent of Shelled corn.

Are the large ears always the heaviest? Why is there always an even number of rows? Can you see any relation between the width of the grains and the number of rows on the cob? How many ears of the average size will be required to make a 70-pound bushel? From your shelling test calculate how many ears are required to make a 56-pound bushel of shelled corn. How many bushels of shelled corn in 100 bushels of ear corn which averages 75 per cent of shelled corn? 85 per cent of shelled corn?

Discussion: A great variation is found in the size, weight and shape of the ears of different varieties of corn and also in the individual ears of a particular variety. Ears with medium-size cob and deep grains are much more valuable for feeding purposes than those with shallow grains and large cobs.

EXERCISE 15. EARLY GROWTH OF THE CORN PLANT

Equipment: Preparation for this exercise must be made four weeks in advance, by planting two small plots of corn, one at the depth of one inch and the other three inches deep. Repeat this planting each week, in order to have, for the exercise, plants one week old and others that have reached the ages of two, three and four weeks. The plantings may be made in soil, but the plants will be much more easily handled if grown in boxes of sand, since the sand will wash off the roots much more readily than soil.

Method: Dig up a sufficient number of plants and carefully wash the sand away without injuring the roots. Examine the root systems of the plants of different ages and compare those planted at different depths. Make drawings of the entire plants at different stages of their development and show the three temporary roots which develop first and also the permanent roots which make their appearance later at one of the joints or nodes situated about one inch below the soil surface.

Discussion: The roots of the corn plant may be divided into three groups: (1) *temporary*, (2) *permanent feeding roots*, and (3) *brace roots*. When the kernel of corn germinates, it sends down into the soil a shoot from which two or three lateral branch roots develop. These roots with their branches form the temporary root system and supply the young plant with moisture. During the early growth stage the young plant is nourished by the food which is stored up in the kernel, but by the time the plants appear above the ground a permanent root system has begun to form about an inch below the surface of the ground. This system grows very rapidly at first and by the time the plants are a month old the roots will meet between the rows. When the permanent roots are well started, the temporary roots wither and die, leaving the plant to depend upon the permanent system. Deep planting of the seed does not secure deep rooting except for the temporary system, and in most seasons is harmful rather than helpful, since the deep planting makes it more difficult for the young plant to get its leaves up through the soil and into the air, from which it must obtain its supply of carbon for the formation of tissue.

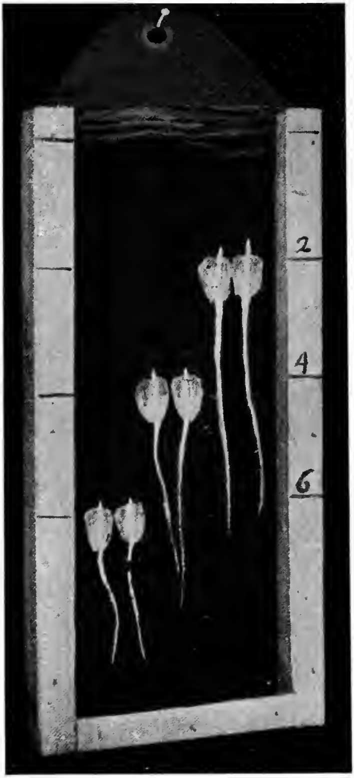


Fig. 12.—A Glass Case Used for Observing the Early Growth and Development of the Corn Plant.

EXERCISE 16. A STUDY OF THE MATURE CORN PLANT

Equipment: Spade and note book.

Method: Carefully dig up a mature stalk of corn and make a careful study, (1) of the parts below ground, and (2) of the parts above the soil.

Discussion: A close examination of the parts below ground will reveal the fact that besides the large roots that hold the plant upright, there are a large number of little threadlike roots passing out into the soil in all directions. How deep would it be safe to plow without injuring these fine feeding roots? About the time the tassels develop the large brace roots appear.

Above the ground the joints of the stalk are called *nodes*, and the portions between the joints the *internodes*. These internodes are flattened on one side. Upon which side of the internode is the ear always found? How are the leaves arranged on the stalk? Notice that the edges of the leaves are longer than the central part, giving the margin a wavy appearance. Does this not help to prevent the leaves from being torn by the wind?

The stamens of the corn plant are located in the tassel at the upper extremity of the stalk, while the pistils are down on the side of the stalk and form the silks of the ear. Open an ear of corn just after the silks have made their appearance

FIG. 13.—The Ear to the Left is Borne too High on the Stalk. Ears Carried at a Medium Height Should be Selected for Seed.

and follow the threads of silk to their attachment to the grains. At about this time there is a great abundance of yellow powder flying in the air and scattered over the ground. What is this powder and why so much of it? When a corn plant grows in a place far from any other corn, what kind of an ear does it develop?

Corn when cut and cured in the field is called *fodder*, but after the ears have been removed, the stalks minus the ears are known as *corn stover*. When the entire plant is harvested while it is yet green and placed in the silo without curing, the resulting material is called *corn silage*. Green corn preserved in the silo is used extensively as a feed for dairy cattle.

It is estimated that there is produced about one and one-third pounds of stover for each pound of ears, and that for every pound of dry matter in the roots and stubs six pounds are produced in the plant above ground.

EXERCISE 17. POLLINATION OF PLANTS

Equipment: A supply of paper bags and a ball of twine.

Method: (*a*) Go into a corn field when the silks are just beginning to show beyond the husks and tie paper bags over four ears. At the same time tie bags over the tassels of three or four plants. Allow the bag to remain undisturbed over one of the ears for three or four weeks or until the plant is ready to harvest. An examination at this time will show that no grains have developed. Why?

A week after the first bagging, cut off one of the tassels and dust the pollen on one of the covered ears, removing the bag for the operation and replacing it as soon as the pollination is accomplished. One week later repeat the operation with the other plants. When the corn is ready to harvest remove the bags and examine the ears.

(*b*) Plant side by side in the home or school garden a number of hills of yellow and white corn or field and pop corn. In the fall when the corn is husked, note the mixture of two kinds of kernels on the same cob. How did this corn become mixed?

Discussion: Some flowers produce seeds while others do not. Some ears of corn have vacant places on the cob, or poorly filled tips. From this exercise it will be seen that if a flower is to produce fruit, its *pistil* must receive

FIG. 11.—The Flowering Parts of the Corn Plant. Pollen from the Tassel to the Right must Fall in the Silks before the Grain will Develop.

pollen or dust from the same or another closely related flower. In the corn plant the silks are the pistils or female parts of the flower, while the tassel is the male part of the flower and produces the pollen with which the silks are fertilized. In such plants as oats and wheat both parts of the flower develop at the same place on the plant and are enclosed within the *glumes* or chaff. When the two parts are separated, as in the corn plant, it is necessary that the wind or insects carry the pollen from the tassel to the silks before the grain can develop. With oats and wheat the parts are so arranged that each flower produces its own pollen and as a consequence they are close fertilized.

By putting the pollen of one kind of a plant on the pistil of another closely related plant, the plant breeder sometime originates a new variety. Plants so produced are called *hybrids* or *crosses.* The hybrid plants are sometimes very much superior to either parent, but it frequently happens that the crossing results in the production of plants that are inferior to the parent forms.

EXERCISE 18. THE SELECTION OF SEED CORN IN THE FIELD

Equipment: A field of corn just ready to be harvested.

Method: Each student should be required to select ten seed ears from the plants in the field. The best time to make this selection is just before the corn is harvested. The seed ears may be gathered at the time the selection is made, but it is better to mark them and allow them to remain attached to the stalk until fully matured. The plants may be marked by breaking over the stalk just above the ear or by spotting the husk of the ear with paint, then later, when the corn is being husked either from the standing stalks in the field or from the shock, the selected ears can be identified and placed in a separate pile.

Discussion: Good-sized ears growing slightly below the middle of the stalk should be selected. Plants with ears borne high on the stalk are frequently late in maturing and are more easily blown over than those carrying the ear lower. Selections should be made from strong, vigorous plants growing under normal stand. A plant growing in a hill with two other plants should be rated much higher for having produced a good, large ear than a stalk growing in a hill by itself. Many of our most productive plants owe their superiority to their immediate environment—extra food, sunlight and moisture—which they secure as the result of a thin stand. It is probable that four out of every five ears

FIG. 15.—Selecting Seed Corn in the Field. Stalks Bearing Desirable Ears are Broken over so that they may be Identified at Harvest and the Ears Saved for Seed.

of seed corn selected from the crib owe their excellent appearance to this lack of competition in the field. The intelligent selection of seed ears from the stalk in the field is helpful, since we can be sure that the excellence which the ear possesses is due to something wrapped up in the seed and not to something which has happened to the plant.

Both heredity and environment are responsible for what we see as we look over a field of corn with its thousands of individual plants, no two of which possess like characters or the same possibilities. The work of the corn grower, young or old, is to determine that which is temporary or accidental and that which is lasting and may be inherited.

EXERCISE 19. THE STORAGE OF SEED CORN

Equipment: Germination box.

Method: At corn-harvest time in the fall, each pupil should select twelve ears of corn from the field. Three of the ears should be left on the stalks, the plants being cut and set against the fence. The remaining nine ears should be husked and divided into three lots of three ears each. One lot should be stored in the cellar, another overhead in the crib and a third in some warm place in the house. At some convenient time during the winter, separate germination tests should be made on all of the ears and the results of the test reported in the following table:

Lot No.	Method of Storage.	Average per cent. of Germination.
1		
2		
3		
4		

Discussion: When seed corn is selected from the stalk in the field, two bushels of ears should be selected for every bushel that will be needed for planting the following spring. This precaution is necessary, since some of the ears will need to be discarded after they are husked. It is well to leave the selected ears on the stalk until they are well matured and

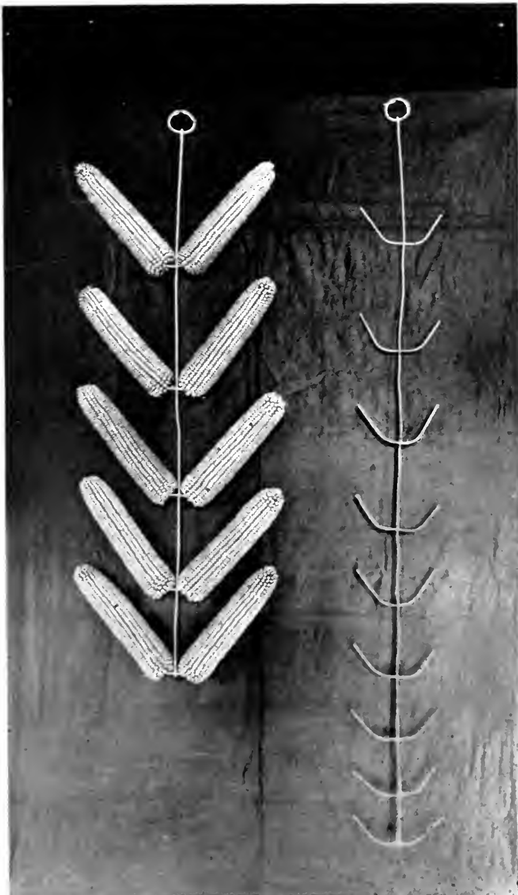


FIG. 16.—Seed Corn Storage Rack Made from a Short Section of Woven-wire Fence.

hardened. Before freezing weather they should be husked and stored in some dry, well-ventilated place. Before planting time in the spring the seed ears should be spread out on the floor or on a table in a well-lighted room and

FIG. 17.—Seed Corn Storage Rack Made of 2×4 Uprights and Lath Nailed on Edge.

after a careful examination all the poorer ears should be rejected.

In this final selection the following rules should be observed:

Rule 1. *Select ears of a medium size for your locality.*

The small-eared early types which do not utilize the entire growing season will not produce the maximum yield. The large-eared types which are so late that they cannot mature a hard, solid ear also fail of the maximum production and yield a product which is inferior both for market and for home consumption.

Rule 2. *Select ears that are very heavy for their size.* The yield seems to be more closely associated with weight of ear than any other one quality.

Rule 3. *Select ears of a bright, healthy color.* Ears of a dull or pale color are usually immature or have been exposed to the weather. The color indicates poor seed condition and low vitality.

Rule 4. *Select ears with grains of uniform size and shape.* Aside from its indication as to trueness of type, uniformity of grain is of considerable importance in getting an even distribution of seed and a uniform stand, when machine planting is practiced.

Finally, all the selected ears should be subjected to the germination test.

EXERCISE 20. JUDGING CORN EARS

Equipment: A five-ear sample of corn for each member of the class; tape measure; a pair of postal scales.

Method: Provide each pupil with five ears of corn and let him practice scoring, using the score card given or one secured from your Agricultural College. Each student should score half a dozen or more five-ear samples before this exercise is passed. Number all of the ears by tying to each a small numbered tag or sticking a numbered tab on the butt of each cob. Have each pupil provide himself with a score card ruled as shown on page 48, providing one column for each ear of corn, and score the individual ears of a five-ear sample. The figures in the score card between the first two perpendicular lines show the number of "points" that should be given for a perfect ear, e.g., if the pupil thinks ear No. 4 is nearly perfect in shape he would probably mark 9 in line 1, column 4, as shown in the table. Each pupil should examine carefully each ear of corn and put down on his score card, in the column of the same number as the ear of corn, his estimate of the qualities named on each line at the left, except line 3—vitality—which should not be filled in until after the ears have been subjected to the germination test as directed in Exercise 22.

Then compute the germinating value of the different samples on the basis of 20 for a perfect ear, as shown in the score card, and give each ear its proper rating in line 3 of

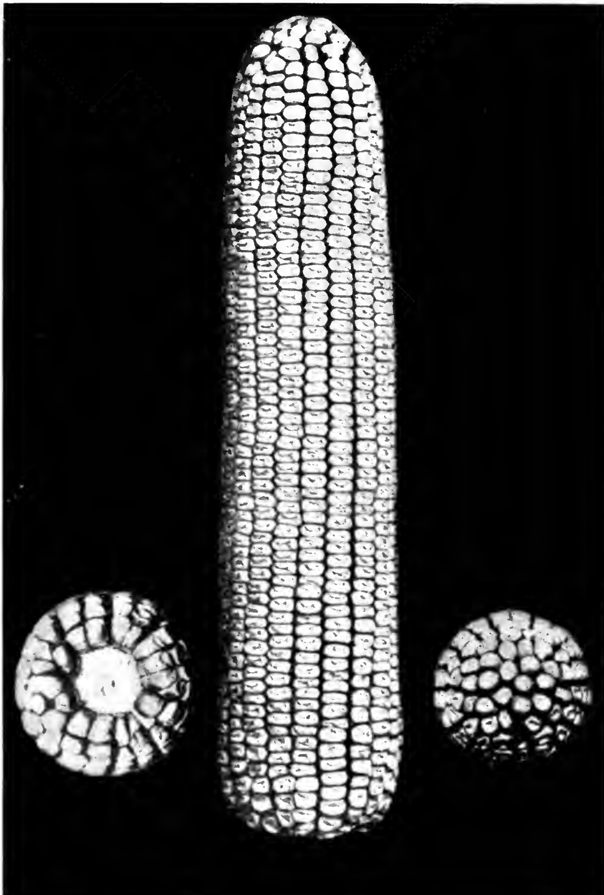


FIG. 18.—An Ideal Ear of Corn. (Missouri.)

the score card. Now add up the different columns of figures in the score card and by means of the totals select the best two ears.

Continue the exercise by treating each five-ear sample as a unit, and scoring them in the same manner as the individual ears.

SCORE CARD FOR CORN

Points.	Perfect Score.	1	2	3	4	5
1. Shape of ear	10	....	....	....	....	....
2. Purity of color in grain and cob	5	....	....	....	....	....
3. Vitality, maturity, germinating power	20	....	....	....	....	...
4. Tips of ears	5	....	....	....	....	...
5. Butts of ears	5	....	....	....	....	...
6. Uniformity of kernels	5	....	....	....	....	..
7. Shape of kernels	5	....	....	....	....	...
8. Length of ear	5	....	....	....	....	...
9. Circumference of ear	5	....	....	....	....	...
10. Furrows between rows	5	....	....	....	....	...
11. Space between kernels at cob	10	....	....	....	....	....
12. Proportion of grain to cob	10	....	....	....	....	....
13. Composition and feeding value	10	....	....	....	....	....
Total	100	....	....	....	....	....

In order to understand the meaning of all the points listed in this score card it is well to write to the State Agricultural College or to the State Corn Breeders' Association, if there is one, for an explanation of the official score card used in your State; or it may be possible to get someone from the Agricultural College to come to your school or county teachers' meeting and explain the score card in detail. A brief explanation of the score-card points will be found in the following discussion:

Discussion: The points on the score card are explained as follows:

1. *Shape of Ear.* A good ear should be nearly cylindrical. This will permit of an equal number of rows the entire length of the ear and will insure grains of uniform size.

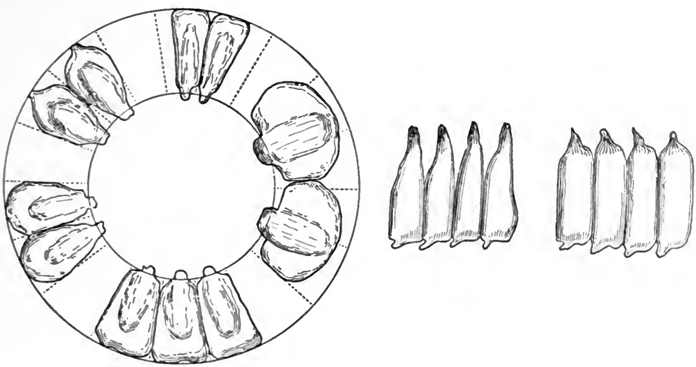


Fig. 19.—Diagram Showing Desirable Kernel Shapes. The Three at the Bottom of the Circle and the Four to the Right are Ideal. (Adapted from Lyon and Montgomery.)

Uniformity in size of grain is important because the planter will give a more uniform drop.

2. *Purity of Color in Grain and Cob.* A uniform color of grain indicates a pure variety. Yellow corn should have a red cob and white corn a white cob.

3. *Vitality, Maturity and Germinating Power.* Corn that is to be used for seed should have good vitality. The germination box is the only reliable test for vitality.

4. *Tips of Ears.* The tips should be well filled and if the ears are full size it is desirable to have the tip of the cob capped over with grains.

5. *Butts of Ears.* This end of the cob should be well rounded over with grains and show a medium-sized attachment for the shank.

6. *Uniformity of Kernels.* Kernels should be uniform in size, otherwise the planter will fail to give a uniform drop.

7. *Shape of Kernels.* The kernels should be slightly wedge shape and retain their thickness well down to the tip.

8. *Length of Ear.* The proper length for an ear will depend upon the locality. A standard length should be established by getting the average length of a number of good matured ears.

9. *Circumference of Ear.* The circumference should be about three-fourths to four-fifths of the length when measured about two inches from the butt.

10. *Furrows between the Rows.* The space between the rows should be small.

11. *Space between the Kernels at Cob.* The kernels should retain their thickness down almost to the tip with no space between them at the point where they are attached to the cob.

12. *Proportion of Grain to Cob.* A medium-sized cob with deep grains is to be desired. The percentage of grain should be between 83 and 86 for most varieties of corn.

13. *Composition and Feeding Value.* A large proportion of hard flinty endosperm is desirable.

EXERCISE 21. TO STUDY THE EFFECT OF STAND UPON THE YIELD OF CORN

Equipment: Basket; 50-foot tape line; a pair of spring balances.

Method: As soon as corn is ripe, go to a nearby field and after selecting a representative row, measure off one-hundredth of an acre * and count: (1) the total number of stalks and (2) the number of stalks which have no ear. Compare the total number of plants actually found with the number necessary to constitute a perfect stand. Husk and weigh the corn, count the number of ears and calculate the average weight. Make the necessary calculations and fill in the blanks in the accompanying form:

Number of stalks necessary for perfect stand.........	....
Number of plants found............................	....
Per cent of perfect stand..........................	....
Total weight of corn harvested.....................	....
Number of ears harvested...........................	....
Average weight of ears............................	....
Yield in bushels per acre..........................	....
Yield for a perfect stand with each stalk producing an average-sized ear......................	....
Yield for a perfect stand if each stalk had produced a $\frac{3}{4}$-lb. ear..............................	....

* If the rows are $3\frac{1}{2}$ feet apart, 125 feet will make a hundredth part of an acre.

Discussion: Many farmers plant their corn fields without having tested the vitality of their seed ears. This neglect frequently results in a poor stand and a low yield of corn. With better cultural methods and more attention given to the selection of good seed it is possible to double the average yield of corn in many communities.

One of the most important steps in securing good seed is the elimination of the ears that will not grow. While ears having weak or dead kernels can sometimes be discarded by their general appearance, it is not always possible to detect them by this means. The only safe way is to plant the kernels and see if they will grow. This can be done by taking several kernels from each ear and planting them in a small box filled with sawdust, sand, or soil. A box 10×20 inches and three inches deep is a convenient size. Detailed directions for making the germination test are given in Exercise 22.

EXERCISE 22. TO TEST THE VITALITY OF SEED CORN

Equipment: Fifty ears of corn; a germination box; sand or sawdust sufficient to fill the box; a piece of muslin 10×20 inches.

Method: Number the ears and place them in consecutive order on a table or a bench where they will remain

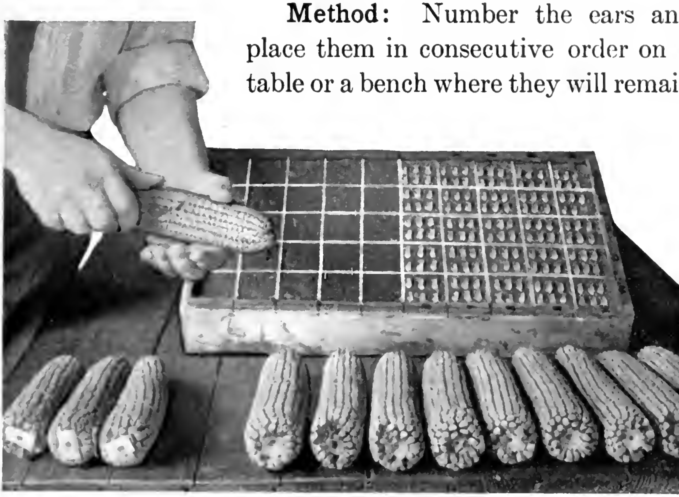


FIG. 20.—The Sandbox Germinator Will Pick out the Dead Ears. (Courtesy of Extension Department.)

undisturbed until the close of the exercise. The germination box may be constructed at the school or home of one of the pupils. It consists of a shallow wooden box 3×10×20 inches inside measurement and three inches deep. Along all four sides of the box are saw cuts one inch deep and two inches apart. The germinator is prepared by filling the box to within one inch of the top with moist sand. The surface, having been leveled and compacted by means of a smooth block of wood, is marked off into small squares 2×2

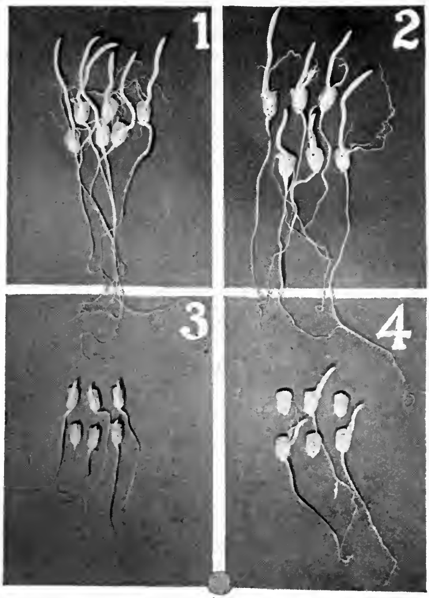


Fig. 21.—Four Sections from the Germination Box. Nos. 1 and 2 Show Strong, Vigorous Growth. No. 3 is Weak, while No. 4 Shows Three Dead and Three Weak Grains.

inches, by means of a cord which is laced back and forth through the saw cuts in the edge of the box. Beginning in the upper left-hand corner, the squares are numbered from one to fifty.

Commencing with ear No. 1, remove six kernels, two near the butt on opposite sides, two near the middle and two near the tip. Place the six kernels in regular order, germ side up, in the germinator in Square No. 1 and proceed with Ear No. 2 in the same manner, placing the kernels from it in Square No. 2. Repeat this process until all of the ears have been sampled.

After the grains are all in place cover the surface of the sand with a square of muslin and add sand until the box is level full. Moisten the sand thoroughly and keep it wet throughout the exercise.

The germinator should be kept at a temperature of 70° to 80° F., during the day, but at night it may fall to 50° or 60° without harm. At the end of five or six days the cloth should be carefully rolled back in order to expose the squares for inspection. Count the grains that have germinated in each square and record the numbers in the following diagram:

1	2	3	4	5	6	7	8	9	10

After careful examination, discard the ears whose numbers correspond to the square in which the grains did not grow or where germination was weak and unsatisfactory.

Discussion: It matters not how much food is available to the plants, how well prepared the seed bed, or how great the amount of moisture conserved, the best results cannot be obtained unless good seed is planted. Heretofore, much more rapid advancement has been made toward cultural methods than toward the securing of good seed. Many have never stopped to consider what constitutes good seed. In good seed there must be stored in the germ that which we call life, or, as we commonly say, the seed must have vitality. Very few do more than look at an ear to determine its vitality. This is a great mistake and frequently results in a poor stand and a low yield. Without a perfect stand, the largest possible yield cannot be expected. If time is taken to count the stalks in one hundred consecutive hills, the average corn grower will doubtless be surprised to find far from a perfect stand. He will probably find not more than 75 per cent or 80 per cent of the stalks that should be there. With such a stand and an allowance of from 5 per cent to 10 per cent for barren stalks, some explanation can be made for the low yield. There are on the average ear about 900 kernels suitable for seed. If out of every hundred ears planted four or five lack vitality, it will mean at least 2000 fewer stalks in the field per 100 seed ears planted.

EXERCISE 23. TESTING THE CORN PLANTER

Equipment: A two-row corn planter; a quantity of shelled corn.

Method: Examine the planter and find answers to the following questions:

Has the planter a drill or full hill drop?

How is the change made from drill to hill drop?

Has the planter edge selection or flat plate?

Will the seed box tip over?

How many valves in each planter shank?

Is the furrow opener a stub or curved runner or a disk?

Set the planter to drop three grains to the hill and measure off a distance of one hundred feet on a smooth level stretch. Draw the planter over this distance and count the kernels dropped in each hill. Repeat the test three times and record the results.

Change the planter to the drill drop and test in the same manner.

	First Count.	Second Count.	Third Count.	Average.
Number of hills with no grains.	....	....	....	....
Number of hills with 1 grain...	....	....	....	....
Number of hills with 2 grains..	....	....	....	....
Number of hills with 3 grains..	....	....	....	....
Number of hills with more than 3 grains..................	....	....	....	....

Divide the total number of grains dropped by the number of hills, to get the average number of grains per hill. If the results are very unsatisfactory, change the plates in the bottom of the grain boxes and repeat the test.

Discussion: A good corn planter should have several sets of plates, in order that adjustments may be made for dropping accurately, small, medium, or large grains. Previous to planting time, the planter should be put in order and the accuracy of its drop tested. In the preparation of seed corn, the small and irregular-shaped grains should be removed from the butts and tips of the ears and discarded. As a further aid to the planter, the shelled seed corn may be graded to uniform size by passing it through a set of sieves, the first one of which will hold back the extra large grains, and the second of which will retain the medium-sized grains but allow the very small to pass.

EXERCISE 24. TO STUDY THE NECESSITY FOR PROPER CULTURAL METHODS FOR CORN

Equipment: Spade; yardstick.

Method: Dig down beside a corn plant in the field to a depth of two or three feet and carefully wash the soil away from the roots. Make a study of the root system and, after reading the discussion which follows, write a report on "Cultural Methods for Corn."

Discussion: The principal objects of cultivation are: (1) to save moisture, (2) to kill weeds and (3) to make plant food available.

Cultivation by means of a harrow or weeder may begin three or four days after planting or as soon as the weeds begin to come through the soil. This process should be repeated frequently, the principal object being to kill the weeds. Workings with the cultivator should be given as the surface soil becomes compact, especially after every heavy rain.

From the time that the ear begins to form until it is nearly matured, a large amount of moisture will be required to supply the necessary food material. This period will extend from the latter part of June to the middle of August. If the moisture is to be conserved, frequent cultivation must be continued as late as possible into the summer, even after the plant has tasseled. A study of the development of the roots of the corn plant will disclose the facts that at first the roots are similar to tap roots which have a tendency to go down in search of moisture and food, and that gradually lateral roots are formed. In the course of sixty or seventy days the soil will be filled with roots from hill to hill. If shallow cultivation has been practiced, these roots will come near the surface of the soil, where they will find the greatest amount of available plant food.

After a heavy rain the greater part of the water which enters the soil passes down through until it reaches a place where all of the openings between the soil particles are completely filled with free water. During the time between rains, the plants must get their moisture from this supply deep down in the soil. The process by which this water rises in the soil is called *capillarity*. This capillary water is sometimes called film moisture, because it is spread out in a thin film over each soil particle. Persistent shallow cultivation forms a mulch over the surface of the soil and prevents excessive loss of moisture by evaporation.

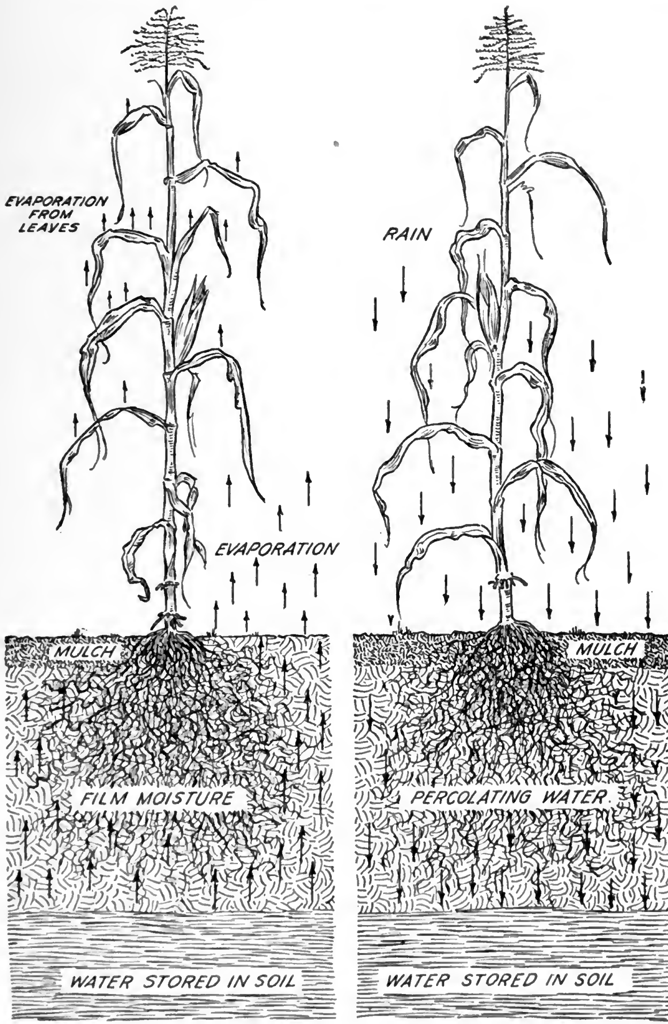


FIG. 22.—Continuous Thorough Cultivation is Necessary to Prevent the Loss of Moisture at the Surface of the Soil.

EXERCISE 25. THE PRODUCTION OF CORN IN THE UNITED STATES

Equipment: Yearbook of the United States Department of Agriculture.*

Method: From the Yearbook obtain the figures for the production of corn in each State of the United States. Represent the geographical distribution of the areas of large production on the accompanying map by the use of appropriate shadings. Those States which produce more than 100 million bushels should be shaded black; those producing more than 50 million and less than 100 million a lighter shade; and those producing less than 50 million left unshaded.

Discussion: Climatic and soil conditions determine the distribution of the crops in the United States. The greater part of the corn grown in this country is produced in seven or eight States of the Middle West, which are known as the corn-belt States. Wheat is more widely distributed, while oats are confined largely to the North Central States.

The United States produces about four-fifths of the world's corn crop.

The corn belt states of this country appear to have the best combination of sunshine, temperature, rainfall and soils for the production of corn. Water is undoubtedly the most important factor in the successful culture of corn. A study of corn yields in connection with the records of the Weather Bureau has brought out the fact that there is a

* A copy of this publication can be obtained free of cost by application to your Senator or Representative at Washington, D. C.

very direct connection between rainfall and yield of corn. The yield does not depend upon the total rainfall alone, but upon its distribution throughout the growing season.

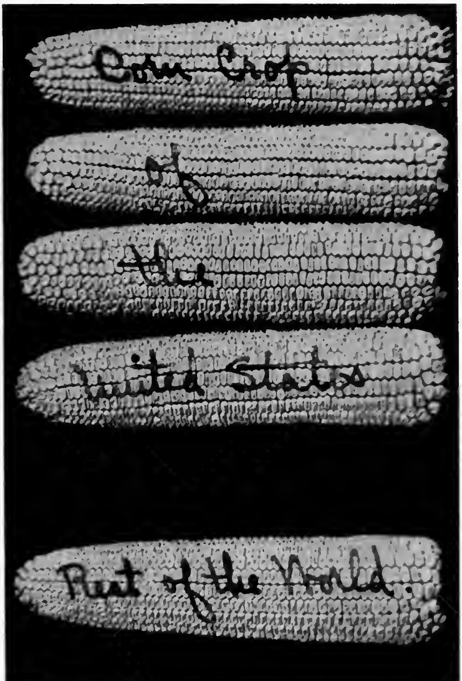


FIG. 23.—Distribution of the World's Corn Crop. United States Produces Four-fifths and the Rest of the World One-fifth of the Total Crop.

The most favorable condition for the growth of corn is heavy rains at considerable intervals, with clear weather and abundant sunshine in the meantime.

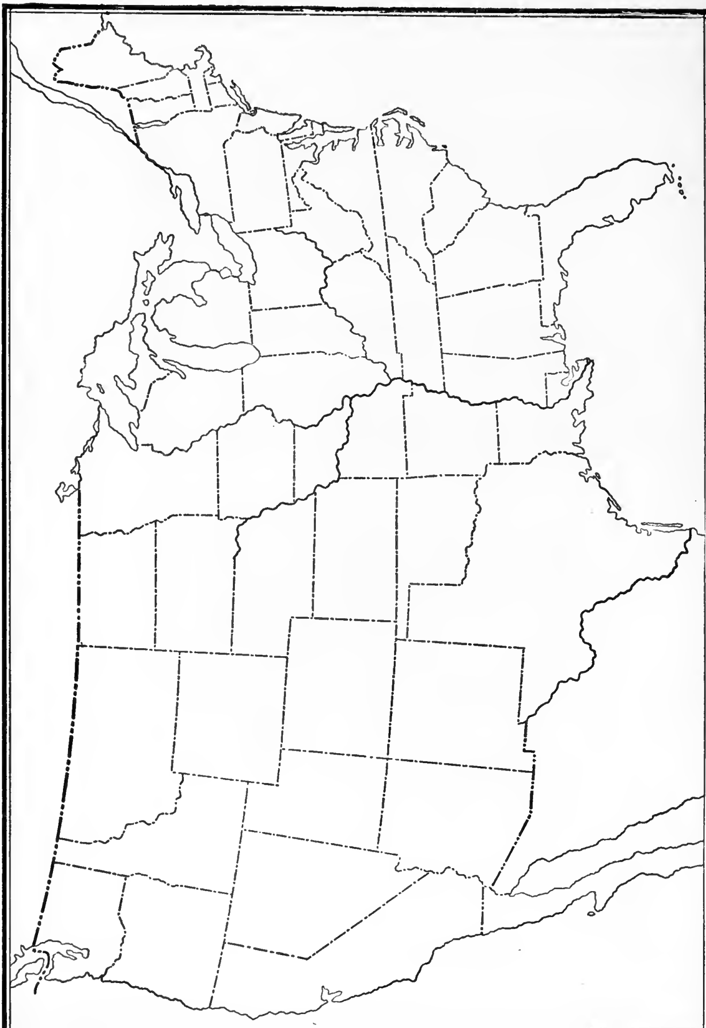


FIG. 24.—Map on which to Show the Production of Corn in the United States.

EXERCISE 26. STUDY OF A HEAD OF WHEAT

Equipment: A sufficient number of wheat heads to supply each member of the class with a head of bearded and one of smooth wheat.

Method: Make a careful examination of the two heads and locate all of the parts. Make a drawing of the entire spike, then separate the parts and make a detailed sketch showing each part in place. Remove a kernel from one of the spikelets and make a drawing showing the crease side, the germ side, and a cross-section view. All drawings should be at least one inch in height.

After the detailed study is finished, fill out the following table with data obtained by the examination of five average-size heads.

Number of the head	1	2	3	4	5
Length of head	.....	.....	.....	.....	.....
Number of developed spikelets	.....	.....	.....	.....	.....
Total number of kernels	.....	.....	.....	.....	.....
Average number of kernels per spikelet	.....	.....	.....	.....	.....

How many average-size heads must there be per acre to give a yield of 20 bushels of threshed grain?

Thresh by hand 100 average heads and weigh the threshed grain.

Discussion: The head of wheat is called a *spike,* and is composed of *spikelets* arranged to alternate on two sides of a

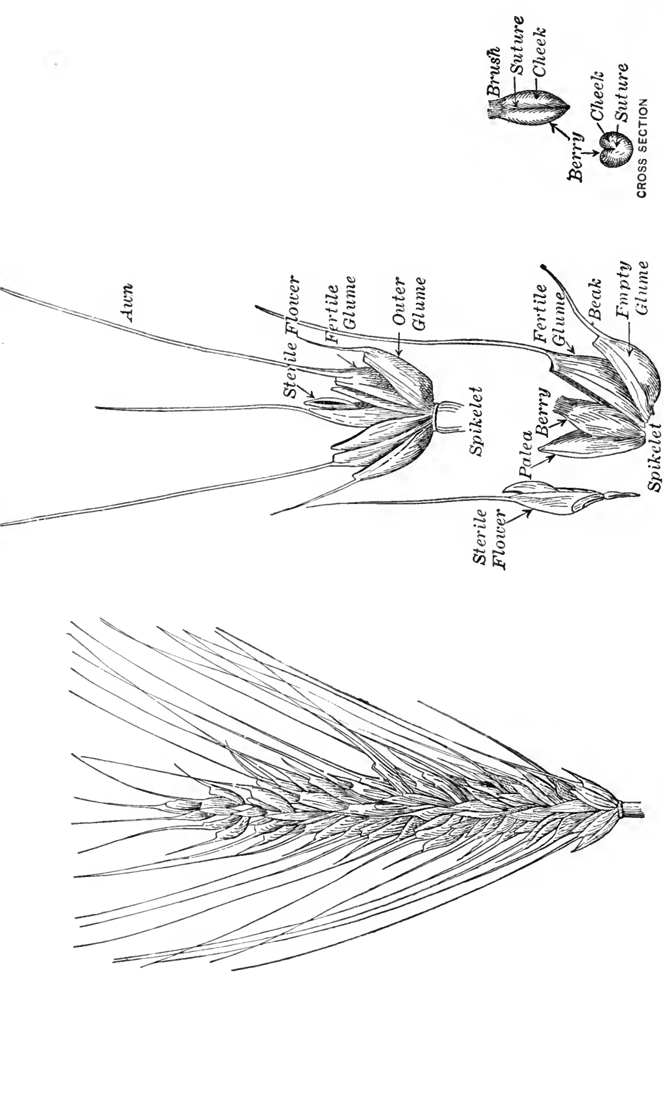


FIG. 25.—*A*, Wheat Spike. *B*, Spikelet Removed from Spike and Dissected out. *C*, External and Cross-section View of Wheat Kernel.

central stem called the *rachis*. Each fully developed spikelet has two or more grains and an undeveloped flower. When only two grains develop in a spikelet each grain is enclosed in an outer glume, a flowering glume, and a thin inner glume called the *palea*. When a third kernel is present, it has no outer glume, but is enclosed between the flowering glume and palea. The germ of the kernel is at the base and faces toward the outside of the spikelet; the creased side of the grain faces toward the center of the spikelet and is covered by the palea. Extending from the upper end of the kernel is a tuft of very fine hairs called the *brush*.

EXERCISE 27. EARLY DEVELOPMENT OF THE WHEAT PLANT

Equipment: Young wheat plants one, two, three and four weeks old a part of which have been planted one inch deep and the remainder three inches deep.

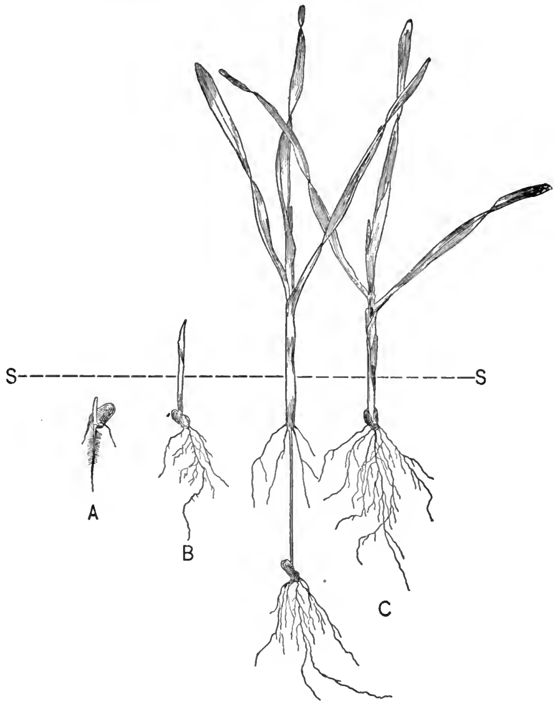


FIG. 26.—The Early Growth of the Wheat Plant. *S–S* is Soil Surface. Note the Fine Root Hairs on *A*. The Plant to the Left of *C* Shows the Temporary Roots Formed when the Grain is Planted Deep. Directly above *C* is the Same Plant a Few Days Later.

Method: Follow the directions given for the study of the early development of the corn plant in Exercise 15.

Discussion: The roots of the wheat plant comprise both a temporary and a permanent set. When the kernel is placed in a warm moist soil it starts to grow, and sends out a whorl of three small roots which supply the temporary connection between the plant and the soil. After the leaves unfold above ground a permanent set of roots develop about an inch below the surface, regardless of the depth at which the grain has been planted. These permanent roots increase rapidly in length and develop into a fibrous root system which serves the plant for the remainder of its life. The greater part of the roots of the mature plant are to be found in the surface fifteen to twenty inches of soil, but in loose mellow soil some of the larger roots may go down five to six feet.

The depth of seeding for wheat will vary with the kind of soil, amount of moisture and the fineness of the seed-bed. Wheat may be seeded deeper in a sandy than in a clay soil and it is desirable to sow deeper in a dry than in a moist soil. Under average conditions it is desirable that the seed be covered with about one inch of moist soil. On uneven, cloddy ground it is necessary to put some of the grains deeper than is usual in order to be sure that all grains will be covered.

EXERCISE 28. JUDGING WHEAT

Equipment: A number of peck samples of wheat; a grain tester; a pair of good balances.

Method: Make a careful examination of each sample and record the scores on the following score card:

	Perfect Score.	Number of Sample.				
		1	2	3	4	5
Weight per bushel	25	.....	.....	.....	.....	.....
Soundness	20	.....	.....	.....	.....	.....
Purity	10	.....	.....	.....	.....	.....
Plumpness	15	.....	.....	.....	.....	.....
Uniformity in hardness	15	.....	.....	.....	.....	.....
Uniformity in color	10	.....	.....	.....	.....	.....
Uniformity in size of grains	5	.....	.....	.....	.....	.....
Total	100	.....	.....	.....	.....	.....

Explanation:

1. *Weight per bushel*—25.

Wheat should weigh sixty pounds per measured bushel. Cut two points for each pound below this.

2. *Soundness*—20.

There should be no sprouted, cracked, smutty, musty, binburned, or otherwise damaged grains in the sample. Cut two points for each per cent of unsound grains.

3. *Purity*—10.

The sample should be free from mixture or foreign matter of any kind. Cut one point for each per cent of foreign matter.

4. *Plumpness*—15.

The grains should be well filled and plump. Cut one point for each two per cent of shriveled grains.

5. *Uniformity in hardness and texture*—15.

The berries should be uniform in hardness and texture. In a lot of 100 grains determine three classes: (1) grains

FIG. 27.—Kettle for Determining the Weight per Measured Bushel. The Vessel Should be Filled to Overflowing by Pouring the Grain from a Bag Held about Two Inches above the Top. Before Weighing the Grain is Leveled Off by a Diagonal Stroke.

hard and vitreous. (2) grains soft and starchy, (3) grains intermediate.

Cut one point for each three per cent representing class 2 and one point for each ten per cent in class 3. In a fairly uniform sample two classes only may be distinguished.

6. *Uniformity in color*—10.

Cut one point for each three per cent not uniform in color with the bulk of the sample.

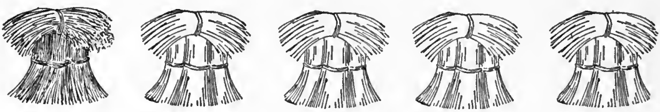
7. *Uniformity in size*—5.

Cut one point for each four per cent of undersized grains.

EXERCISE 29. THE PRODUCTION OF WHEAT IN THE UNITED STATES

Equipment: Yearbook of the United States Department of Agriculture.

Method: From the Yearbook obtain the figures for the production of wheat in each State in the United States. Represent the geographical distribution of the areas of large production on the accompanying blank map by the use of appropriate shadings. Those States which produce more



United States. Rest of the World.

Fig. 28.—Of the Total World's Wheat Crop, United States Produces about One-fifth.

than 50 million bushels should be shaded black; those producing more than 25 million but less than 50 million bushels a lighter shade; and those having a production less than 25 million bushels left unshaded.

Discussion: The United States is the largest wheat-producing country of the world, while Russia occupies the second place. In this country about one-half of the crop is produced in the North Central States west of the Mississippi River, including Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska and Kansas. In Minnesota and the Dakotas practically all of the wheat is seeded in the spring, while in the other States the crop is seeded in the fall.

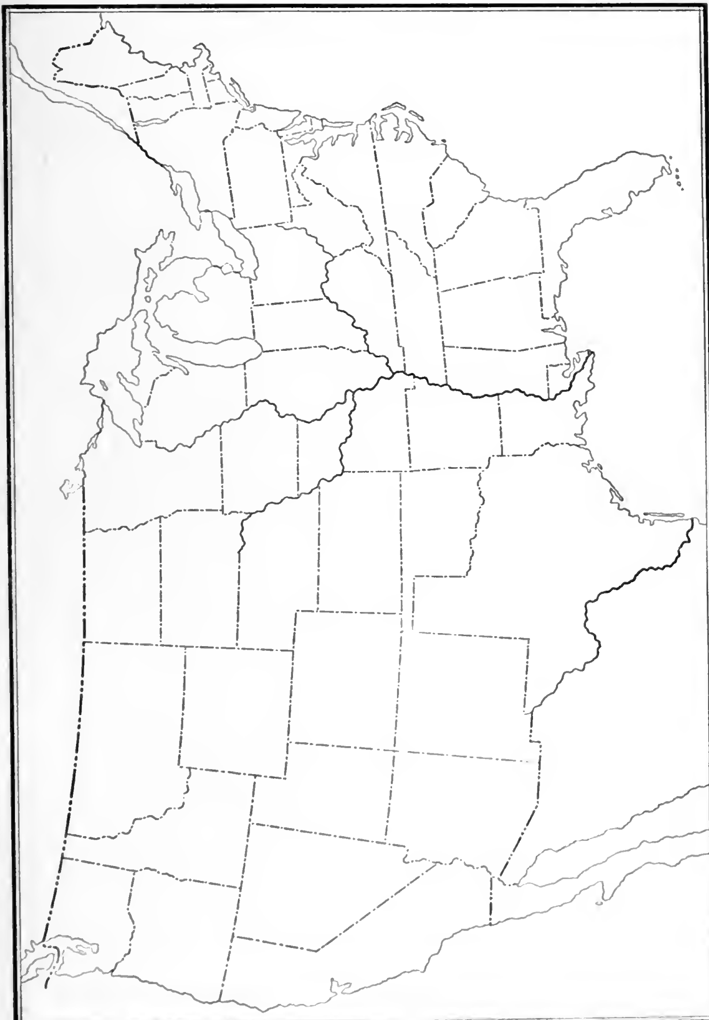


FIG. 29.—Map to Show the Production of Wheat in the United States.

EXERCISE 30. EARLY GROWTH OF THE OAT PLANT

Equipment: For this exercise the same preparation is to be made as that described for corn.

Method: Follow the directions given for corn in Exercise 15.

Discussion: Unlike the wheat grain, the oat kernel is enclosed in a loose hull, which is considered as a part of the grain. In the germination of the grain and the formation of the temporary and permanent root systems, the oat is similar in its development to wheat. In the South, where the winters are mild, oats are seeded in the fall and get their root system developed before cold weather, but in the North the seeding is delayed until early spring. It is essential, however, that oats be seeded quite early in the spring in order that the plants may have an opportunity to come to maturity before the dry, hot summer season is far advanced.

Experiments concerning the depth of seeding oats indicate that the best depth is from one to two inches, but in case the soil is quite dry a greater depth may be desirable. In some sections the oats are seeded broadcast over the surface and plowed or harrowed into the surface of the soil without any previous preparation of seed bed. The best yields are obtained, however, when the oats are drilled into a seed bed that has been prepared by thorough disking and harrowing.

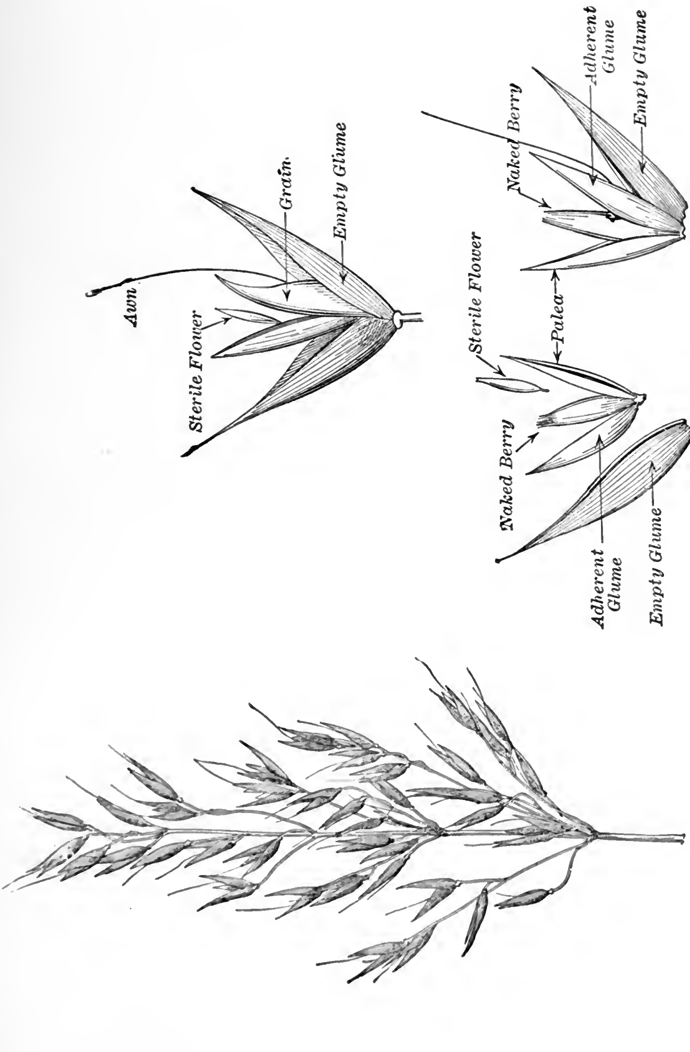


FIG. 30.—The Cat Head with a Spikelet Dissected Out to Show the Grain and its Coverings.

EXERCISE 31. JUDGING OATS

Equipment: A number of peck samples of oats; a grain tester; and a pair of good balances.

Method: Make a careful examination of each sample and mark the scores on the following card:

	Perfect Score.	Sample Number.				
		1	2	3	4	5
Weight per bushel	35	.....	.....	.....	.....	.....
Soundness	20	.....	.....	.....	.....	.....
Color	15	.....	.....	.....	.....	.....
Purity	10	.....	.....	.....	.....	.....
Per cent of hull	20	.....	.....	.....	.....	.....
Total	100	.....	.....	.....	.....	.....

Explanation: In this score card oats are judged principally from the market standpoint. It is not possible to make a score card which can be used to judge oats from the feeder's and the miller's standpoint, and at the same time be used to determine the quality of the grain for seeding. Different points would be used in each case, and different values given them.

1. *Weight per bushel*—35.

Weight per bushel is important as a means of estimating the value of oats for market and feeding as well, since a heavy weight indicates that the grain was well matured and the hull well filled out. In the same variety, a heavy oat usually has a smaller per cent of hull. A good sample of oats should weigh 32 pounds per measured bushel. Cut four points for each pound below standard weight.

2. *Soundness*—20.

The sample should be sound, dry, bright, and free from musty, smutted, sprouted, or otherwise damaged grains.

3. *Color*—15.

The color of the grains should be bright and uniform for the bulk of the sample.

Cut one point for each per cent of discolored grains and grains not uniform in color with the bulk of the sample.

4. *Purity*—10.

The sample should be free from mixture, other grain, weed seeds, straw, chaff, and any other foreign matter of any kind.

Cut one point for each per cent of mixture and the same for each per cent of foreign matter.

5. *Per cent of hull*—20.

A good oat may have as much as thirty per cent of hull. Cut two points for each per cent of hull above this, for each per cent below, add one point to the total score.

EXERCISE 32. THE TREATMENT OF SEED OATS FOR SMUT

Equipment: A bag of seed oats; formalin (forty per cent solution); a clean sprinkling can; a shovel.

Method: Spread the oats to be treated on a clean, tight floor. Make up a solution which shall contain formalin to the amount of one pint to fifty gallons of water. Apply the formalin solution by means of the sprinkling can, shoveling the oats over during the application, in order to secure a complete wetting of the grains. Continue the application until all of the grains are thoroughly moistened, but not so wet that they will stick together when pressed in the hand. Shovel the oats into a pile and cover with clean bags for a period of three or four hours. After the removal of the bags the grain should be dried as rapidly as possible by spreading it in a thin layer and shoveling it over occasionally. The same treatment is effective in destroying the spores of the stinking smut on seed wheat.

The exercise may be continued by seeding two plots side by side, one with the treated and the other with the untreated seed. After the grain is ready to harvest determine by count the per cent of smutted heads in the two plots.

Discussion: Smut spores adhere to the grain and, when the kernel sprouts, the fungus enters the plant, where it grows without becoming visible until the plant is ready to ripen. At this time the smut develops and converts the grains into a mass of dry, stinking powder. The yield of wheat and oats is frequently very much reduced by the presence of this fungus, and in case of wheat the grain may be rendered unfit for flour because of the offensive odor. The treatment of the seed with the formalin solution is an effective remedy against the smut of oats and the stinking smut of wheat. Corn smut, however, has a different life history and cannot be controlled by seed treatment.

This fungus develops in the soil and produces spores which are carried by the wind. If one of these spores finds lodgment in a wound on the stalk or ear, it develops and forms a smut mass. In some years the climatic conditions are much more favorable for the development of these smut masses than in other years. The only remedy is to go through the field, cut off the masses of smut and burn them to prevent the further production of spores.

EXERCISE 33. THE PRODUCTION OF OATS IN THE UNITED STATES

Equipment: Yearbook of the United States Department of Agriculture.

Method: From the Yearbook obtain the figures for the production of oats in each state in the United States. Represent the production on the accompanying blank map by the

Fig. 31.—United States Produces about One-fourth of the World's Oat Crop.

use of appropriate shadings to indicate the areas of large production. Those States which produce more than 100 million bushels of oats should be shaded black; those producing more than 50 million but less than 100 million a lighter shade; and those producing less than 50 million bushels left unshaded.

Discussion: The world's production of corn and wheat when measured in pounds is greater than that of oats, but

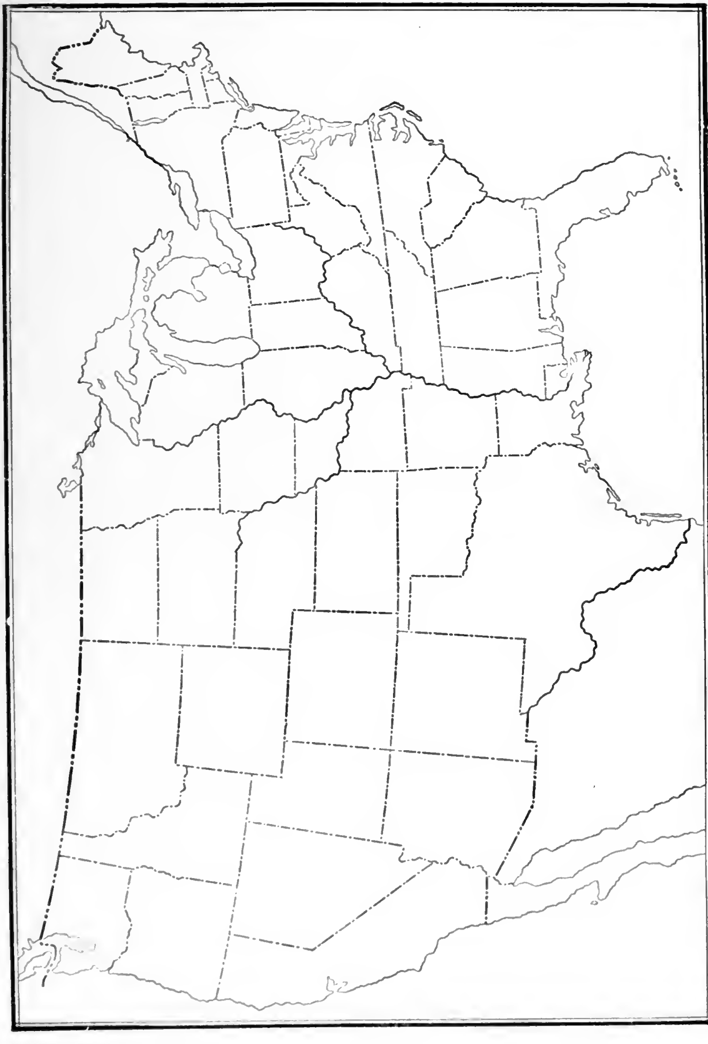


FIG. 32.—Map to Show the Production of Oats in the United States.

when measured in bushels the production of oats exceeds that of any other cereal. Of the total world's production the United States produces more bushels than any other country, while Russia occupies second place. In the United States oats rank second to corn in number of bushels produced, but in value the oat crop is surpassed by corn, cotton, hay, and wheat.

In 1850 New York, Pennsylvania and Ohio constituted the center of production for oats in the United States but by 1900 the center of production had moved westward to Illinois, Iowa and Wisconsin. Statistics show that in those states where there has been a decrease in the acreage devoted to oats, there has been an increase in the corn acreage.

During the past fifty years the oat crop of the United States has about doubled in proportion to the population.

EXERCISE 34. EARLY GROWTH OF THE RYE PLANT

Equipment: For this exercise make the same preparation as described for corn.

Method: Follow the directions given in Exercise 15.

Discussion: Almost forty per cent of the rye produced in the United States is grown in the three States—Pennsylvania, Wisconsin and Michigan. Rye will grow on rather poor soils and for this reason it is frequently seeded in the fall to be plowed under and used as a green manure in the spring. Very little of the rye grown in the United States is used for human food. In Russia and other parts of northern Europe, however, rye bread is one of the chief articles of food.

Rye is a hardy plant and stands the winter better than wheat. It may be seeded in the standing corn in September or after the corn is cut and shocked the rye may be disked in without plowing. In the spring the rye may be plowed down and the land again planted to corn or seeded to some other crop Care should be taken, however, to plow the rye under in the early spring before it has made too rank growth, otherwise it may exhaust the moisture from the soil and thus injure the crop which is to follow. As a cover crop for orchards it has given good results.

EXERCISE 35. EARLY GROWTH OF THE BARLEY PLANT

Equipment: For this exercise make the same preparation as that described in Exercise 15.

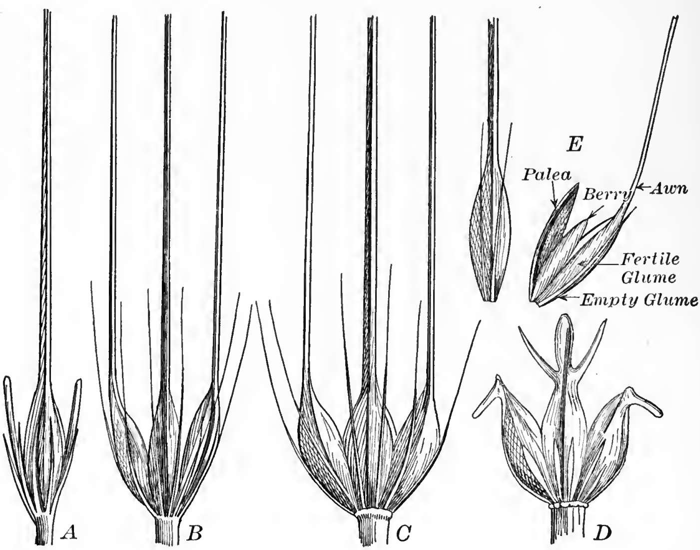


FIG. 33.—Different Types of Barley. *A*, Two-rowed. *B* and *C*, Three-rowed. *D*, Hooded and *E*, Parts of the Spikelet. (After Lyon and Montgomery.)

Method: Follow the direction given for corn in Exercise 15.

Discussion: Russia is the leading country in the production of barley. In the United States barley ranks ninth in point of value. The market grades of barley are largely based upon color and uniformity of germination.

Two kinds are grown in the United States—the two-rowed and the six-rowed. A head of the former has the appearance of having only two rows of spikelets situated on opposite sides of the stem, while the latter type has three rows on either side of the stem. The two-rowed varieties are grown extensively in the Dakotas, while the six-rowed type is grown quite generally throughout the United States.

Spring seeding is practiced in the North, while in the Southern States and on the Pacific Coast the barley is seeded in the fall. The winter varieties of barley are not so hardy, however, as the winter wheat varieties.

EXERCISE 36. THE IDENTIFICATION OF LEGUME SEEDS

Equipment: A supply of small bottles; samples of the following legume seeds *: red clover, white clover, alsike clover, alfalfa and yellow trefoil; a pocket magnifying glass.

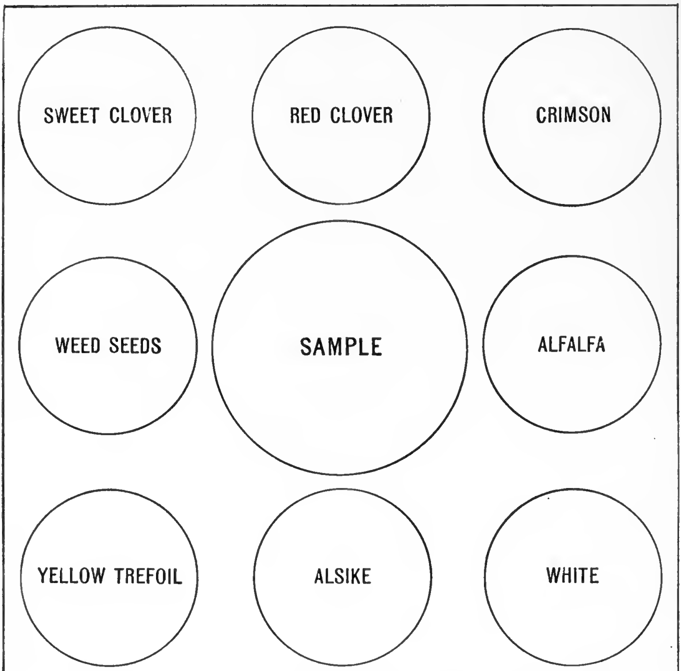


Fig. 34.—Diagram to be Used in Identifying Seeds.

* If the local seedsman cannot supply you write to your Agricultural College or to the United States Department of Agriculture for samples.

Method: Supply each pupil with a bottle containing a small quantity of a mixture of the above seeds. The pupil should empty the contents of the bottle into the circle in the center of the diagram given below and separate from the mixture all of the red clover seed, then remove the alfalfa seed into a separate pile within the proper circle and continue until all of the different kinds have been separated. If weed seeds are present, they should be separated also.

EXERCISE 37. PURITY TEST FOR GRASS, CLOVER, OR ALFALFA SEED

Equipment: Samples of seed from several sources and a hand lens or magnifying glass.

Method: Each student should be given two grams of the sample, on a sheet of white paper. With the help of the lens he should separate the seed into three piles: (1) chaff,

FIG. 35.—Examining Clover Seed for Impurities and the Presence of Other Seeds. (Courtesy of Extension Department.)

dirt, broken seed and stones; (2) weed seed; and (3) pure clover seed. Save the clover seed for Exercise 41.

Alfalfa, timothy, or other small grain may be substituted for clover in this exercise if they are more important crops than clover in the community. The selling price of the seed

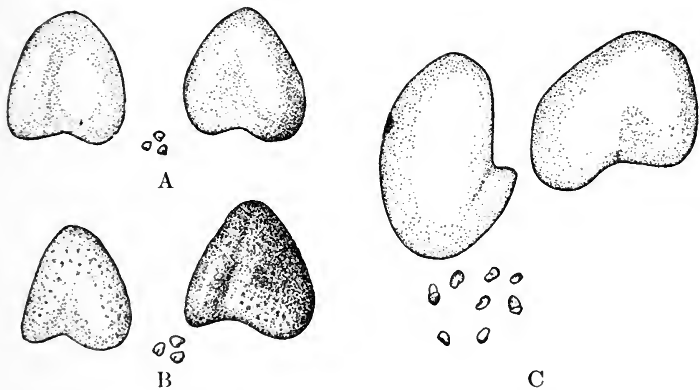


FIG. 36.—Natural Size and Magnified Seeds of *A*, White Clover; *B*, Alsike Clover and *C*, Red Clover.

should be secured when the samples are collected. Fill out the following table:

Sample No.	Weed Seed, Grams.	Chaff, Dirt, etc., Grams.	Pure Seed, Grams.	Per cent of Pure Seed.	Selling Price per Bu.	Cost per Bu. of Pure Seed.

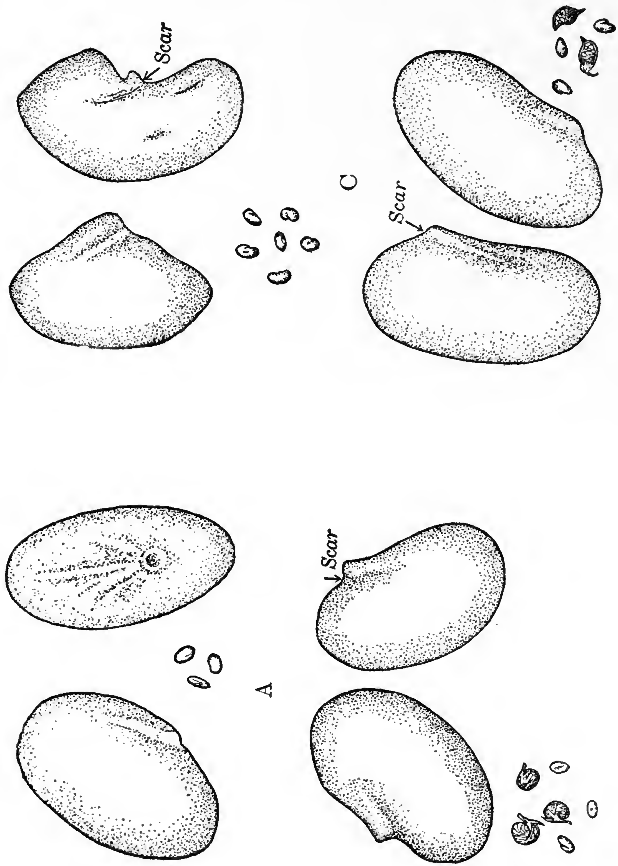


FIG. 37.—Natural Size and Magnified Seed. *A*, Crimson Clover; *B*, Yellow Trefoil; *C*, Alfa'fa; and *D*, Sweet Clover.

Which sample gives the largest amount of pure seed for the money invested? Can you identify any of the weed seeds? Taking into consideration the quality and the weed seeds, which sample should be purchased?

Discussion: Low-priced seeds are usually the most expensive that can be purchased, because they frequently show low vitality and may be seriously contaminated by the presence of troublesome weed seed.

Fig. 38.—A Good Magnifying Glass for the Examination of Seeds.

Before seed is purchased for the farm a small sample should be secured, tested for vitality, and examined for the weed seeds. In many States the Agricultural Experiment Station will test samples free of charge for the farmers of the State.

Weed seeds may be sent to the State Station or to the United States Department of Agriculture, Washington, D. C., for identification.

EXERCISE 38. A STUDY OF WEED SEEDS

Equipment: A collection of weed seeds properly labeled;* a hand lens.

Method: Have each member of the class bring in a collection of at least five weeds. Learn the names of these weeds and study their habits of growth, nature of their root system and the kind of seed which they produce.

Make a very careful study of the seeds so that each student will learn to recognize the more common weed seeds that are found in grass and clover seed. Extend the exercise by bringing in seed samples containing weed seeds and requiring the class to separate and identify as many as possible of the seed present.

Discussion: Some weeds are annual in their habits of growth and if prevented from producing seed will soon disappear from the fields. Many of the more troublesome weeds, however, are perennial, and send up new stems from the roots year after year. After the name of the weed has been learned, its habits of growth can be found described in any good manual of botany.

In connection with this exercise the pupils should read the following Farmers' Bulletins:

No. 28. Weeds and How to Kill Them.

No. 260. Seed of Red Clover and Its Impurities.

No. 382. The Adulteration of Forage Plant Seeds.

* In many States such a collection may be secured from the Experiment Station.

No. 428. Testing Farm Seeds in the Home and in the Rural School.

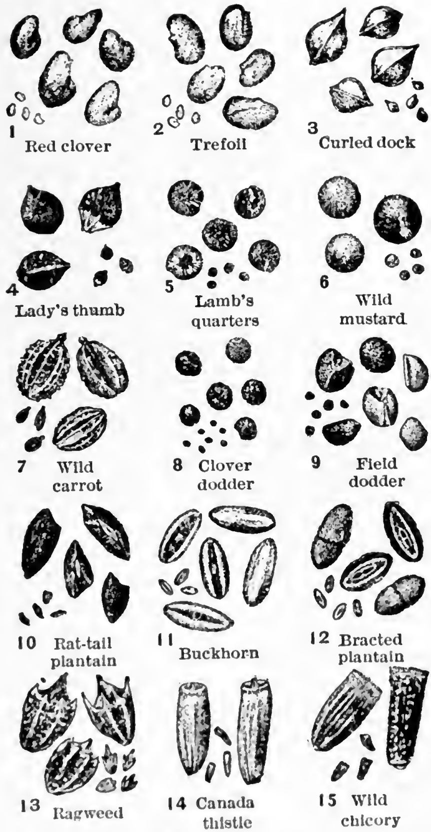


FIG. 39.—Some Weed Seeds Frequently Found in Clover and Grass Seed. Natural Size and Magnified.

In addition to the above bulletins the school should be provided with weed bulletins from the State Experiment Station.

EXERCISE 39. WEED DISSEMINATION

Equipment: Notebook and pencil.

Method: Study at least ten different kinds of weeds and determine how they scatter their seeds. Record the results in the following table:

Name of Weed.	Method of Dissemination.
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Discussion: Some seeds are provided with wings, or feathery tufts, which make them easily carried long distances by the wind; others have hooks which cause them to become attached to the clothing or to cattle and be carried from place to place. Weed seeds are also widely disseminated by birds and by streams.

The seeds of the common milkweed are provided with

Fig. 40.—Canada Thistle. It spreads by Seeds and by Underground Stems as Well. (Second Ohio Weed Manual.)

a tuft of hairs which cause them to be carried along easily by every gentle breeze. The common thistle, dandelion, wild lettuce, and many others, have seeds which are provided with tiny parachutes by the aid of which they are carried long distances by the wind. The manner in which the burrs of burdock, cockle burrs, Spanish needles and beggar lice stick to the hair of animals and to the clothing of persons, is familiar to all. Many plants, such as the wild raspberry and pokeweed, have fleshy fruits that are eaten by birds and the hard seeds pass through undigested. Many of these seeds germinate and grow wherever dropped.

EXERCISE 40. A FIELD STUDY OF WEEDS

Equipment: Spade and magnifying glass.

Method: During the early fall season make a trip across the neighboring corn fields and secure a sample of each different weed that is encountered. Dig or pull the weeds and see that each specimen includes *roots, stems, leaves,* and *seed* or *blossom.*

The small plants may be pressed between the leaves of a book and mounted entire on pieces of cardboard. Strips of gummed paper or court plaster may be used to attach the specimens to the cardboard. Specimens of some of the larger plants may be confined to a section of the stem, a leaf, and the flower or seed. In the lower right-hand corner of the cardboard give the common name, the scientific name, and the date when the weed was collected. Doubtful specimens should be sent to the State agricultural college or experiment station for identification. These mounted specimens will furnish material for a second exercise, at which time a detailed study should be made of the root systems and flowering parts with reference to the method by which the plants are propagated.

Discussion: Weeds are one of the most persistent and costly annoyances on the farm. They injure the farmer by reducing his crop yields and greatly increasing the labor necessary to produce a crop. Some of the injurious effects of weeds are the following:

(1) Weeds rob the soil of food materials that are required by other plants. While the total amount of food elements in the soil is sufficient in amount, the quantity

FIG. 41.—Horse Sorrel, the Presence of Which Indicates an Acid Soil. (Second Ohio Weed Manual.)

which is available at any one time is not sufficient to supply both the crop and covering of weeds.

(2) Weeds rob the soil of moisture. In dry seasons, when the moisture supply is limited, it is easy to see that

a crop of weeds will deprive the soil of the moisture needed for the useful plants.

(3) Weeds crowd the cultivated plants and deprive them of sunlight and of space, both in the air and in the soil.

(4) Weeds growing along fences and ditches afford a good place in which troublesome insects may live over the winter.

Successful measures in destroying weeds are founded upon a knowledge of the life of the weed and the manner of its propagation. To avoid introducing or spreading weeds is always better than destroying them. It is to be remembered, also, that while some weeds may be completely eradicated, others can only be held in check and subdued. While methods must vary for different weeds, a few general principles are applicable to all. The following methods are effective in keeping weeds in check:

(1) Prevent all weeds from going to seed and the introduction of weed seeds. This will be sufficient to subdue the annuals and biennials. The numerous ways, both natural and artificial, by which seeds may come in, makes it impossible to carry out fully the above rule, but much can be done in this direction that will prove helpful.

(2) Perennial weeds of all kinds must be cut repeatedly to starve out the underground roots or stems, which in this class of weeds gives rise to a new individual without the production of seeds. If the foliage of a plant is constantly destroyed, the death of the plant is only a matter of time and will be caused directly by root starvation. Any breaking or cultivating of the soil in which these

plants grow only serves the purpose of scattering them, unless that cultivation is persistent enough to keep down *all* growth of foliage. Salt, coal oil, and sulphuric acid may also be applied, but these are expensive, and persistent cutting will usually be found to be the cheapest and most effective method.

(3) Some weeds indicate poor soil conditions, and the remedy is to improve these conditions. For example, the presence of horse sorrel indicates an acid condition of the soil. An application of lime will improve the soil and cause this weed to be crowded out by more desirable plants. No amount of cutting or cultivating will eradicate it so thoroughly. Wet spots are usually covered with swamp grass and sedges. No amount of cutting will destroy them, but tile drainage will cause them to disappear.

EXERCISE 41. GERMINATION TEST FOR CLOVER OR GRASS SEED

Equipment: A pint of clover or alfalfa seed; two fiber plates; two pieces of white blotting paper and a pair of forceps for each student.

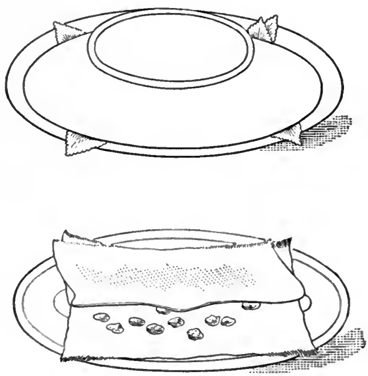
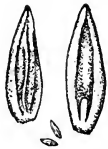
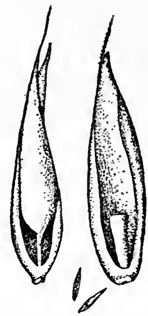


Fig. 42.—Dinner Plate Germinator.

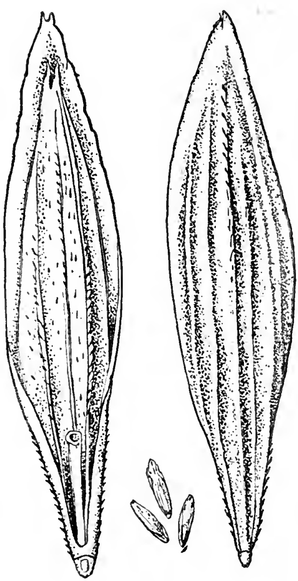
Method: Prepare the germinator by moistening one piece of blotting paper and placing it in the bottom of the fiber plate. Now count out 100 sound seeds and place them on the moist blotter. Moisten the second piece of blotter and lay it over the seed. Finally, protect the blotters from drying out by covering them with the second plate. Keep the blotters well moistened and at a temperature of 60° to 80° F.



Kentucky Blue Grass: Magnified Seeds and Natural Size.

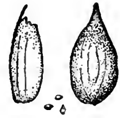


Orchard Grass: Magnified and Natural Size.



Brome Grass: Magnified Seeds and Natural Size.

Redtop: Magnified Seeds and Natural Size.



Timothy: Magnified Seeds and Natural Size.

Fig. 43.—Seeds of Some of the Common Grasses.

At the end of four days count and record the number of seeds that have sprouted. Remove all of the sprouted seed so that they will not interfere with the subsequent countings. Examine and count the sprouted seeds every other day for eight days.

The table below may be used to record the results of the germination tests of alfalfa and grass seeds.

Name of Sample.	No. of Seeds in Sample.	Number of Seeds Sprouted After			Total Per Cent Sprouted.
		4 Days.	6 Days.	8 Days.	

Discussion: Many samples of clover and grass seeds are low in vitality. It is essential, therefore, that a germination test be made before the seed is planted. Before purchasing, it is wise to secure samples and test them for vitality and for purity. A poor stand of clover or grass frequently results from the purchase of seed of low vitality

EXERCISE 42. A FIELD STUDY OF LEGUMES

Equipment: Spade; yardstick.

Method: Carefully dig up a clover plant in the field, noting the tiny *nodules* on the roots.

Dig up other legumes and observe their root system and the presence of nodules.

These nodules are the homes of the bacteria which have the power of taking the nitrogen from the soil and making it available for the use of the clover plant.

Discussion: Nitrogen is a very important food for plants and is very expensive when purchased in a fertilizer. Only the legumes that have the nodules on their roots are able to use this free nitrogen of the soil air. The legumes include the common clovers, alfalfa, soy beans, cow peas, garden peas and many other plants, all of which have a beneficial effect upon the soil.

In sections where a legume has been grown for many years the bacteria which work upon its roots may be found in abundance in the soil, but when a legume is taken to a new locality for the first time it is frequently desirable to add to the soil the proper bacteria. This process is called *inoculation*, and may be performed by means of pure cultures or by the shipment of soil from a locality where the legume has been growing.

Roots showing the nodules may be preserved in glass cans or wide-mouthed bottles by the use of a formalin solution consisting of one tablespoonful of formalin to each quart of water.

NOTE.—Formalin (forty per cent) can be purchased at any drug store. It is a clear, colorless liquid.

FIG. 44.—Soy Beans. The Plant to the Left Inoculated, the One to the Right Uninoculated. (Courtesy of Extension Department.)

EXERCISE 43. A STUDY OF SOY BEANS

Equipment: Samples of different varieties of soy beans, including type samples, a balance and a weight-per-bushel tester.

Method: Give each student a half pint of soy beans containing a small admixture of two or three other varieties and some impurities. Divide the sample into two equal parts, make an examination for purity and condition, and record the results in the table, using the type samples to aid in the identification of the varieties.

		Weight.	Per Cent.
Purity	Soy beans of the variety class..	....	....
	Soy beans of other varieties....	....	....
	Other seeds................	....	....
	Foreign matter.............	....	....
Condition	Sound seeds............	....	....
	Broken seeds............	....	....
	Moldy seeds.....	....	....
Weight of 100 soy beans of variety class..		....	
Weight per measured bushel...........		....	

The same procedure may be used in the study of cow peas.

Discussion: Soy beans are easily broken in the threshing process, hence the grain found on the market usually has a great many broken seed. The broken grains are not fit for seed, therefore, a sample which contains a large number of broken seed has its value for seeding purposes much reduced. Both purity and condition should be taken into consideration in determining the value of a given sample for seed purpose.

Some varieties of soy beans have been given names which indicate the length of the growing season required for their development and the color of the bean. For example we have such varieties as medium yellow, medium green and mammoth yellow. When harvested for seed the soy bean must be cut before the pods are dry, otherwise they shatter badly and a large percentage of the beans will be lost in the handling before the crop gets to the thresher.

EXERCISE 44. A STUDY OF THE POTATO

Equipment: Fifteen pounds of potatoes of various sizes and shapes and if possible representing different varieties; a paring knife; a balance.

Method: Weigh out ten pounds of potatoes and make a study of the qualities that affect the value of the individual tubers.

		Sample Number. 1	Sample Number. 2
Shape	Round		
	Oval		
	Flat oval		
Size	Large		
	Small		
Color of skin	Yellowish white		
	Pink		
	Russet		
	Red		
	Other colors		
Texture of skin	Corky		
	Medium smooth		
	Very smooth		
Depth of eyes	Deep		
	Shallow		
Condition	Clean		
	Cracked or broken		
	Diseased		

Separate the potatoes into groups with respect (1) to shape, (2) to size, (3) color of skin, (4) texture of skin, (5) depth of eyes, and (6) condition, and record the results of each separation.

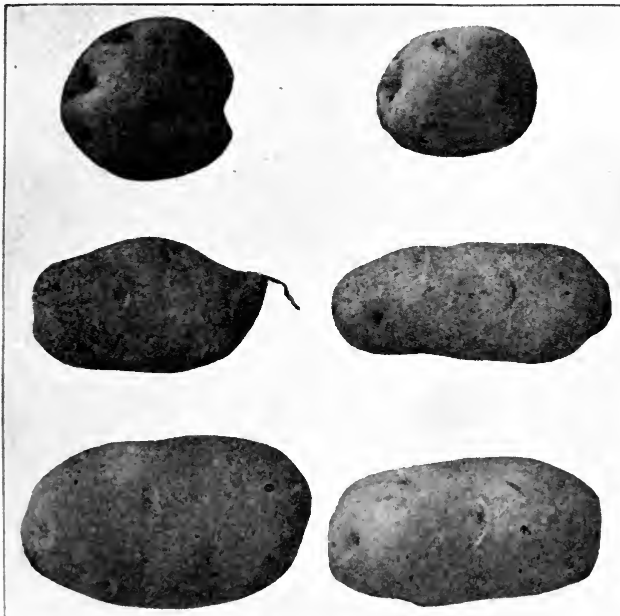


FIG. 45.—Tubers of Desirable and Undesirable Shape. The Potato at the Bottom is of the Desired Shape. (After Frazer.)

Select from the sample five large, five small, and five knotty, rough potatoes. Weigh each group separately and after recording the weight, peel the potatoes in each group. Weigh and record the weight of peeled potatoes and from the weighings determine the per cent loss in the peelings.

	Weight of Whole Potatoes.	Weight of Peeled Potatoes.	Weight of Peelings.	Per Cent of Waste.
Large potatoes.......	....	....	....	....
Small potatoes.......	....	....	....	....
Rough potatoes......	....	....	....	....

Discussion: The part of the potato which we eat—the tuber—is an underground stem. Every tuber has a number of *eyes* on the surface, each of which marks the location of a bud. In some varieties the eyes are shallow while in others they are quite deep, and in all varieties they are more numerous toward the end of the potato which is attached to the stolon. Practically all higher plants have some means of storing up food which can be used at a time when they need material to start growth from a dormant condition. For the potato plant, the tuber serves as a storage organ for this reserve food.

EXERCISE 45. A FIELD STUDY OF THE POTATO

Equipment: A pail; a potato fork and a pair of spring balances.

Method: Dig ten hills of potatoes. Count and weigh the large, marketable, and the small tubers in each hill. Record the results in the following table:

Hill.	Large Tubers.		Small Tubers.	
	Number.	Weight.	Number.	Weight.
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
Total				

Note the variation in the individual hills. Which hill would be the most desirable to save for seed? Would you prefer large seed potatoes from a poor-yielding hill or medium tubers selected from good hills?

Discussion: In the improvement of potatoes, the seed should be selected from the best hills rather than with reference to the individual tubers. The careful selection of

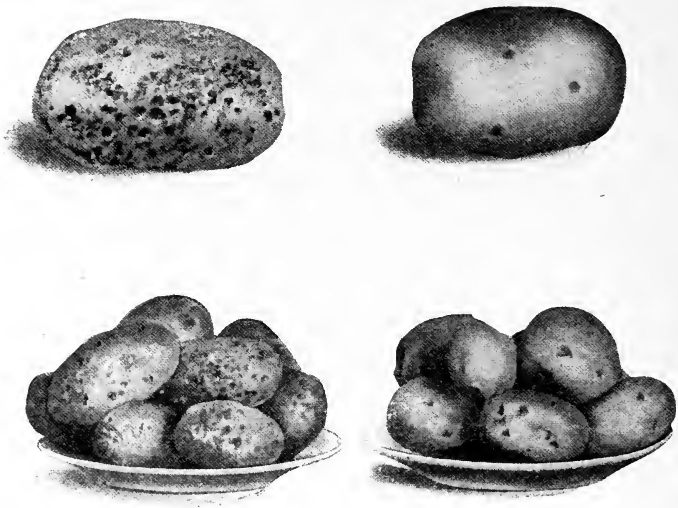


FIG. 46.—The Use of Scabby Seed Potatoes will Produce a Scabby Crop. Seed Treatment will Prevent the Disease.

potatoes from the best hills will result in increased yields and an improvement in the quality of the potato. Many growers believe that if the same variety is grown in the same locality for a long time it will run out. The better growers, however, believe that good cultural methods and proper care and selecting of the seed will keep varieties in a productive condition for many years.

EXERCISE 46. TREATMENT OF SEED POTATOES FOR SCAB

Equipment: A supply of seed potatoes, one ounce of formalin (forty per cent) and a clean three-gallon bucket.

Method: Mix the ounce of formalin with two gallons of water.* This will make sufficient solution to treat a bushel of seed or more, since the solution can be used repeatedly. Soak the seed in this formalin solution for about two hours just before planting. A convenient method of treatment consists in putting the formalin solution in a barrel or tub, the potatoes in a basket or bag, and immersing them in the barrel or tub of solution.

Discussion: The scab is a fungous growth upon the surface of the potato and greatly diminishes the market value of the crop. When scabby potatoes are planted, the spores of the disease are carried over to the next crop and the result is a large number of undesirable, scabby tubers. Since this disease is known to live over in the soil for several years, a change of soil is sometimes necessary. However, it is not difficult to keep the disease in check if proper precautions are taken regarding the treatment of the seed and rotation of the crop.

* One pint of corrosive sublimate in thirty gallons of water will be quite as satisfactory as the formalin solution, if the latter is more convenient to obtain.

Fig. 47.—Treating Seed Potatoes for Scab. The Tubers are Placed in a Wire Cylinder and Immersed in the Barrel of Solution.

EXERCISE 47. A LABORATORY STUDY OF COTTON

Equipment: A sufficient number of bolls of cotton to supply each student with three different types. They should be picked at least two weeks before they are needed. The different types of bolls may be obtained from different varieties or by taking bolls from the base, middle and top of the same plant.

Method: Determine the length of the lint taken from the middle portion of the seed and record the average of five determinations. Count the number of seeds in each lock; note the color and amount of fuzz. Make counts and weighings necessary to fill in the blanks in the following table:

Sample.	Average Length of Lint in inches.	No. of Seeds per Lock.	Color of Fuzz.	Number of Bolls to Make a Pound.		Number of Seeds per Pound.
				Seed Cotton.	Lint Cotton.	

Discussion: The cotton fiber grows in large capsules called *bolls.* In the large varieties 50 or 60 bolls will make a

Fig. 48.—The Cotton Plant in Full Fruit.

pound of cotton, while in some of the small varieties 100 to 130 bolls are required to weigh a pound.

Each boll usually contains four lobes or cells which split open as the cotton ripens, exposing the dark-colored seeds which are covered with white fibers. The seed cotton in each cell is called a lock of cotton, and will have from six to ten seeds. The short staple, upland cotton grown in America has lint varying in length from $\frac{7}{8}$ to $1\frac{1}{4}$ inches, while the long staple has fibers greater than $1\frac{1}{4}$ inches in length. The Sea Island cotton produces lint from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in length. In proportion to the diameter of their fibers, silk has a greater tensile strength than cotton and wool a less. All of these fibers, however, have great tensile strength. It is estimated that wool fiber must be five miles, cotton fifteen miles, and silk twenty miles long before it will break of its own weight.

EXERCISE 48. A STUDY OF COTTON IN THE FIELD

Equipment: A tape measure and a fine-toothed comb.

Method: The pupils may be taken to the field for this exercise any time during the harvesting season, but preferably at the second picking. Make the observations and measurements necessary to fill in the following table:

Distance apart of rows..............................	....
Distance apart of plants in row..........................	....
Average height of plants............................	....
Average width of plants............................	....
Average number of bolls per plant...................	....
Average number of seeds per lock.....................	....
Seeds fuzzy or naked................................	....
Color of the seed.................................	....
Average length of the lint..........................	....
Color of the lint.................................	....

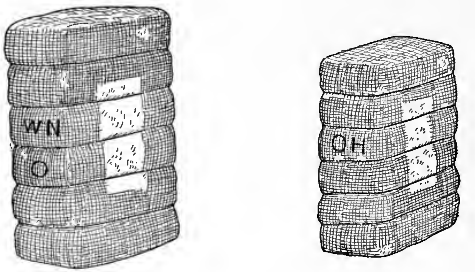
Where does the longest lint occur?

Make a longitudinal and cross-section drawing of a boll, showing locks and seeds.

Discussion: Cotton plants should be thinned to one plant in a place and twelve to eighteen inches apart. The width of rows may vary from thirty to sixty inches. The narrow row with the plants further apart in the rows will usually give a better yield of cotton, but the narrow rows are more expensive to cultivate. Cotton usually receives its first cultivation when the plants are four to six inches high,

Fig. 49.—Picking Cotton on a Southern Plantation.

which is two to four weeks after the date of planting. This first operation consists in throwing a small furrow away from the row with a one-horse turning plow. The plants are then chopped out with a hoe, leaving one plant every twelve to fourteen inches. In the second cultivation the soil is



United States. Rest of the World.

Fig. 50.—Cotton Crop of the United States as Compared with the World's Crop.

thrown back to the plants by going twice around each row. These two operations should follow each other in rapid succession, in order to prevent an excessive loss of moisture. For the remainder of the season the cultivation should be no deeper than is necessary to eradicate the weeds.

EXERCISE 49. A STUDY OF RICE

Equipment: A supply of rice heads comprising two or three different varieties such as Honduras, Carolina and Japan.

Method: Give each student a head or a few grains of each variety and require him to fill in the outline given below:

Variety			
Color of hull			
Color of cuticle			
Density of endosperm			
Endosperm vitreous or white			
Average length of 10 grains			
Average width of 10 grains			
Average length of 10 kernels			
Average width of 10 kernels			
Weight of 10 grains			
Weight of 10 kernels			
Per cent of hull to grain			

How many grains on an average head of rice?

How is the rice grain prepared for table use?

Discussion: The greater part of the rice produced in the United States is grown by the wet-culture method. The land is flooded immediately after planting in order to sprout the seed. As soon as this is accomplished the water is withdrawn until the plants have attained the height of six to ten inches, at which time the land is again flooded and the water retained until the grain is in the milk stage, when it is again removed to permit the grain to ripen.

EXERCISE 50. PLANNING THE HOME GARDEN

Equipment: A 50-foot tape and some plain drawing paper.

Method: Carefully measure your home garden and lay it off to scale on a plain sheet of paper. If the garden is 200 feet long and 100 feet wide, it may be laid off on the scale of 1 inch on the paper for 10 feet, which will make the drawing 10×20 inches. Every part of the plan should be drawn to the same scale. Make a list of the garden crops which you wish to grow, and calculate the area that should be devoted to each. Finally, draw on your outline a plan for the garden, showing where all of the crops are to be located and the area that is to be devoted to each.

Discussion: Wherever it is possible, every home should have a plot of ground set aside for the growing of fresh vegetables and small fruits. For the farm home the garden should be large enough to permit of horse cultivation. Here the rows should be long and wide apart. In the village where the space is limited the rows may be placed close together and the plants given hand cultivation.

A knowledge of the seasons and habits of growth of the various vegetables will enable a gardener to take advantage of two systems, known as *companion* and *succession cropping.* These are designed to economize space, labor, and plant food and to give an opportunity of producing a larger yield or a greater variety on a certain area.

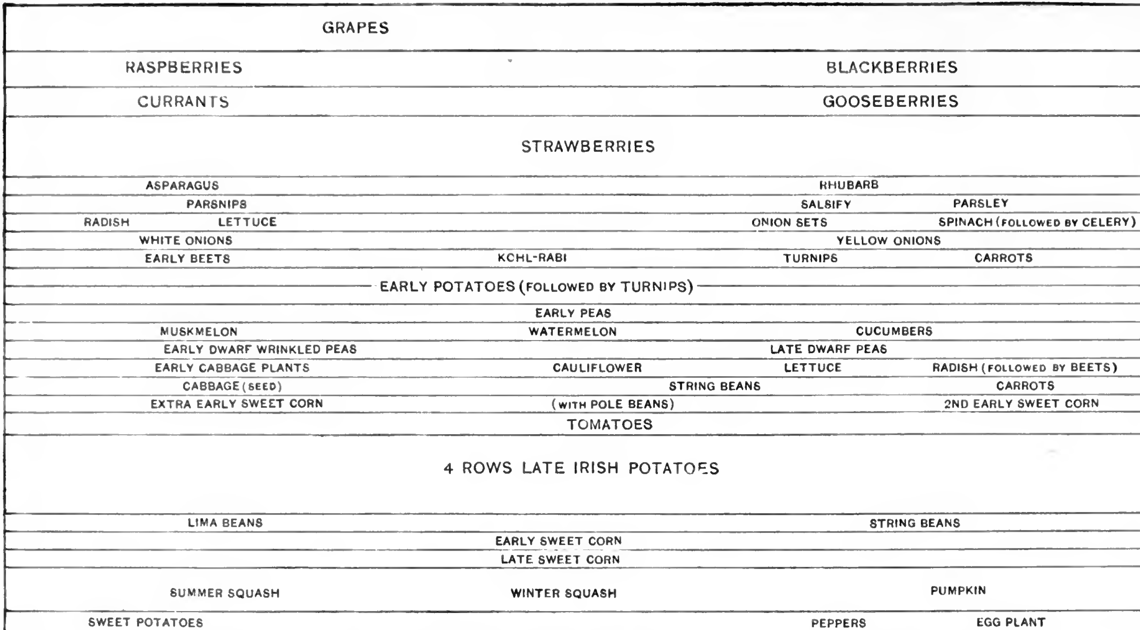


FIG. 51.—Diagram of a Farmer's Garden, 96 ft. by 200 ft. (Courtesy of Extension Department.)

Companion cropping is the growing of more than one kind of crop in the same space at the same time. That is, two or more crops occupy the ground together, but their seasons for full development are of different lengths and the earlier-maturing ones are up and utilized before their slower-growing companions are large enough to need the space. The first crop to mature may be planted in the same rows with the others or between the rows. Companion cropping ordinarily would not be practiced to any great extent in the farm garden. It often requires an increased use of the smaller hand tools and more time and attention must be given to details if the system is to be a success. On the farm, there is usually sufficient space for the garden, so that the grower can better afford to use more ground than to obligate himself to spend more time and labor there. In limited areas, companion cropping is usually an advantageous practice.

Vegetable growers make use of a large number of combinations in their work, a few of the more common ones being as follows: Lettuce and early cabbage grown alternately in the row. The lettuce will be ready for consumption early, and after its removal the cabbage has the entire space. Radish seeds may be sown thinly in the same rows with onions, parsnips, parsley, salsify, beets, kohlrabi, turnips, carrots and others.

Succession cropping will probably prove of more value to the farmer than companion cropping. By this system, the ground is kept occupied by a crop nearly all of the time. When an early-maturing kind is removed, it is followed by some other vegetable whose season will permit its being

Fig. 52.—A Well-arranged Garden. (Courtesy of Extension Department.)

planted at that time. Successions allow of a much greater variety of produce being raised on a given area than would be possible by single planting.

The following are a few suggestions for successions: Celery to be used succeeding radishes, lettuce, onions, turnips, spinach, early potatoes and other early crops; turnips

Fig. 53.—Berry Boxes may be Used to Advantage for Starting Tomato or Other Plants Indoors in the Early Spring.

after the same vegetables; beets following lettuce, radishes, etc.; early sweet corn replaced by beans, early potatoes by late sweet corn. There is opportunity for making a very large number of combinations, but the above are given merely as examples. The home or school garden can be used by the teacher as a laboratory for the demonstration of the principles of soil management and for illustrating methods of plant propagation.

The pupils should be encouraged to do all the work of preparing the land as well as planting the seed and caring for the plants. The preparation of the soil can be converted into a lesson in soil physics, the teacher explaining the nature of the soil as a source of plant food, as a mechanical support to the plant, and as a storehouse and conveyor of water and air. The influence of tillage on the liberation of plant food and water content, the importance of hoeing or cultivating to eliminate competition by the destruction of weeds and to conserve moisture by the maintenance of a soil mulch, and the necessity of thinning the plants in the row in order to reduce competition and increase the feeding area of the individual plant, should be clearly presented.

The influence of pruning on tomatoes to lessen competition among the branches and increase the food supply to the fruits retained should be brought out. The plants themselves offer material to use as a basis for discussing their life processes, including germination, growth, the functions of leaves, stems, roots, and flowers, and, finally, the storing of material in the finished product.

APPENDIX

TO OBSERVE CORN DAY *

Equipment: Enthusiasm and the cooperation of the pupils and their parents.

Method: To make this day a success, not only the children, but the parents, must be enlisted. The social element in it is very important. Every parent must be so interested that he will feel he must be present. Plan for an entire day given to the special occasion. If there is anyone in the vicinity who is an authority on agriculture, secure him as a speaker. If this is done, have two programs, one in the forenoon for the speaker and one in the afternoon, when the children shall take a prominent part.

For the children's program, plan to show the results of the work done in the study of corn. Let it include the best compositions written on the more interesting phases of the work. The History of Corn, The Indian Corn Dance, The Importance of Corn in America, The Development of Breakfast Foods, The Possibilities in a Corn Stalk, How Six Ears went to Market, The Story of a Stalk of Corn, Number of Days of Work Needed for One Man and a Team to Raise and

* Adapted from Farmers' Bul. 617.

Harvest an Acre of Corn, are suggested subjects. The history and work of the farmers' institute may be reported by one of the older pupils. Another might give an account of what the agricultural college is doing for the State.

If sufficient interest has been aroused, a corn-judging contest might be held. For judging the corn exhibits prepared by the pupils secure some man who has studied corn judging. Be sure to make this a feature of the day, making the announcing of the results a part of the program.

Music should not be omitted from the program. Some patriotic music should be included, as should the State song.

Plan to have dinner at the school, and use every device possible to make it a corn dinner. There are many ways in which corn can be prepared which will add to the effectiveness of the plan. Souvenirs of the day should be made by the pupils, carrying out the corn idea. For a language lesson, prepare written invitations to the patrons of the school. Be sure to include the local editor in the list of invitations. Having a report of Corn Day written by some of the pupils for the local papers.

The decoration of the school room should not be neglected. Use some fine specimens of corn in completing the decorations. Grains of yellow, white, and red corn are full of possibilities, as are the stalks. The rooms should be decorated so as to give joy and impress the thought that the man who raises a good crop of corn is engaged in an exalted work. The following letter might be sent to all patrons of the school:

Dear Friend and Patron of the ....School

The teachers and pupils of .... School, have decided to have, on ...., a "Corn and Other Products Day," and we cordially invite your cooperation and attendance. Bring good samples of corn, fruit, potatoes, tomatoes, poultry, and other home or farm products that you care to exhibit, and help us to make it a day of educational value. A special program, participated in by the pupils and others, will be a feature of the day.

Please bear in mind that this is your school and that your cooperation and presence will be both a help and an inspiration.

Sincerely yours,

...., Teacher.

Selecting the Exhibit for Corn Day. The exhibit from one person usually consists of five or ten ears of corn. Sometimes a ten-ear exhibit to represent the entire local school is made up by selecting that number of ears from the best ones brought in by all the members of the school.

One very important thing to observe in choosing and arranging such exhibits is the principle of *uniformity*. This means that in order to get a high rating all the ears in the set must *look alike* as nearly as possible. A corn judge often discards a set of five to ten ears from any further consideration simply because the exhibitor included among them one ear that was an inch longer than the rest, or of a different shade in color, or that has a different number of rows of kernels, or kernels of noticeably different shape or size than those on the rest of the ears. Sometimes the size of cob in one ear differs from all the others, or one ear is crooked or has "twisted" rows of kernels, while all the rest are straight. Any of these defects spoil the uniformity of the set and cause

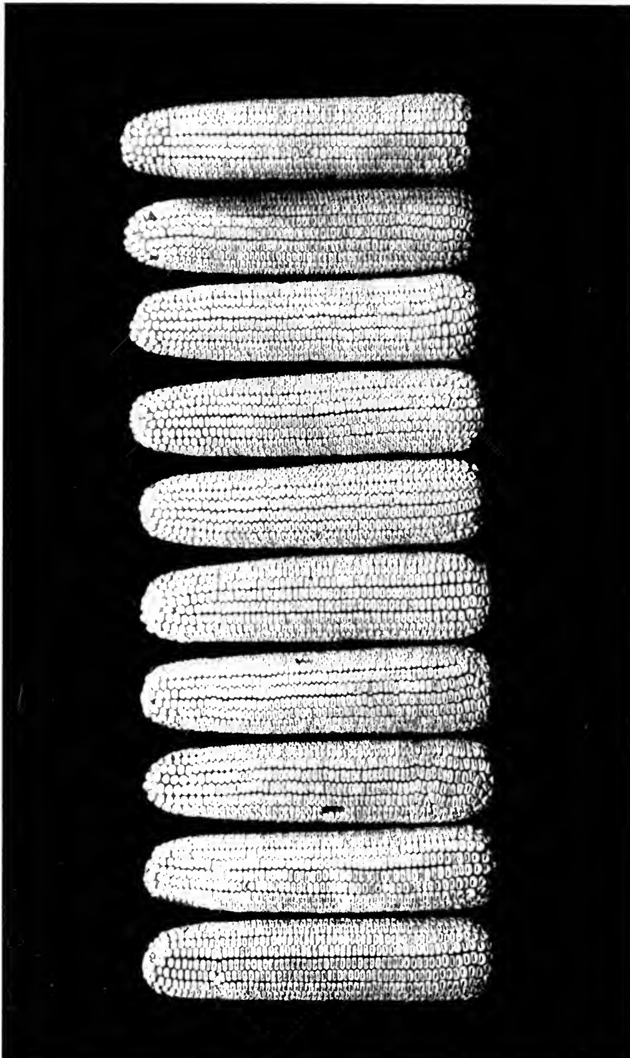


FIG. 54.—Prize Sample of White Corn at the National Corn Show.

the set to be marked severely. It is better to select ten ears that are not the very best, but are *alike,* than to include one ear that is either much better or much worse than all the rest in the set. Pick out the best forty or fifty ears you can find, and then from these, by careful measurement and comparison, select for your exhibit the five or ten that are nearest alike.

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