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I.

SOILS AND FARM CROPS.

II.

FARM ANIMALS AND THEIR PRODUCTS.

III.

FARM BUSINESS.

Soils and Crops of the Farm

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PREFACE.

THE attempt has been made in this volume to give a brief statement of the elementary principles and chief facts on the subjects of which it treats. Chapters one to eight, and twenty, twenty-one and twenty-two were prepared by Mr. Morrow; the others by Mr. Hunt.

The authors have drawn freely from many sources, both for matter and illustrations, and can only acknowledge in this general way their indebtedness to many sources of information.

In the preparation of the chapters on Soils, Warington's "Chemistry of the Farm" was found especially helpful, and for the chapters on Cereals especial indebtedness is acknowledged to the exhaustive monograph on cereals by Prof. W. H. Brewer, in the Reports of the Tenth Census. Dr. W. C. Stubbs kindly revised manuscript of chapter on Sugar Plants and Prof. S. M. Tracy that on Cotton.

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THE SOILS AND CROPS OF THE FARM.

CHAPTER I.

PLANT FOOD AND GROWTH.

Plants live and grow. Growth comes from food. Plant food must come from, or through, the soil or air, or both. Plants cannot move about to seek food. They do not have mouths like those of animals. They cannot take in solid substances. Their food must be brought into contact with them and be either liquid or gaseous in form.

Finding out of what a plant is composed will help to an understanding of how and from whence it gets its food.

Water is found in any living plant in larger quantity than is any other substance. Generally there is a greater quantity of water in a living plant than of all other substances. This is true of all farm crops while they are growing. Turnips or pumpkins have more than nine-tenths of their weight made up of water. There is less solid matter in such vegetables than in milk. The percentage of water in farm crops is much lessened when they have been harvested and are ready for use, but there is rarely less than ten per cent of water in either the grain, stalk or leaf of farm crops when called thoroughly dry. To drive off all the water from a plant it must be exposed to a high temperature for many hours.

Burning a plant causes it to divide into two classes of substances; those which pass into the air as gas or vapor, and those which remain as ash. The first may be called the combustible; the second the incombustible or mineral part of the plant.

If the burning has been thoroughly done, the ash will be found to be but a small part of the plant, either in bulk or weight; generally not more than five per cent, or one part in twenty of the total dry matter. The parts of the plant differ much in the percentage of ash or mineral matter. The leaves have most; the stems next, and the seeds least.

Plants obtain from the soil, by means of their roots, all the mineral or ash matter found in them. The soil also furnishes most of the water they contain. The air furnishes to plants through their leaves nearly all the matter, except water, which passes off as gas when the plants are burned.

The soil proper gives to plants but a small part of their bulk or weight. Several wagon-loads would be required to remove soil equal to a great tree in weight or bulk. Had the matter of which the tree is composed been mainly taken from the soil, the surface would have been lowered so that the tree would have stood in a hole. Instead of this the surface of the soil about a large tree is often above the general level. If thoroughly burned all the wood in the tree would leave but a comparatively small quantity of ash.

Chemical Elements in Plants.—The chemical elements usually found in plants are thirteen in number—three gases and ten solids. Of these, ten—three gases and seven solids—are essential to the life and growth of plants. The other three

substances are not believed to be absolutely essential, but are almost always found in plants and probably serve important purposes. These substances are:

	GASES.	
Oxygen.	Nitrogen.	Hydrogen.
	SOLIDS.	
	Carbon.	Magnesium.
	Sulphur.	Iron.
	Phosphorus.	—————
	Potassium.	Sodium.
	Calcium or Lime.	Silicon.
	Chlorine.	

The first five named elements compose the combustible parts of plants—that is, these elements pass off into the air as gases when the plant is burned. The five next named are essential ash or mineral elements—as is also sulphur, a part of the sulphur in the plant remaining as ash when the plant is burned. The three elements last named are those not considered essential to plant growth. In the case of some plants, one or more other chemical elements may be found in very small quantity.

Oxygen and hydrogen, chemically united so as to form water, make up the largest part of any living plant. They also, in different combinations, make up perhaps forty per cent of the dry matter. Nearly or quite one-half the dry matter is carbon. Nitrogen sometimes makes as much as four per cent of the dry matter, but generally not nearly so much. No other element is in nearly so large supply, and the percentage of some is very small. There may be less than one pound of iron in the hay grown on an acre of

good soil, but without this very small quantity the grass could not have grown.

The Structure of Plants.—Plants are made up of bags or sacks called cells, usually so small as to be seen only when magnified. These cells contain a soft, whitish substance named protoplasm, of which we know but little, but which a great scientist has called “the physical basis of life.” This is enclosed in a “cell wall.” The cells differ much in form. They may be round or long, soft or hard. Tubes or vessels are formed in the plant by rows of cells. There are many cells in each plant of the kinds grown by farmers, but there are plants each of which has but one cell.

Most plants with which farmers have to do have roots, stems, leaves, and flowers, producing seeds.

The roots of plants vary much in form. The long, thick tap root of a clover plant is much unlike the thread-like roots of most grasses. The tap root has many small branches which serve important purposes but may scarcely be noticed. The fibrous or hair-like grass roots have a “body” to which they are attached, but this may be so short and small as not to be noticed.

Roots of plants have four important purposes. They absorb plant food from the soil. They often act upon the solid matter of the soil and prepare it to be absorbed. In many cases they store up nourishment for the plant and hold it for future use. They support and hold the plant in its place.

The absorption of water and of the substances dissolved and held in solution by it is one of the most important purposes served by roots. All the ash in-

redients are taken up in solution, almost always in a very weak solution. Roots also have the power of dissolving some solid substances in the soil, such as potash or phosphorus, and then absorbing them. This action probably depends upon the acid sap in the roots. Roots take up oxygen gas and also nitrogen, when this is found in certain chemical combinations.

The power of absorption by roots is believed to be confined to a small space nearly at their tips; the extreme tip being covered with a "root cap" of solid dead matter. The large part of the roots have important uses, but not as food gatherers.

The stem and its branches connect the roots and leaves, carrying the water and dissolved solids taken up by the roots to the leaves.

The leaves are often called the lungs of plants. Their action in relation to air is not, however, the same as that of animals in breathing, either in manner or effect. Animals inspire the air and give it back charged with carbonic acid. Plants do the same to a considerable extent. But plants also have another and most important power, entirely unlike anything possessed by animals. The leaves especially have the power of taking in carbonic acid and other gases from the air. The carbonic acid is decomposed, the oxygen given back to the air, the carbon being retained and used by the plant. Starch is first formed from the carbon and water. This is changed into sugar, which is carried in the sap to different parts of the plant and used to build them up. It is hard to understand just how this is done, but it is probably the most simple of the several processes necessary to the building up of the plant which are carried on by means of the leaves.

Plants can exercise this power of assimilating carbon from the air only in the light, while what we may properly call the breathing of plants goes on continuously. They take in and use much more carbon than they give off. They thus make the air more suitable to be breathed by animals, carbonic acid in any considerable quantity in the air being injurious to animal life. The breathing of animals, the burning or slow decay of vegetable or animal matter, increases the supply of carbonic acid in the air, thus better fitting it for the use of plants.

Leaves are believed to absorb some water, especially in times of drouth, when the soil supplies less than the plant needs. They also absorb some nitrogen in the form of ammonia. They give off very large quantities of water, chiefly through small openings on their under sides. These openings are called stomata. Although the shading of the surface by plants tends to decrease the evaporation of water from the soil, the leaves give off so much water that the soil is usually drier when covered with a growing crop than when it is free from vegetation. The evaporation of water from the leaves greatly aids the upward flow of the sap.

Much of the work of the leaves is dependent on sunlight, and much of it is done by means of the green coloring matter of the leaves, called chlorophyll.

The production of flowers and seeds is not essential to the growth of the individual plant. The seeds may be useful to man in many ways and may be necessary for a future supply of plants, but not to the growth and health of the plant producing them. In many plants maturing the seed is accompanied or followed by the death of the plant.

The seeds each contain a very small plant called the germ or embryo; also a quantity of plant food, enclosed in a coat or outer covering. The germ or little plant is readily examined in such seeds as corn or peas, if these are soaked in water until they begin to swell.

The matter surrounding the germ contains all the food needed to support the little plant when it commences to grow, except oxygen and water. The principal content of most seeds is starch; of some, as flax, fat. There is also nitrogenous or albuminous matter, and all the ash ingredients needed by the plant. The young plant is fed and nourished by the food stored up in the seed much as the embryo chick is nourished by the store of food in the egg.

Germination and Growth.—Germination of the plant, or growth of the germ in the seed, commences when there is a suitable temperature and a sufficient supply of moisture and oxygen. Warmth, moisture and air, or oxygen from the air, are essential to the growth of any plant. These supplied the growth of any perfect seed will certainly commence. Under like conditions the growth of the “eye” or bud in a potato or other tuber will commence.

The seed first swells; the solid matter becomes soluble; the starch or fat is changed into a form of sugar; the germ sends out a root called the “radicle,” and the leaf called the “plumule.” If the seed is surrounded by soil in suitable condition the radicle soon begins to absorb food from the soil. The plumule extends upward until it reaches the surface, when the leaves more fully develop and begin their work.

The degree of heat necessary varies much with different plants. Some seeds will start growth at a temperature but little above the freezing point; others may need 60 deg. F. The quantity of moisture necessary also varies considerably. There may be enough to cause the growth to commence but not enough to continue it. If the seed is deeply buried, the food supply contained in it may be exhausted before the plumule reaches the surface. Usually there is no good reason for covering seeds more deeply than is sufficient to secure the needed supply of moisture. Deep covering of small seeds especially, is not desirable.

The order of growth and development of most plants is much the same, with variations depending upon whether they are *annuals*; that is, plants like corn or wheat, which complete their growth and die within a year; *biennials*, which live two years, producing seeds only the second year, or *perennials*, which live several or many years, sometimes producing seeds each year and sometimes only rarely.

In each class there is first a considerable growth of both roots and leaves. With annual plants there is next a rapid growth of the seed stalk; then blooming and the production of seed. With biennial plants there is a storing up of plant food in the roots, stems, thick leaves or tubers, near the close of the first year's growth. The second year a seed stalk is produced, bearing seed largely made up from the food stored up the first year. Beets and cabbages are good illustrations of this class of plants.

In the young plants the roots furnish a larger percentage of food than after growth is further ad-

vanced. In the later stages of growth comparatively little is received from the soil, but so long as the plant remains green it continues to absorb carbon from the air and to produce starch, sugar, and other compounds. The dry matter in the corn plant may more than double in weight after it has reached its full height.

Much of the material stored up in the matured seed has been taken from the roots, stalks and leaves, in the case of annual as well as biennial plants. There is valuable food for animals in the stalks and leaves of fully matured plants—notably in the grasses and clovers—but much less than before the seeds have matured. The food is not lost, but transferred from other parts of the plant to the seed. The production of seed is the chief purpose of many plants, not only that they may perpetuate their kind but that they may be most useful to man.

CHAPTER II.

THE SOIL.

The soil is the upper stratum of the earth; the finely divided portion of the surface into which plants send their roots and from which they obtain much of their food. The sub-soil is that which lies beneath the surface soil. Sometimes the word is used to describe the soil lying below the depth which is usually cultivated, and sometimes it means a stratum of soil differing in color, texture or composition from that at the surface. Examination of different soils shows that in some there is much stone or gravel; of others the greater part is sand of differing degrees of fineness, still others being mainly made up of matter in very small particles, which we call clay.

In all soil capable of producing crops traces of decaying or decayed vegetable matter are found; in some this matter forms a considerable percentage of the soil. Most soils may be described as either sandy or clayey, according as one or the other of these substances is evidently present in largest percentage. If there is more than 90 per cent. of either, the surface is spoken of, not as soil, but as sand or clay.

If there is a nearly equal division the soil is best described as loam—or as sandy loam or clayey loam, if one or the other ingredient is in somewhat larger supply than the other. If stones or gravel are present in large amount, the soil is called stony or gravelly, without regard to whether it is otherwise clay or sand.

So, if lime is present in an unusually large amount, the soil may be spoken of as limey or calcareous.

The decayed vegetable matter in soils is called humus. If this is in large supply the soil is called peat, swamp muck, or more rarely, vegetable mold.

Formation and Distribution of Soils.—

All the mineral matter in soil was once solid rock. The breaking up or disintegration of rocks and the addition of vegetable matter has formed the soil as it now exists. Not only are fragments of rock found in many soils by even careless inspection; not only does chemical analysis show that soil is composed of the same elements as those which are found in rocks, but the process of soil formation may be seen and studied in many places. It is said that in less than 100 years lava rock thrown from volcanoes, in such quantity as to thickly cover the mountain sides or the valleys below, has been changed into fertile soil.

Air and water have been the chief agents in soil formation; not pure air and pure water, but air and water as they are ordinarily found in nature. In the air there is always a very small percentage of carbonic acid. This is dissolved in or absorbed by water and has a powerful effect in causing rocks to disintegrate into sand or clay. It works slowly but surely. The oxygen of the air also unites with the iron or manganese compounds in the rocks, thus hastening the breaking up of the rocks.

Water has even a greater influence on rocks than has the air. Pure water has a considerable power of dissolving mineral compounds. This power is much greater when the water contains carbonic acid. The freezing of water aids greatly in this work. Water

expands as it freezes and exerts a great force in so doing. When water which has collected in cracks or low places on the surface of rocks freezes it may split off a great mass from the mountain side or a tiny fragment from a grain of sand. As freezing and thawing go on year after year the effect in breaking up rocks and in pulverizing the soil is very great. Water and ice in motion have a great influence in the formation and distribution of soils. A little stream as it flows down a hill-side carries with its water, especially when swollen by rains, little stones, sand and earth. As these move they loosen other stones. A large stream or a great river does the same work on a vastly larger scale. Streams may change their course, washing out new channels and carrying the rocks and soils to be distributed over lower lying land. The great deltas at the mouths of the Mississippi, the Nile and the Amazon illustrate on a large scale the kind of work which running water is doing in moving soil wherever there is a stream. The worn and rounded pebbles at the brook side, contrasted with sharp-edged, freshly broken rock, show the power of moving water to wear and pulverize as well as to carry solid substances.

Glaciers or streams of ice slowly moving down mountain sides, carry with them masses of stone and earth, and crush and grind the rocks over which or past which they move. There is good evidence that in past ages glaciers have done much work in many parts of the earth. Icebergs carry masses of rock and much earth, and distribute these as they melt.

With some or all these forces acting continuously

for many centuries, it can be understood how what was once solid rock has become as finely divided as is the mineral part of the best soils.

It is evident that comparatively a small portion of the soil of the earth remains where it was when it was rock. Analysis of some soils shows that they have the same composition as the rocks which underlie them. Such soils are usually of only moderate depths. In most soils, however, there are fragments of rock different from that found underlying or in adjacent hills. It needs no argument to show that the surface soil at the foot of hills, along the banks of many streams, or where there was once a lake, has been carried there by water. Sometimes valleys have been filled to a great depth and, later, a channel worn through this filled valley by a river. Soils which remain where they were formed are called sedentary soils, or soils in place. Those which have been moved in, or after, the process of soil formation, are called transported soils. Those which have been carried by moving water are called alluvial soils. These usually are in layers or strata, sometimes differing in the kind of material, almost always differing noticeably in the fineness of division. Soils which were deposited by glaciers are called drift. The most noticeable quality of these is the presence of boulders. Wherever these large, rounded rocks are found it may safely be decided there has been glacial action in the remote past. Sometimes drift and alluvial soils are mingled together. Drift soils cover much of the United States north of the 39th. parallel of latitude.

Vegetable Matter in Soils.—Plants of a low order, as lichens and mosses, are able to live on rocks the surface of which has been very slightly acted on by the air and moisture. These plants have the power, probably through the agency of the acid sap, of partly or wholly burying their roots in the rock, clinging so closely to it that it is sometimes necessary to chip off pieces of the rock to secure specimens of the plants. Minute furrows are often left in the rock surface after the plants have decayed. The decay of these plants adds a trifle of vegetable matter to the mineral elements of the soil, thus fitting for a more abundant growth or for plants of a higher order. At last there is a considerable supply of humus or decayed vegetable matter mingled with the mineral matter. The plants have aided in the work of disintegrating the rock in several ways, both while living and when decaying, and the humus they leave in the soil is a most important element of fertility, being a chief source of the nitrogen of the soil.

The decayed and decaying vegetable matter in soils is often spoken of as “organic matter,” and the same term is applied to animal matter in the soil.

Chemical Composition of Soils.—A soil capable of sustaining plants must contain all the mineral, ash, or incombustible substances found in plants, for the plants can obtain these from no other source. It will also contain alumina. Such a soil will also always contain, in some form, sometimes in several combinations, each of the elements which pass into the air when a plant is burned; but as the air is the source from which the soil obtains these substances,

the soil proper may be said to be composed of the following substances:

Phosphorus—(Phosphoric acid.)	Sodium—(Soda.)
Potassium—(Potash.)	Magnesium—(Magnesia.)
Lime.	Chlorine.
Iron —(Oxide of Iron.)	Silicon—(Silica.)
Sulphur—(Sulphuric acid.)	Aluminum—(Alumina.)

These substances make up 90 or 95 per cent. of most fertile soils, the remainder being humus, or decayed vegetable matter. In peaty soils this last may be a fourth or even a half of the soil, but some fertile soils have not more than two or three per cent of humus. It will be remembered that the mineral or ash constituents of plants usually constitute not more than five per cent. of the whole plant. All the substances named above, except alumina, are always found in plants, and alumina is always found in good soils. In one sense it may be said all are essential; hence equally important. Some, however, are always found in abundance, while others are frequently in insufficient supply for the production of good crops. This is especially true of phosphoric acid and potash. Hence these substances are often spoken of as the most important mineral elements in the soil.

If sand be thought of as silica, and alumina as the base or foundation of clay, the other element being silica, it will be evident there is no lack of these two substances. Lime and iron are found in most soils in great abundance, so far as their use as plant food is concerned. The other substances are not found in so large quantities, but almost any soil contains more of them than crops need. A like condition is found as

regards the elements of plant food which pass into the air when the plant is burned or decays. There is a great abundance of carbon, in the form of carbonic acid, in the air and in most soils. Oxygen and hydrogen as water, and oxygen in combination with many substances, are usually in abundant supply. Nitrogen, however, although it forms the larger part of the air, is often only sparingly found in either the soil or air in such a state that plants can feed upon it, most plants being able to make use of nitrogen only when it is combined with some other element—in such compounds as ammonia and nitric acid. Hence, while no more essential to plant growth than is oxygen, hydrogen or carbon, nitrogen is commonly spoken of as the most important of the combustible parts of plants.

In discussions concerning manuring or the value of different artificial manures or commercial fertilizers, nitrogen, as ammonia or as nitric acid; phosphorus, as phosphoric acid, and potassium, as potash, are referred to very much more than any other or than all other substances.

Soils differ much in their fertility, or power of producing crops. This may be because in one soil there is a more abundant supply of one or more of the chemical elements which have been named as essential to the growth of plants. A soil may, however, have an abundant supply of each of these elements, and yet not produce good crops, because some of them may not be in a condition in which the plants can use them. This may be because of poor physical conditions or because the elements of plant food are in such chemical combinations as to make them useless for the present, at least. Much of the soil is not

capable of furnishing food to plants. Neither pure silica nor pure clay can be used as food by plants.

By far the largest part of the substances in the soil which are capable of being made plant food is not available for this use at any given time. Probably not one per cent. of even the most fertile soils is available plant food. It is fortunate this is the case. In order that the mineral ingredients of the soil may be used as food for plants they must be soluble in water or in weak acid solutions. Were the mass of them in such condition there would be much waste and loss. The air, the water, the frost; the action of worms and burrowing animals; the tillage of the soil by man; the growth and decay of plants—all these are continually changing the dormant, unavailable, potential plant food of the soil into forms in which it may be active or available in the nourishment of plants. Sometimes the processes of manufacture of available food go on faster than the food is used by the crops grown. In such case the fertility of the soil increases. Sometimes the new supplies of available food are furnished more slowly than the crops grown and removed by the farmer make use of such food. In such cases the land becomes less fertile; tends to become exhausted.

Value of Chemical Analysis of Soil.—An examination of a soil by a chemist will show, with great exactness, of what it is composed, and the relative proportions of the elements. It may show that there is evidently a too small supply of some essential ingredient. Or it may show that there is some substance or some combination present which will be injurious to plants. In these ways such an examination may give most valuable suggestions as to manur-

ing the soil or other methods of improving its fertility. A chemical analysis, however, will not show with certainty whether the substances of which the soil is composed are in condition to be available as plant food. Often it gives very little help to an understanding of whether or no the soil is in good physical condition. The chemist is able to state not only the actual and relative quantity of each element found in the soil but also the percentage of this which is soluble in water and soluble in acids. This information helps greatly in estimating the quantity of each which is probably in suitable condition to be taken up and used by plants.

Uses of the Soil.—So far as plant growth is concerned the soil has three important uses. It furnishes a home for plants. The roots penetrate it and thus are enabled to hold the plant firmly in place. It also is a store-house of plant food; both of the large, but relatively small quantity which is available for immediate use by the plant, and the vastly greater quantity which is capable of being made available. It is also a laboratory in which the work of preparation of available plant food is continually going on. The soil is not to be thought of as a finished product; as containing simply a fixed supply of food for plants. Soil formation is still going on. The forces of nature are every day making available plant food in the soil of materials which, heretofore, were unfitted for use by plants.

Fortunately the farmer can help the soil to be better for his purpose. He can so treat it that roots may more readily penetrate it, and more readily find access to its store of available plant food, and he can aid the "weathering" forces of nature in increasing the supply of such food.

CHAPTER III.

PHYSICAL PROPERTIES OF SOILS.

Among the most noticeable or important physical characteristics of soils are weight, color, adhesiveness, fineness of division, and their relations to heat, to moisture, to gases, and to dissolved solids. In regard to all these, soils differ much, and these differences have much to do with the differing capabilities of soils in producing crops. Differences in physical properties depend largely on the proportion in which sand, clay, lime, stones, and vegetable matter are combined in the soil.

Sand is heavy; is usually light colored; the grains do not stick together. It has little power of attracting moisture from the air, and allows water to run through it readily. It absorbs and retains heat well. A soil with much sand in it will be dry and warm; easy to work; not sticky; will not "bake." In dry weather crops on such soils will suffer from lack of moisture. Soluble plant food will leach through such a soil.

Clay, or a soil with much clay, has a fine texture, and the particles adhere tenaciously. It absorbs moisture from the air readily, draws water from below by what is known as capillary power, holds it well. This tends to make such a soil cool, but it will absorb heat readily. It absorbs and holds ammonia and other gases readily. If stirred while wet it becomes hard; often cracks in drying. It differs much in color. The presence of iron will give a red color. Common-

ly it is a light yellowish color. Clay soils usually have more plant food than sandy ones; they hold moisture better, and there is less loss of soluble manures or available plant food by leaching. They are hard to work, and are often too cold and wet unless well drained. They "heave" as the result of freezing and thawing.

A mixture of sand and clay makes a better soil than one almost entirely composed of either. The addition of clay to sand makes it more tenacious; enables it the better to absorb and hold moisture and gases; gives it greater capillary power; enables it to withstand drouth better, and, usually, will make it cooler. The addition of sand to clay makes it more easily penetrable by the roots of plants; more easy to work; somewhat warmer; less injured by being worked when wet; less apt to "heave."

Humus, or decayed vegetable matter in soils, makes them light in weight and dark in color; greatly increases their power to absorb moisture from the air and their capillary power; makes clay soil less and sandy soil more compact. It will be seen that, aside from its value as a source of plant food, humus is important in improving the physical condition of the soil. Most soils containing much humus are fertile, if not too wet.

Lime in soils has a considerable importance aside from its use as food for plants. It improves the texture by making clay soils more easily worked and sandy soils more compact. It hastens the decay of vegetable matter.

Weight.—The weight of a cubic foot of dry, loamy soil may be one hundred pounds, or even more. The

more sand or gravel the heavier the soil; the more vegetable matter, the lighter it will be. It is said some peat soils weigh not more than thirty pounds per cubic foot. Few soils ordinarily cultivated will weigh less than seventy-five or eighty pounds per cubic foot. The soil on an acre, 43,560 square feet, to the depth of one foot, will weigh rarely less than 3,000,000 pounds and often more than 4,000,000 pounds, or 1,500 to 2,000 wagon-loads of one ton each. It will be seen that even though only a small percentage of the soil is ever in condition to be available as plant food, there may still be an enormous quantity of such food present in the first few inches of soil—enough to produce the largest crops. A sandy soil may have a greater supply of plant food than a clay soil, because of the greater weight, even though it have, as is usually the case, a smaller percentage of such food.

Soils are often spoken of as “light” or “heavy” not with reference to their actual weight, but to their tenacity. In this sense a sandy soil is “light” and easily worked, and a clay soil “heavy,” although lighter in weight than the sandy soil. A soil with much vegetable matter will be light in both senses of the word.

Texture.—All soils are porous, that is, have small open spaces between the solid particles. Into these the air and water pass, gases are condensed, and the roots of plants penetrate in search for food. A solid mass of pure plant food would give little nourishment to a plant. A finely divided soil in which there is a very small percentage of plant food may produce fair crops. A large number of small pores is desirable. Coarse sand has large openings between its grains. A good loam or a well pulverized clay soil has a multi-

itude of minute pores. The sand can do little in absorbing or drawing up water or holding it; has little power to condense or hold gases and can give little food to plants.

It is possible to have a soil too finely divided. The particles of which it is composed may be so closely compacted that neither air, water, gases, nor the roots of plants can freely penetrate to the soil. This condition is not a common one, is rarely found except in compact clay soils. Often the most important work of the farmer in preparing a soil for crops is in pulverizing it—crushing clods, reducing the number of large open spaces and so greatly increasing the number of minute pores, and the quantity of plant food with which the roots of plants can come into close contact and thus be enabled to use.

Prof. James Mills says: “No matter what the composition of a soil may be, it will not produce good crops unless it is of a proper mechanical texture. It must be firm enough to give the required support to the crops growing in it, and yet sufficiently loose to allow the delicate root fibers to extend freely in all directions, according to their habit of growth—fine enough to give capillary power, to hold water, to retain fertilizers, to absorb and retain atmospheric moisture and ammonia, and yet loose and open enough to admit air freely down among its particles and to let the excess of water drain away. In soil of the right texture water neither lies on the surface nor soaks very quickly through into the sub-soil. The excess soon passes away and enough is retained to keep the soil moist and in a fit condition for the growth of crops, except in very wet or excessively dry weather.

Rain water is the great carrier, the distributor, and, to some extent, the manufacturer, of plant food, and unless there is a free passage for it through the soil, the food of plants will not be well prepared, nor will the stationary plant root be properly fed."

Relations of Soil to Water.--All soils have the power of absorbing and retaining water, but the extent to which this can be done differs much, depending on the composition of the soil and its porosity. A soil with large pores, as coarse sand, allows water to percolate or run through it readily, retaining little. Water poured on a soil with many small pores will permeate it, saturating it thoroughly, and the soil will hold much of it, unless the pores are very small, in which case the water may not be able to enter them.

Soils not only have the power to hold some of the water which passes through them but also the power of drawing water from below and holding it. This is known as capillary power. The action of the soil in this respect is like that of a lamp-wick in drawing up oil. If the bottom of a tube containing soil is placed in contact with water, the latter will be drawn up one, two, three or even more feet owing to the character and fineness of division of the soil. The soil will take up so much in this way that if a little more water is poured into the top of the tube, the water will begin to run out below. Good soils will frequently absorb and hold one-half or more of their own weight of water; some will hold much more than this. Those with a large percentage of humus will hold the largest percentage of water.

Soils also have the power of absorbing moisture or vapor of water from the air. This is called hygro-

scopic power. The quantity of water so absorbed is comparatively small, although in extreme cases it may be as much as five per cent. A thoroughly dried soil will absorb moisture from the air if the latter contains it, but, ordinarily, the soil gives to the air much more moisture by evaporation than it absorbs from it. Even when the soil seems perfectly dry it contains considerable moisture, as may be proved by heating it. In examinations of a large number of samples of the loamy prairie soil at the Illinois Agricultural Experiment Station, during times of unusual drouth, the surface soil, to the depth of six inches, was found to contain less than ten per cent of water, in only a few samples; in but a single sample was as little as eight per cent of water found. The soil at greater depths contained more than the surface soil in each sample examined.

When rain falls in time of drouth, the surface soil becomes saturated. As the rain continues the depth of saturation increases until rock, impervious clay or hard-pan is reached, or the water in excess of what the soil can hold passes down into the sandy or gravelly sub-soil, or through underground drains. As the water goes down, carrying with it carbonic acid and oxygen, it helps decompose the materials of the soil, making the potash, phosphoric acid, lime, etc., soluble and suitable for the use of plants. Some of this dissolved mineral matter is carried down by the water. In time of heavy rains there is a loss of plant food through drains or in the open sub-soil.

After the rain ceases, evaporation commences, with greater or less rapidity, depending on the temperature and dryness of the atmosphere. As the surface be-

comes dry, water begins to ascend, because of the capillary power of the soil. The water brings with it some of the soluble plant food in the soil, thus bringing to the surface roots of plants a good supply of food. The water as it evaporates cannot carry the dissolved mineral plant food into the air, so that, so long as evaporation goes on, the surface soil accumulates these salts. In regions in which there is little or no rain there is a considerable accumulation on the surface. The alkaline plains of our western territories are a good illustration, but the best is found in the great beds of nitrate of soda on the west coast of South America. In caves or under old houses the soil often contains a large supply of saltpetre and other salts.

Although there is often some loss from plant food being carried off in drainage water the upward and downward movement of water in soils is helpful in several ways. The water not only does a great work in making plant food available in the soil and bringing it into contact with the roots of plants, but it also carries into the soil carbonic acid, ammonia and nitric acid from the air. Often the rain is warmer than the soil and thus increases the temperature of the latter. As the water goes down it is followed by the air and this aids in decomposing the mineral matter of the soil.

While water, especially when charged with gases, has the power of dissolving some of the mineral matter of the soil, and has a tendency to carry with it the finely divided matter and all dissolved solids, the soil has the important property of attracting and holding the dissolved solids it finds in water. The

water which flows from a heap of stable manure will not only carry away some of the small fragments of litter but will be discolored and offensive to smell and taste because it has absorbed and holds gases and dissolved solid substances. If this water be made to pass through a vessel containing finely divided soil, it will come out comparatively pure as tested by sight, smell and taste. The soil has not only collected on its surface the matter which was not finely enough divided to enter the pores of the soil, but its particles have had a stronger attraction for the dissolved solids than that possessed by the water. If, however, a large quantity of water charged with this solid matter passes through the soil, the power of the soil to absorb the solid matter will be exhausted and the water will come through in much the same condition in which it entered the soil. If now pure water be passed through this soil fully charged with the solid matter it has absorbed, the water will flow out more or less affected in color, smell and taste. Did not soils have this power, the water in many wells would be unfit for use. That it does not possess this property in unlimited degree is illustrated by the fact that the water in a good many wells is unfit for use.

Clay soils possess this power in a much greater degree than sandy soils. A soil with much humus also has this power in a noticeable degree. In a sandy soil there is much more loss of plant food by the leaching power of water than in a clayey or humus soil.

Absorption and Condensation of Gases.—It has already been indicated that soils have the power of absorbing gases from air or from water. The offensive smell of decaying animal matter is entirely

prevented by burying the putrid matter in the soil. The efficiency of the earth-closet system of disposing of human excrement largely depends on this power. As vegetable or animal matter decays in the soil the latter absorbs and holds much of the ammonia and carbonic acid given off, and also absorbs these as they are brought to and into the soil by the rain and winds. Clayey and humus soils can do this to a greater extent than can sandy soils.

Relations of Soil to Heat.—The temperature of the soil near the surface changes as that of the air varies, although more slowly. During the day, especially if the sun shines brightly, the soil becomes warmer but not so rapidly as does the air, chiefly because of the cooling effect of the evaporation of moisture from the surface of the soil. At night the air first cools, then the heat gained by the soil is radiated into the air; the evaporation of water is checked and often there is a considerable deposit of dew on the surface and an increase of moisture in the air held in the pores of the soil. A wet soil is cooler than the same soil would be if dry. Usually a dark-colored soil is warmer than a light-colored one. A soil with much sand or gravel will become warm more slowly and will retain the heat longer than an equally dry clay or humus soil. A plant surrounded with stone or growing near a gravel walk may be uninjured by frost when those growing in a clay soil may be seriously injured. A soil covered with a sod is usually cooler during the day but does not cool so rapidly at night as does one bare of vegetation. A soil which slopes southward will be warmer than one with a northward inclination.

Color of Soil.—The color of a soil is a matter of some importance. Not only is a dark-colored soil warmer than a light-colored one, but the dark color is generally an indication of fertility, as it is usually the result of a considerable percentage of humus in the soil.

The Sub-soil.—The character of the sub-soil has much to do with the fertility of a soil. The surface soil may have the best possible chemical composition and the most desirable physical characteristics, but if it has an undesirable sub-soil at the depth of a few inches, its ability to produce crops is greatly lessened. A sub-soil of impervious clay or hard-pan is very objectionable. A soil so underlaid cannot have a large store of plant-food. In wet weather crops will suffer from excess of moisture; in dry weather from drouth. A coarse sand or gravel sub-soil near the surface is also objectionable. The water passes through too readily and takes with it much plant food.

CHAPTER IV.

IMPROVEMENT OF SOIL BY MANURING.

The growth of crops does not necessarily decrease the fertility of soils, if the product is not removed but is allowed to decay on the land. In most cases soils improve so long as they are not cultivated by man. The growth of plants through ages has been a chief cause of the fertility of many soils. The mineral matter drawn up from the sub-soil by the roots of plants remains near the surface when the plants have decayed. The supply of carbon and nitrogen in the surface soil is also increased. In most cases the physical properties of soils which have long produced natural crops, whether of trees, grass or weeds, are such as well to fit the soils to continue producing them in abundance. On hill-sides the best of the soil may be washed away. There may be no accumulation of plant food on coarse, porous, sandy soils. But generally either prairie or forest soils are fertile in a marked degree, when first brought into cultivation.

Cropping Reduces Fertility.—The work of the farmer tends to reduce the fertility of the soil. The crops grown are removed from the soil; or, if consumed by animals, the animal product is removed. In either case plant food has been removed from the soil. There may still remain an abundant supply. At the famous Experiment Station, at Rothamsted, England, after wheat had been grown on the same ground for about fifty years, without the application of plant food, the crop sometimes nearly equaled the average

yield of wheat in the United States. On some fertile soils in this country grain has been profitably grown for more than a half-century without the direct application of plant food. On many soils, however, a decrease in the yield of crops is noticed after they have been cultivated for a few years, unless some return of plant food is made.

The term "exhaustion of soils," although often used, is somewhat misleading. Continuous cropping may reduce the fertility of the soil so that it may not be profitable to cultivate it longer, but it is not probable any soil could be exhausted, that is, made absolutely barren, by the cultivation and removal of crops. As has been said, the soil is not a finished product. The supply of plant food in the soil is not like grain in a bin, continued use from which exhausts the supply. The forces of nature are continually manufacturing available plant food in the soil. More or less of this may be washed away, or leach into the sub-soil; some of it passes into the air; man may remove some of it in crops. But all soils, properly so-called, contain plant food enough to support something of a crop.

It may be said that all soils have a "natural fertility." Under like conditions each will produce a crop not greatly varying from year to year. As a consequence of the growth and decay of forest trees or prairie grasses, virgin soils have accumulated a large supply of material for the growth of plants, either available for their use or capable of being made available. This may be called "surplus fertility," "accumulated fertility" or "natural manuring." Cropping without return of plant food may exhaust this surplus store and reduce the land to its natural fertility.

It should be kept in mind that a part of the plant remains on the soil in almost all cases. The roots and stubble of grain and hay crops do much to keep up the supply of humus in the soil and keep the surface in a good physical condition.

Classification of Manures.—To manure land, according to the original meaning of the word, was to cultivate it by manual, or hand labor. Tillage or cultivation, properly done, does increase the fertility of the soil. Probably crops were grown for centuries before the practice of applying plant food to enrich the land was thought of. Now, by manuring we mean the application of something to increase the fertility of the soil.

Manures may act in three ways:

1. They may directly add plant food to the soil. Manure is sometimes defined as plant food and this is the most common thought in regard to it and its action.

2. They may hasten decomposition and chemical changes in the soil by which available plant food is prepared from material which has been lying dormant.

3. They may improve the physical condition of the soil. The application of pure sand to a clay soil, or pure clay to a sandy soil, does not add plant food, nor directly affect chemical action in the soil, but by making the one soil more open, and the other more compact, the fertility of each may be largely increased.

Manures may be divided into two classes: General and special; or complete and partial. They are also sometimes divided into “mineral” and “organic” classes.

A complete manure is one which contains all the elements of plant food. Such a manure will increase the growth of almost any crop if applied to almost any kind of soil. It may increase the growth of the stalk and leaves at the expense of the seed. Stable or barn-yard manure is the typical, complete or general manure.

A special manure is one which supplies some but not all the elements needed by plants, or which is specially prepared for certain classes of crops or of soils. This class is known as artificial manures, chemical manures or commercial fertilizers. They may be by-products of manufacturing establishments; they may be specially compounded, or they may be obtained from the great stores of possible plant food nature has stored up, as in beds of marl, of gypsum, or of phosphatic rocks.

Stable manure ordinarily acts in all three of the ways named. Artificial manures usually are helpful by directly adding plant food, or by aiding chemical action in the soil, thus hastening the preparation of a sufficient supply of available plant food.

It has already been stated that the only mineral elements of plant food probably in insufficient supply in the soil are phosphorus and potassium; and that nitrogen, in a form in which plants can make use of it, is the only gaseous element of which plants find it difficult to secure a sufficient supply. To supply some one, or two, or all three of these scarce or "precious"—because scarce—elements, is the purpose of most artificial manures. If prepared to supply one or both the mineral elements, they may be called by their names; if to supply all the mineral elements

needed by plants, they are called complete mineral manures. Wood ashes are a good specimen of such a manure. If the supply of nitrogen is the chief purpose of the manure, it may be called a nitrogenous manure.

The commercial value of artificial manures is estimated from the quantity of phosphoric acid, potash and nitrogen they contain. A sample of such a manure may be said to contain a given percentage of potash, of "soluble phosphoric acid," or of "nitrogen, equivalent to ammonia." The number of pounds of each of these substances contained in a ton can then be determined. By multiplying this by the prices at which they can be bought from manufacturing chemists, the estimated value per ton of the manure is obtained.

This expression is often misunderstood and its common use is unfortunate.

It is not meant that if a farmer uses an artificial manure his crops will be increased in value to the amount the manure is said to be worth. This may or may not be true. On soils already well supplied with plant food it may not perceptibly increase the yield. Thus in experiments with several kinds of artificial manures at the Agricultural Experiment Station in Illinois, on the fertile prairie soils of that State, and at the Station in Ohio, on equally fertile river bottom soil, little or no increase of yield was found by liberal use of manures which produce remarkable results on many soils. Even if the crop is increased by the use of the manure, the money value of the increase varies greatly in different parts of the country.

It would be better, in speaking of manures or of the manurial value of foods, to say that the valuable plant food elements they contain would cost a given sum, rather than that the manure is worth that sum. The actual value of any manure for a given piece of land or for a particular crop on that land, can only be determined by repeated trials. The physical effects of stable manure and some other manures is often quite as important as the addition of plant food by their use.

In some countries where the soil has long been cultivated and lands are high-priced, the purchase of manures by farmers is the rule rather than the exception. Writing especially of English farming, Warrington says: "The farmer is generally obliged to purchase manures for the land in exchange for the crops and stock sold off it." This practice is becoming more common in the United States but it is still the exception rather than the rule, taking the country as a whole. It is most common in the older settled portions of the country, near large cities, or where attention is largely given to special crops. The practice of purchasing both stable manure from cities and artificial manures will doubtless become increasingly necessary and profitable

In some cases, but more commonly among market gardeners than among general farmers, manures are applied in such quantity as considerably to increase the fertility of the land, even above that it possessed when first cultivated.

Stable Manure.—The chief reliance of most farmers in the United States, in the way of direct application of manures, is stable or yard manure. The value of this depends on its composition, condition and the method of application.

The composition will depend on the kind and quantity of food used, the kind and quantity of litter used, and, to some extent, on the kind of animals fed. In general, the more nutritious the food, the more valuable will be the manure. That from grain-fed animals will be worth more than that from animals only straw-fed. A large quantity of litter reduces the value of the manure; an insufficient supply usually makes it less valuable because of probable loss of the liquid manure. Manure from mature animals, especially those being fattened, is somewhat more valuable than that from growing animals or those giving milk, because the latter use more of the mineral substances needed by plants and found in the food.

Manure from horses, unless there is a too large supply of straw or other litter, is usually more valuable than that from cows, because the horses have a larger proportion of grain food, and there is less water in their excrement. Horse manure is "heating;" cow manure is cold. The manure from hogs is concentrated and very valuable. That of sheep is also valuable. The droppings of poultry are especially valuable, largely because the solid and liquid excrement is voided together. Often it is better to mix the manure from all classes of farm animals than to use that of each separately. The urine is often fully as valuable as the dung of animals. It contains more nitrogen than does the solid excrement.

Treatment of Manure.—Before stable manure can act as plant food it must not only be brought into close contact with the roots of the plants but must also have been decomposed—well rotted. The application of straw or of grain to land may make the

physical condition better or worse, but plants cannot feed upon them until they have rotted. In many cases it is wise to immediately apply stable manure, but it cannot act as plant food until fermentation has commenced.

Fermentation begins promptly. Especially horse manure and this loosely piled, will very soon become hot, and carbonic acid will rapidly pass into the air, greatly reducing the weight and bulk, but without much reducing the direct value of the manure, unless it has been too dry and "fire-fanged." If kept saturated with water, fermentation is checked unduly. Unless litter is freely used there is a considerable loss of ammonia while the manure is fresh. The use of gypsum or even of earth will check this loss. Keeping the manure moderately moist and well compacted will best prevent loss of nitrogen. If necessary to keep it in heaps for a considerable time, covering the heaps with a layer of earth will still further prevent loss.

In many cases the loss from water is much more important than that by evaporation or vaporization. If manure is scattered about yards or piled under the eaves of stables, more than half its value may be lost in a few months. The water carries away much of the nitrogen and some of the potash.

Manure kept under cover, if kept sufficiently moist, is more valuable than that kept in the open air. Many farmers, with present arrangements, cannot keep the manure in either boxes or under sheds. If they keep it in reasonably compact piles, not exposed to washing from eaves of buildings, the loss will not be especially serious.

In very many cases, the best practice is to draw the manure direct from the stables and spread it on the land. Top-dressing grass lands is a practice deservedly growing in favor. Applying the manure to land which is to be plowed later, even if it be stubble-land, is often good practice. Some nitrogen passes into the air, but there is a great saving of labor, and the loss is believed to be less than was formerly supposed. The laborious methods formerly much recommended, of frequent stirring the manure; of drawing it to the field and there putting it in heaps, etc., are less in favor than formerly and not adapted to the conditions under which most American farmers work.

Comparatively fresh and unfermented manure may more advisably be applied on stubble-land some considerable time before it is to be plowed, than well-rotted manure.

Barn-yard manure, unless very thoroughly rotted, is bulky and heavy in proportion to the quantity of plant food it contains. Often three-fourths of its weight is made up of water. But it will probably long remain the most general reliance of farmers in this country, and in most cases it is, especially when produced on the farm where it is to be applied, the cheapest and best manure that can be used. Its value in keeping the soil in good physical condition is to be considered as well as its value in supplying plant food.

Lime is an essential element of all soils and of all plants. Most soils in the United States have sufficient lime to supply crops with all they need. When used as manure the chief value of lime, as a rule, is probably in its indirect effects in hastening decomposition of vegetable matter in the soil and in correcting

acidity. Over much of the United States lime is rarely used and its cost, in many regions, will prevent its use. In some parts it is largely used. English writers usually attach more value to it than do American farmers.

Gypsum, or sulphate of lime, often called land plaster, is a valuable manure on some soils, especially on clover. On many soils it has no perceptible effect.

Ashes may be called a complete mineral manure, but are especially valued for the potash they contain. Where attainable at moderate price their use can be safely recommended. Coal ashes are not considered of much value as manure.

Bones are valued especially for phosphoric acid. They also contain nitrogen. The principal objection to their use is the long time required before they decompose in the soil. The finer they are crushed the better in this respect. Steamed bones have less nitrogen but the phosphoric acid is more readily soluble.

Superphosphate of Lime may be formed by treating bones with sulphuric acid or by so treating any mineral phosphate. The bone superphosphate is often called dissolved bone. On many soils this is one of the best manures. On others it has little effect. Generally speaking, its use is not profitable on naturally fertile land still in good condition.

Nitrate of Sodium and Sulphate of Ammonium are two manures valued for their nitrogen. They are quick-acting manures, and on some soils, usually clayey soils, have a marked effect both on grain and grass crops. It is advised that they be used generally in connection with superphosphate.

Large quantities of valuable manures are made

from the refuse at the great slaughter houses in large cities. The blood, bones, pieces of flesh, etc., may all be utilized. The manure is usually offensive in smell but is valuable on many soils.

No attempt is made here to fully discuss the value or methods of applying any of these manures. Probably the best possible place for any manure, so far as fitting it to furnish the largest quantity of plant food to crops is concerned, would be near but not on the surface soil. The roots could then readily get access to the manure; loss by evaporation would be lessened or prevented by the layer of soil over the manure; loss by leaching would be less than if the manures were more deeply covered. There is always some loss if nitrogenous manures are applied on the surface. There is almost always some loss if the manures are covered several inches in the soil. In wet weather, on porous soils, especially if the manures are applied when there is no growing crop on the land, the loss by leaching may be great. It will be comparatively little in dry weather, on compact soils, or if the manure is applied while a crop is growing, or shortly before the crop is sown.

Stable manure, bones, superphosphate and ashes are slow acting manures. They may continue to produce good effects for several years. Nitrate of sodium and sulphate of ammonium are quick acting manures, rarely producing any considerable effect except during the year they are applied. It is unwise to apply these long before the crop can make use of them, or to cover them deep in the earth.

CHAPTER V.

SOIL IMPROVEMENT BY DRAINAGE AND IRRIGATION.

Water in the soil is essential to the growth of crops. There are soils which are barren simply from lack of sufficient moisture. An excess of water in the soil is always injurious, sometimes fatal to crops. There are plants which thrive in soils saturated with water, or even covered with it, but these are not the common crops of the farm. Before any land can be used to the best advantage it must be able, either naturally or by artificial means, to rid itself of surplus water.

The rain-fall is the primary source of the water in the soil. If a piece of land is too wet, it is because the water which comes to it cannot readily enough flow off or through it. The immediate source of the water may be either the direct rain-fall or water which flows from higher lands. This last may flow down over the surface, or come up from below in springs; in some cases it may ooze out from hillsides or up from the sub-soil.

Some soils have good natural drainage, even when the rain-fall is abundant. The natural tendency of water is to flow downward, either directly into the soil, or over the surface if this be inclined. If the surface soil admits water freely and the sub-soil is open to a considerable depth, or if a porous soil be underlaid with rocks with many crevices in them, even level land will rid itself readily of surplus water. In such soils there will be little or no water, even after heavy rains, in holes dug in the ground; there may

be no necessity for providing aids to drainage of cellars. Sometimes the surplus water so readily passes down to a great depth that it is difficult to get water from wells. There are vast areas of farm lands in the United States where, in a few hours after a heavy rain-fall, the soil is in good condition for cultivation. There is no need that man should undertake to do that which nature has done well for him.

Reasons for Drainage.—By far the larger part of the land in the United States east of the Missouri river either has needed or still needs more or less artificial drainage. Without this much now valuable land would have been comparatively worthless. Probably no one thing has done more to increase the value of the farm lands of several of the central western states than has the extensive work recently done in them in the way of land drainage.

Obviously swampy land, or that with ponds, or that on which water stands for a considerable time after heavy rains, is not naturally well-drained and should have work done to it in this direction. Much land which does not show the signs of need of better drainage may be greatly improved by either surface or underground drainage.

A wet soil is a cold soil. If the surface water can not flow off or down into the deep sub-soil, it can be removed by evaporation only. Evaporation is a cooling process. Much heat is consumed in causing the evaporation of stagnant water in wet soils. Water is, relatively, a poor conductor of heat. Warming a vessel of water by applying heat at the top is a slow process. The heat from the sun's rays has much less effect in warming a wet soil than it has on a dry soil.

Stagnant water in the soil checks chemical action and the preparation of plant food. It prevents the access of air.

The roots of most plants make only slow and feeble growth in such a soil. The yield of farm crops is much reduced, and often the quality of the produce is made poorer. Land which is too wet to be profitably cultivated may give a fair return if kept in grass, but the quality of the pasture or the hay is usually not so good as that grown on well-drained land.

The working season is often shortened if the land is wet. The land cannot be cultivated so early in spring. Heavy rains may unfit it for being tilled for days at a time when the crops are in need of cultivation. In many cases such land is cultivated when too wet, to the serious injury of the crop.

On fairly level land the presence of a few small ponds or swampy places may indicate that drainage of the whole tract is needed; for, although the water stands on the surface over only a small per cent of the area, the soil may be saturated with water to within a few inches of the surface over much of the tract.

Drainage of wet land tends to make the region more healthful for both man and the domestic animals.

In general, it may be said, well-drained land can be cultivated at less cost, with more ease, and will give larger yields of a larger variety of crops, with less danger of loss during bad weather or from frosts, and that it is often more healthful and always more attractive than undrained, wet land.

Surface and Underground Drainage.—The good results from improving the surface drainage of wet land, by straightening and clearing the natural

water courses, opening ditches, running furrows through the fields, etc., have long been known and such work has generally been done to some extent in all civilized countries. Sometimes improving the surface drainage may be all that is necessary or desirable. It is better, however, that the surplus water, unless in great excess, should pass down through the soil rather than over it.

Water flowing over the surface washes away more or less of the best of the soil and of manures which have been applied. It may seriously wash the surface.

It is also true that while stagnant water in the soil is almost always injurious, moving water, in reasonable quantity, is beneficial. While the stagnant water makes the soil cold, the rains in spring are often warmer than the soil and increase its temperature by passing down into it. The rain carries with it ammonia and carbonic acid from the air. It aids in the preparation of plant food. The air will freely follow the water as it could not if the water remained saturating the soil. When the surface has become dryer than the deeper soil water will be carried up again by capillary action, which cannot go on in a soil full of water.

Underground or covered drains have advantages over open ditches. They do not lessen the area to be cultivated nor interfere with the passage of teams. They do not invite the growth of weeds. Oftentimes they are more effective than open ditches of equal depth.

Material for Drains.—Many classes of material have been used in making underground drains, but nothing is so good as round tile made of clay, usually

in pieces about one foot long. Where stones are abundant and it is desired to get rid of them, they may be used, sometimes giving good satisfaction. Boards, poles, brush; even straw may be worth using under exceptional circumstances. "Mole drains," made by drawing a conical shaped piece of iron or wood through the soil at the desired depth, have done good work for years in fairly retentive soils. In most parts of this country, however, there is little reason for using anything else than the ordinary drain tile, or "pipes," as they are called in England. The use of drainage tile was not common until about fifty years ago, and comparatively few had been used in this country until after the civil war. Within the last few years there have been more than eight hundred factories for their manufacture at work in Illinois. Formerly they were made in the shape of a horseshoe, at first without, afterward with a "sole." Now round tiles are almost universally used. It has been found that good tile can be made from any clay suited for brick-making.

The most desirable qualities in drain tile are that they shall be straight, smooth on the inside, with the ends squarely cut off, free from cracks and fairly hard burned. As the water enters the tile almost entirely at the joints in any case, the porosity of the tile is a matter of little importance.

Method of Action of Tile Drains.—Lands are wet because the water is held on or near the surface of a soil so compact it cannot freely enter it; or because the soil is underlaid with rock, clay, hard-pan, or other substance nearly impervious to water. The land may be wet on hillsides because the impervious

sub-soil comes near the surface and causes a discharge of the water which has passed into the soil on the higher land. In time of heavy rains land, such as has been described, becomes full of water, and becomes dry slowly by the aid of evaporation from the surface and the slow passage of water through the retentive soil and sub-soil.

If an open ditch be cut in such a soil, with the bottom having a uniform slope to a stream or other free outlet, it is evident it will rapidly carry off the water until the line of saturated soil, near the ditch, is on a level with its bottom. As the water cannot move freely through the soil the line of saturation gradually rises on either side, until at a distance depending on the depth of the ditch and the character of the soil, no appreciable effect is produced by the ditch.

If the ditch were cut in very retentive soil, it could carry off the water very slowly. If the surface soil be open, but the ditch be cut into the impervious sub-soil, it is evident the water can only enter it by flowing along the top of the compact sub-soil until the ditch is reached. If the surface slope up on either side of the ditch, it will affect the soil to a greater distance than if the surface be level.

If a line of tile be placed in the bottom of the ditch, with their ends so close together that dirt cannot be washed in, and care is taken to see that there is a uniform fall toward a good outlet, and the ditch be filled up, the action will be much the same as in the case of the open ditch.

The efficiency of tile drains depends on many things, as the character of the rain-fall, the retentiveness of

the soil, the size of the tile, the distance apart and the depth of the drains, as well as on the rate of fall, the skill with which the work is done and the character of the outlet.

The total rain-fall for a year is of less consequence than the quantity which may fall in twelve or twenty-four hours. It is useless to undertake to carry off at once the water which may fall in extraordinary cases. Comparatively little harm is done by standing water if it be removed in a few hours. The percentage of water which will pass through the soil depends not only on the amount which falls but upon the character of the soil.

Size of Tile.—Smaller tile are used in England than in this country. Those one inch in diameter were formerly used, and two-inch tile are not uncommon. In many parts of this country tile less than three inches in diameter are rarely used. A two-inch tile is abundantly large for use in many places, but there is danger of mistakes in deciding this point and errors in laying small tile are more serious in their effects than with large tile; hence it is safer to use larger sizes. The carrying capacity of tile varies with the square of their diameter. Thus a six-inch tile will carry four times as much as a three-inch tile; in fact somewhat more, because the resistance from friction against the sides is relatively less in the larger tile. It is a mistake to lay a long line of tile all of the same size. The quantity of water to be carried increases as the line extends, and the rate of fall is rarely great enough to allow an increase in velocity.

For ordinary farm drainage, tile varying from three to six inches in diameter are most commonly used in

this country, with larger sizes for mains in most cases. In the central Western States tile twelve, fourteen or sixteen inches in diameter are not uncommon in main drains on large farms, or where several farmers have united in a system of drainage.

Depth and Distance Apart of Drains—There is a close relation between these two points. The deeper the tile is laid, ordinarily, the greater may be the distance between the drains. Shallow drains cannot affect the land to any considerable distance, and will not lower the line of saturation sufficiently to give the best results. The tile may be injured by frost. Little good comes from cutting deep drains in very retentive soils. Frequent, shallow drains are best for such. In open, porous soils, such as those of the prairie States, drains laid three feet deep will appreciably affect the soil for 100 feet or more on either side. In some very compact English clay soil drains are laid not more than 15 feet apart.

Usually a deep laid drain will begin to flow sooner when rain comes, after a period of drouth, will continue to flow longer, and will carry off somewhat more water in a given time than a shallow drain. The reason these statements are true will be apparent if the results of pouring water into a barrel filled with earth, and with holes bored into its sides at different depths, be thought of.

The cost of digging ditches rapidly increases with their depth. There is no advantage, and some disadvantages, from lowering the line of saturated soil far below the surface. In practice three feet is a desirable depth for tile drains in ordinary soils. The nature of the soil and other conditions vary so much

that it is not wise to attempt to specify the best distance apart. In prairie soils, 100 feet apart is usually a safe distance, even when the land is quite wet.

Cost of Tile Drainage.—What is known as “thorough drainage” is rare in this country. The cost would be so great that the practice is not advisable on lands of moderate price. In many cases the cost would be greater than the price of lands equally desirable and not needing much drainage. Drainage is a permanent improvement, and if a fair interest on the amount invested in it be returned by the increased crops, the outlay is advisable. With drains three feet deep and with tile obtainable near the farm, using the sizes most common, the total cost of the work may vary from fifty to seventy-five cents per rod.

Rate of Fall.—A line of tile laid on an exact level in wet land would carry off much water, if one end were open. A slight fall would greatly increase the carrying capacity of the tile. It is difficult to have tile laid with accuracy; hence more fall is desirable. A fall of one foot in one hundred of length is abundance. Good work is done by many ditches where the fall is not one-tenth this rate. On level land a safe rule is to get all the fall practicable, but not to leave the work undone because the fall is slight. In case of very slight fall the rate can be increased by making the ditch shallower at the upper end.

Planning and Making the Drains.—It is wise to lay out the plan for a system of drains for the farm; but the work may commence where it is most needed. The advice and work of a drainage engineer is helpful but not essential. A good outlet is essential

No drain can do good work without a free outlet. The main drains should follow the lowest land, the natural water courses, unless this line be very crooked. Side drains should, usually, run up and down the slope. Where the surplus water mainly comes from higher land, it is often possible to cut it off by a line of tile running across the slope. The tile for the main drains should be selected with reference to the water they may be ultimately required to carry, and not simply with reference to present needs. Digging the ditch and laying the tile should commence at the outlet. A leveling instrument is advisable, but good results can be obtained by noticing the flow of water in the bottom of the ditch. The tile should be placed as close together as possible. The side drains should enter the main at an acute angle, and a little above the bottom.

The plow may often be profitably used for opening the ditch. A common mistake in digging is in making the ditch wider than is necessary. Another is in determining the depth by measuring from the surface. Many machines for digging ditches for the tile drains have been invented. Some do good work under favorable conditions. The great mass of the work is still done by hand labor.

In exceptional localities ponds and swamps may be drained or good outlets secured for tile drains by openings through the compact subsoil into beds of sand or other porous subsoil underlying the impervious strata.

Where there are large areas of level, wet lands, large open ditches often have to be made as outlets for the farm systems of tile drains. In some States great canals many miles in length and often thirty feet wide have been dug for this purpose.

Losses from Drainage.—The great benefits from underground drainage are accompanied with some loss. There is, sometimes, a considerable loss of nitrogen in the drainage water. It is possible that, if the water level is reduced to the depth of several feet, the surface soil may be dryer during drouth, as the soil cannot draw water up by capillary power from a great depth. Usually, however, a well drained soil has rather more than less moisture in it during dry weather, than an undrained one. It is possible that drainage of large areas may have some effect on the climate, possibly affecting slightly the rainfall. Wherever done with ordinary discretion, it may be safely affirmed that tile drainage will do much more good than harm.

Irrigation.—Where the rainfall is insufficient or comes at long intervals irrigation is necessary for profitable farming. The practice is very ancient. Perhaps it was first introduced along the valley of the Nile. In England the practice is most common in the case of low-lying grass lands, often called “water meadows,” on which water is kept for a considerable time in winter. In this country irrigation is practiced with remarkable success in what is termed the “arid region,” and on the plains of California. The water from rivers or large streams is carried along hillsides by canals and ditches and from these distributed over the land, sometimes by means of elaborate systems of shallow ditches. In some parts of the country great supplies of water are obtained from artesian wells. As yet, however, the regions in which irrigation is practiced, while actually large, are relatively but a very small fraction of the country, and the methods

adopted vary greatly in different parts of the country.

The fact that the yield of crops where the land is irrigated are often surprisingly large, coupled with the fact that the rainfall is uncertain in many localities, makes the problem of irrigation one of importance to farmers in many parts of the country. For exceptional crops profitable use of irrigation by water pumped from wells by means of windmills or steam engines has been secured. The utilization of streams on hillsides or other high-lying land may already be profitably attempted in some parts of the country. However, irrigation is a problem of the future rather than the present so far as most farmers in this country are concerned.

CHAPTER VI.

TILLAGE.

The farmer is called a tiller of the soil. Agriculture is defined as the culture of the field. The soil is no more essential to crop production than is the air, water, heat or light. But the farmer can directly affect the condition of the soil, making it more suitable for crop production, and, through it, can make the supplies of air, heat and water more helpful.

The abundant natural vegetation in forest and on prairie shows that tillage is not essential to the growth of many plants. But nature is very prodigal in seeding. Often not one seed in a thousand of those which fall to the ground produces a plant. Most crops cultivated by farmers would scarcely maintain themselves without the aid of man.

Objects of Tillage.—The chief objects of tillage operations are:

1. To prepare a suitable seed bed and properly cover the seed sown.
2. To keep the soil in good condition during the growth of the crop.
3. "Tillage is manure."

The first object is accomplished by stirring, pulverizing, often inverting the surface soil, and by covering grass, weeds, stubble or manure growing or deposited on the surface.

The second object is generally accomplished by keeping the surface loose and preventing the growth of weeds.

That proper tillage or cultivation of the soil often increases its productive power is undoubtedly true. The ability of a soil to produce crops is often as directly increased by tillage as by the application of manures. The saying that "tillage is manure" as understood by Jethro Tull and by an occasional writer of modern times—that is, that good tillage makes manuring unnecessary—may lead to bad practice. Good tillage, liberal manuring, and good drainage combined are much more likely to continue to give satisfactory crops than if one places chief reliance on either operation.

Some of the reasons why cultivation makes soils more productive are easily seen. Stirring and pulverizing a hard, compact soil enables the roots of plants to penetrate it more easily and greatly increases the quantity of plant food reached by the roots. These operations also permit air and water to enter the soil more freely and thus increase the supply of available plant food. Autumn cultivation exposes the loosened surface to the action of the frost. Prof. Wrightson says: "No implement is so effective in pulverizing the ground as frost."

Sometimes tillage greatly improves very open, coarse textured soils by making them more compact, increasing the number and reducing the size of the pores. This increases the capillary power of the soil.

Surface cultivation, keeping the surface soil loose and dry, causes it to act as a mulch, retarding evaporation.

The destruction of weeds prevents their robbing the crop of food and water.

Plowing.—The plow is the typical farm imple-

ment. The story of its development forms one of the most interesting pages in the history of agriculture. Many attempts have been made to introduce substitutes for it, and these have been largely successful so far as cultivation of the soil while crops are growing is concerned; but the plow is still the chief reliance in preparing soils for crops.

The modern plow cuts, lifts, and turns a furrow. Sometimes it does a good deal in the way of breaking up and pulverizing the furrow slice. There is much difference as regards this last point between the common practice in the United States and in England. American plows, especially those designed for use in loose soils, take a wide and comparatively shallow furrow, crumbling the earth in stubble land, sometimes leaving it in fair condition for seeding without further tillage. English plows, as a rule, take a narrower and deeper furrow and the effort is made, especially in autumn plowing, to expose as much surface to the air as possible, by laying the furrow slice at an angle of about forty-five degrees. Nine inches is a common width of furrow slice in England; twelve, fourteen or sixteen inches, the latter for three-horse plows, are common in the United States, especially in prairie soils. An acre to an acre and a quarter is counted a good day's work in plowing in England. In this country, twice as much is often done with a pair of horses.

Plows have been much improved in recent years. The draft has been reduced and the quality of work done improved. But the best plows are not perfect working implements. Plowing is relatively slow and costly work. A man and team will go over a greater

area in a day in almost any other tillage operation than in plowing. There is a tendency to compact the subsoil unduly by the trampling of the horses and the pressure of the plow. At the best, the plow imperfectly pulverizes the soil. The spading principle seems better, but this has not been successfully applied in general practice, although some ingenious machines for the purpose have been introduced.

Depth of Plowing.—Plow deep has often been given as sound advice for all farmers. Sometimes it is very bad advice. In some soils deep plowing is worse than shallow plowing; in many more it is no better in its results, while it always costs more.

The statement that the deeper the good soil into which roots may descend for food the better for the crops, is a sound one. Where the soil is of like quality to a considerable depth, and is not naturally sufficiently loose, deep plowing will generally be advisable. Sometimes excellent results come from mixing a portion of the subsoil with the surface soil, by deep plowing. Plant food which has been carried down several inches in the soil will be brought to the surface. Exposing a portion of the deeper soil to the action of the frost during winter often is a great help to productiveness.

Deep plowing is rarely advisable on wet, undrained soils. Often this simply increases the depth to which the soil becomes saturated with water, which must escape by evaporation. In shallow soils, with a poor subsoil, any marked increase in depth of plowing at one operation will almost certainly do harm. Gradually deepening the soil by increasing the depth of plowing about an inch each year, may be helpful in such soils.

Much of the fertile prairie soils of the central west and some alluvial soils in other parts of the country often show no increase of yield from deep plowing. Deep plowing is less common on the black prairie soil of Central Illinois, for instance, than it formerly was. These soils are so open in texture that neither roots, air nor water find difficulty in descending to a considerable depth. Repeated experiments have shown that good crops may be grown on such soils without plowing; in fact without other preparation than covering the seed, it being understood that the surface must be freed from rubbish in some way. This practice is not advised, but it illustrates the fact that the physical condition of some soils may be as good without tillage as that of others after much work has been done by the farmer. The latter may produce as large crops as the former, but it is at the cost of more labor.

There is a disposition to over-estimate the depth of plowing. For many soils six inches may be called deep; comparatively few soils need frequent plowing deeper than eight inches. Fall plowing may usually be deeper than is advisable when the work is done in the spring.

Subsoil and Trench Plowing.—Subsoil plowing is loosening the subsoil without bringing it to the surface. In trench plowing the loosened subsoil is laid on the surface. Neither of these operations is commonly practiced by American farmers. Many thousands of acres are annually so treated, but the total is but a small percentage of the cultivated area. Subsoiling is probably advisable on a larger variety of soils in this country than is trench plowing. On undrained soils it often is worse than useless, unless

in rare cases, where there is a thin layer of compact soil above a porous soil. In heavy clay soils the effects are not permanent. In deep, loose soils the practice may do some good but not always enough to repay the extra cost.

Subsoiling may be done either by a separate plow or an attachment to the ordinary plow.

A double plow with a small share and mold board in front which cuts and turns over a shallow furrow, followed by a larger plow which covers this furrow with a deeper furrow, gives good satisfaction to many farmers, especially in plowing sod land.

Time for Plowing.—There are some obvious advantages in fall plowing lands designed for spring sown crops. The pressure of work in the spring is lessened. The crops can often be put in more promptly. Exposing the upturned surface to the freezing and thawing, to the snow and rain of winter, often helps much. Some insects may be destroyed by the process. With some soils reploting in spring may be advisable, but this is not the rule. For fall sown grains, as wheat and rye, it is generally thought best to plow as long before time for seeding as is conveniently practicable; these crops often doing better when the seed bed, while well pulverized, is well compacted. On the other hand there are advantages, in many cases, when plowing ground in the spring, from planting or sowing the crop very promptly after the plowing is done. This is especially true if there is little moisture in the soil. If a crop of clover or other green manuring crop is to be turned under, the plowing will naturally be delayed as long as possible to allow greater growth to the manure crop.

Summer fallowing, or plowing land in the spring or fall and allowing it to lie during the summer, either with or without further cultivation, is only exceptionally practiced in this country, and is not generally growing in favor. Where soils are badly infested with weeds difficult to eradicate, or are especially compact and tenacious, or have only a small supply of available plant food, this practice may be advisable. The condition of the soil may be improved; mineral plant food may accumulate; nitrogen will be absorbed from the air and brought to the soil by rains, or by the decay of vegetable matter. But, if the soil be open textured, and if there be much rain, more nitrogen will be lost than is gained. There is the additional great practical objection that the land makes no return in crop during the year.

Few soils can be plowed when wet without injury. Some sandy soils are little affected, but clay soils are much injured by this practice. It is often almost impossible to get a compact clay soil in good condition after it has been plowed, or even much trampled by live-stock when wet, until it has been exposed to the action of frost.

Harrowing.—Harrowing with any form of toothed harrows affects the soil only to a moderate depth. The operation is cheaply done. The same force of men and teams may go over ten times as much ground when harrowing as when plowing. It is a good method of leveling the surface, helping pulverize the clods, covering seeds, and of destroying weeds. The best of the toothed harrows, however, only slowly and imperfectly pulverize land where there are hard clods, and have almost no effect at a greater depth

than three or four inches. For clay land especially it is better to harrow promptly after plowing if a crop is to be soon sown.

In recent years there has been a great increase in the number and variety of implements or machines which, instead of pushing the soil about as does the harrow tooth, cut it by means of blades or revolving disks. For many purposes such implements are very valuable. They pulverize the surface more effectually than the harrow, and often loosen it to a greater depth. They do not leave the surface smooth and level as will a good harrow. They are being increasingly used instead of the plow for preparing loose soils, when comparatively free from stubble, for spring-sown small grain crops.

Rolling.—On many soils a good roller is one of the most useful of farm machines. Used soon after the land is plowed, when the surface is neither wet nor thoroughly dry, it quite effectually breaks up clods and tends to level and compact the surface. Rolling cloddy, compact soils which have been plowed when wet, may do some good, but the tendency is to push the clods into the ground rather than to pulverize them. Rolling light soils tends to check evaporation. Seeds are often better covered if the land be rolled after the seeds have been harrowed in. Rolling grass, clover or small grain in the early spring often greatly reduces injury from freezing and thawing, as well as makes the surface smoother for mowing. A roller of large diameter is better for this last use; one of equal weight but less diameter will be more effective in pulverizing the surface soil.

Instead of rollers, many farmers use what may be

called "smoothers." These are made in many forms. A cheap and effective form is made by fastening two or three planks together, preferably with some distance between them, and dragging them, broadside, over the surface. For leveling the surface and pulverizing clods such an implement is often better than either harrow or roller.

Tillage During Crop Growth.—The statement that a large part of the cultivation of a crop should be done before it is planted, and that of the rest a considerable part before the crop has started to grow, may seem extravagant, but it suggests a truth—that many farmers do not prepare the ground sufficiently before sowing or planting the crops. As a rule the only cultivation soil designed for small grains, grass or clover receives is that given before sowing the seed. These crops may be lightly harrowed in the spring with possible benefit, but the practice is not a general one. For the cultivated crops, as Indian corn, work in pulverizing the soil and destroying weeds can often be done to better advantage before planting than afterwards.

One chief object in cultivating the soil while a crop is growing is to prevent the growth of weeds. The best time to kill a plant is soon after it has commenced its growth. A weed or grain seed will withstand much rough treatment without apparent injury. A plant when well established, may lose much of its roots or top and yet live. A slight disturbance will usually kill a plant just starting to grow. Harrowing or otherwise stirring the surface after the crop has been planted will often kill many weeds just starting, without injuring the deeper covered seed of the crop.

The longer weeds are allowed to grow the greater the loss of food and water which the crop might otherwise have made use of.

Another chief purpose of crop cultivation is to keep the surface of the soil loose and porous. Some soils "bake" or "cake" on the surface, especially if they have been stirred while wet. Shallow cultivation is all that is needed in such cases. If the soil has been deeply plowed or is naturally loose, it will hardly become too compact while the crop is growing. The roots of such plants as corn often grow more rapidly than do the stalks while the plant is young. Close, deep culture necessarily injures or destroys many roots. Root pruning is almost always injurious to the crop. It may be a necessary evil, but no more of it should be done than is necessary. Deep culture should be given, if at all, while the plants are small.

The relation of cultivation to soil moisture and its evaporation is important. Improving the capillary power of the soil may be accomplished by tillage in many cases, by compacting too open soil, and loosening too compact soils. This work, except at the surface, should be done before the crop is planted. Attempts to improve the physical condition of the soil to the depth of six inches after the crop has well started its growth will usually do more harm than good. Stirring the surface soil during drouth causes some loss of moisture by increase of evaporation. If it is desired to have a pan of wet sand dry rapidly, it is well to stir it. But the loosening of the surface soil and its becoming quite dry saves the moisture in the soil by the dried surface acting as a mulch and thus checking evaporation. A thin coating of finely di-

vided dry earth will have much effect in this direction. Deeply stirring the soil causes the loss of more moisture, injury to more roots and little increase in the benefit in the way of checking evaporation. Comparatively shallow cultivation while crops are growing is very generally better than deeper cultivation.

So long as the ground is kept free from weeds and does not become hard or very compact, there seems no good reason for constant or very frequent cultivation. Many crops are injured by lack of sufficient cultivation; more by improper cultivation; some undoubtedly receive more than is profitable. The labor of men and teams may be more profitably employed than by repeated culture of a field already free from weeds and with the soil in good condition for growth of the crop. The condition of the soil and the crop is a better means of determining whether additional cultivation is needed than is the number of times the land has been stirred.

Of recent years there has been a marked increase in the number and popularity of the tools which stir the whole surface but only to a moderate depth, as compared with the small plows or large shoveled cultivators, which stirred the soil to a greater depth.

Hand hoeing of field grain crops is not common in this country. The work can be better done than by horse power, but the cost is too great.

CHAPTER VII.

ROTATION OF CROPS.

A rotation of crops implies not only change, but change in a regular order; that is, that different crops shall be grown in something like a regular order through a longer or shorter series of years, finally getting back to the starting point. The practice is believed to be very ancient. It is said that, hundred of years ago, it was the custom in parts of England to divide the land into three parts, allowing one to lie in bare fallow; having one in fall-sown and the third in spring-sown grain, thus making a three years' rotation.

Probably the first approach to rotation would be the abandonment of a field after it had been cultivated for some years, thus allowing it to become covered with natural vegetation, the decay of which would tend to increase its fertility.

Rotation not Essential.—A rotation of crops is not absolutely essential to large harvests or, in some cases, profitable farming. It has been noticed that Sir John B. Lawes has grown wheat on the same ground for about fifty years, and that, even where no manure has been applied, the land still produces a fairly good crop. Like trials have been made with barley and roots, although not for so many years, with similar results. The need of helping the fertility of the soil in some way has been clearly shown in the case of each crop. But where either stable or artificial manures have been regularly applied, it has been shown to be possible to produce large crops for a

long series of years, without change, or rest to the land. In a good many cases in this country, where some special crop has been thought particularly profitable, it has been shown possible to grow it annually for many years on the same land, by reasonable use of manures.

In exceptional cases such a course of continued cropping without change may be wise and profitable. The general practice of good farmers and abundant experimental evidence, however, show that a rotation of crops is usually wise.

Reasons for Rotating Crops.—The reasons why a rotation of crops is usually good practice may be divided into two classes: Those which concern the convenience and probable immediate profit of the farm work, and, secondly, those which relate to maintaining or increasing the fertility of the soil.

Aside from the usual arguments in favor of producing something of a variety of crops on a farm, such as that this practice reduces the risks of the farmer, since it is not probable that all will be poor in yield or low in price, and that it better distributes the work of the year, enables the farmer better to provide for live-stock, etc., all of which have some bearing on rotation, it is also true that one crop may more profitably follow another than itself, from its leaving the soil in better condition. Land long kept in crops which are not cultivated while growing is liable to become infested with weeds.

The most important reason for rotation is that the practice helps keep up the productiveness of the land. Three reasons why this is true may be given:

1. While all farm crops are made up of the same

chemical elements the proportion in which they use these varies greatly. So, also, the quantity and proportion of these they leave on the soil, in the stubble or refuse, differs much.

2. The range of the roots and the power of assimilating plant food differs much in different crops.

3. Farm crops differ much in the length of time required to come to maturity, and in the time of year in which they make much of their growth.

An ordinary grain crop will take from the soil much less potash than will a crop of clover, potatoes or any of the root crops. A crop of oats will take more potash than will one of wheat or Indian corn. A crop of clover will take considerably more phosphoric acid than will a grain crop, while one of mangels or turnips will take considerably more than will the clover. Obviously there is an advantage so far as the supply of these substances is concerned in alternating crops which take less with those which take more.

The red clover plant, in a suitable soil, sends its roots down to a greater depth than the mass of the roots of such a grass as Kentucky blue grass. A long, large mangel or sugar beet sends its roots much deeper than a round turnip. The strong growing, far-reaching roots of corn go deeper than those of oats. The deep and shallow-rooted plants will obtain much of their mineral food at different depths. A well established crop of red clover would obtain a large part of its food from a depth scarcely reached by a crop of white clover or potatoes.

The unusual depth to which clover sends its roots, and the large size of these roots, which greatly increases the stock of vegetable matter left in the soil,

are reasons for the high esteem in which clover is held as a valuable crop in any system of rotation. Another important reason is found in the fact that the clovers and other leguminous crops, such as peas and beans, are able to assimilate greater quantities of nitrogen than are the cereal, grass, or root crops. In recent years it has been shown that leguminous plants have the power, not possessed by other plants, of assimilating the free nitrogen of the air. It is believed that this power is the result of the action of minute organisms which cause the formation of tubercles on the roots of plants of this order. It is a remarkable fact that, although a crop of clover hay will often contain twice as much nitrogen as will a crop of wheat, oats, corn or grass, it leaves so much nitrogen in its roots and stems that the soil contains more of this especially valuable element than it had before the clover was grown. A good crop of clover may be grown on soil which, because of lack of nitrogen, would not produce a good crop of wheat. After removing the hay, the soil may be fitted to give a good grain crop the next year by plowing under the stubble.

It has already been stated that there is a loss of nitrogen from the soil in drainage water or by its being washed into an open subsoil. In wet weather, especially where there are warm and wet winters, the loss in this way may be considerable. The loss is greater on soils free from vegetation than on those on which a crop is growing. The roots of the growing plants take up and make use of nitrogen which otherwise might be lost. Especially is this true of deep-rooted plants. The roots of red clover have been called "nitrogen traps." Obviously crops like pasture

grasses, or clover, which continue to grow from early spring until late autumn, can make use of more nitrogen than those which finish their growth in early summer, as wheat. Indian corn, in this respect, has a great advantage over the small grains. It makes much of its growth after wheat has fully matured. It is thus able to make use of the supplies of available nitrogen which are being formed during the summer. Still more is this true of grass or clover, which continue to grow still later in the season.

It seems reasonable to believe that plants which have a long season of growth can thrive fairly well on soils with a less supply of available plant food of any kind than can those which make their growth in a short time.

In soils with loose, open subsoils or where manure with much nitrogen has been applied, especially in regions where there is considerable rain in the autumn and early spring, there is good reason for following early ripening crops with some fall-growing crops, as wheat or rye, or for seeding the land with clover or grass.

Green Manuring.—One form of rotation of crops which is often highly recommended is the growth of crops with sole reference to their manurial value. In this country, sowing a crop of clover or buckwheat, or of cow peas in the Southern States, in the spring, or of rye in the fall, and plowing the crop under when it has made a good growth, are the most common methods of green manuring. The effects are often very noticeable. The store of vegetable matter in the soil is largely increased. Sometimes this much improves the physical condition of the soil. Always the

decay of this matter increases the humus and, ultimately, the supply of available mineral plant food near the surface.

The objection to this practice is that no direct return, aside from the increase of fertility of the soil, is made for the time, labor and seed used, or, in many cases, the land brings no money crop for a year. Sowing clover with small grain crops and plowing this under in preparation for a wheat crop in the fall or corn crop in the spring is a practice becoming more and more common. The only extra expenditure in this case is the cost of the seed. Some one has said the only objection to this practice is that, as a rule, it would be still better practice to allow the clover to stand another year, utilizing the crop for pasturage or hay, and then plowing under the second growth.

Fortunately it is not usually necessary to use a crop solely for manuring. A part of the growth may be utilized for hay or, better, for pasture, with little loss of the manurial value of the crop, it being understood that the manure made from the crop taken off is to be returned, as well as the part of the crop not removed plowed under.

Choice of Crops in Rotation.—The crops to be used in a rotation will be selected with reference to the ease with which they can be grown, and their market or feeding value, as well as their value in maintaining fertility, and the needs of the soil of the locality. Fixed rotations have never been so common in the United States as in Great Britain, and, even there, more variation is allowed than formerly. Soil and climate must have large influence, but the relative

value of different crops, the facilities for marketing them, the greater or less price of live-stock products and the present money needs of the farmer, often must determine the exact rotation he adopts.

The alternation of grain with green crops; of cultivated with uncultivated crops, are fundamental principles in theoretical rotations. So far as maintaining fertility is concerned it would probably never be best to repeat a grain crop without an intervening green crop, but in practice it is often best to cultivate the same crop two, sometimes even more, years in succession.

In Great Britain roots are the chief cultivated crop. In the United States, Indian corn is the principal cultivated crop. Unlike as maize and root crops are in other respects this one point in common makes each prominent in the best systems of rotation in the country in which they are grown.

The "Norfolk" four course, or four years rotation, has been very popular on light land in England. The order of cropping is: Roots; grain, usually barley; "seeds," that is, a mixture of clover and grasses; grain, usually wheat—each one year. The roots are turnips, or mangels, and are often eaten by sheep on the ground where they grew. Sometimes, clover, rye, turnips, or vetches are sown after the wheat is harvested and these crops followed by the regular root crop. On poorer soils, or where it is not desired to have a grain crop so frequently, the "seeds" may be left two or three years, as is the usual practice in this country. In some parts of England the rotations are very elaborate, lasting several years and introducing a variety of "catch crops."

Prof. Wrightson gives the following specimen rotations for clay lands in England: Poor clays—Fallow, bare or cropped; wheat; beans, or oats, or clover. Better clays—Fallow; wheat; beans; oats. Rich clays—Fallow; wheat; beans; wheat; clover; wheat. In each case the fallow land may be cultivated throughout the season or have a “catch crop” on it in the latter part of the season.

In this country “roots,” even including potatoes, are little grown in comparison with the cereals. Peas and beans also form but a very small percentage of the crop acreage. Over much of the country the choice in rotation is practically limited to grass and clover, as the green crop; the small grains, usually either wheat or oats or both, and Indian corn as the hoed or cultivated crop. In a rotation made up of these, the grass, and especially the clover, will be the “manuring crop,” the corn the “cleansing crop,” and the small grains will be, as a whole, the most “exhausting crops.” There are large regions to which these statements do not apply—as in the cotton, special potato, or tobacco-growing regions, but the totals of these, large as they are, are relatively small.

Where it is adapted to the soil and climate, red clover is the most valuable crop in a rotation for this country. It gives a large crop of good food for either pasture or hay. It leaves a large quantity of vegetable matter on and in the soil, in its roots and stubble. This contains much nitrogen, and the mineral matter has largely been brought from a lower depth of soil than the roots of some crops reach. The decay of the roots not only increases the stock of humus in the soil but helps its physical condition.

The usual meadow and pasture grasses also do good, if well managed. Where live-stock is pastured on a grass field comparatively little valuable matter is carried off. If the animals are well fed with grain, their droppings may make the soil more fertile. The quantity of both nitrogen and ash ingredients in the surface soil will be considerably increased. That an old pasture ground, when broken up, will usually give a fine corn crop is well known. Permanent pastures are not so common in this country as in Great Britain, the pasture lands here being usually included in the rotation. As a whole, this tends to keep up the fertility of the whole farm. Hay-making and selling is more exhaustive than pasturage, and a continuance of this practice without manuring the meadows is not advisable, but the accumulation of humus and readily available mineral plant food in the roots and stems of the grass is such that when an old meadow is plowed it frequently gives a good yield of grain, notwithstanding the loss of plant food by the sale of the hay.

Indian corn is now generally thought a less exhaustive crop than it was formerly believed to be. The longer period of growth, as compared with the small grains; the fact that it can make use of nitrogen supplies made available during the summer and early autumn; the fact that it has abundant, wide-spreading and deep running roots, and the fact, that, in many parts of the country, only the grain is removed, the stalks, leaves and husks being left on the ground, help explain why it does not decrease fertility so rapidly as its large yield might suggest.

Oats are popularly supposed to be exhaustive, but the oat crop is the one crop the application of ma-

nure to which, when grown on lands of moderate fertility, is often injurious. The growth of straw is liable to be unduly stimulated and the crop to fall down.

The great maize growing states are also great cattle rearing regions, hence there is much pasturage and meadow required. In these states the following rotation is not uncommon: Three years in grass and clover, two years corn, one year small grain (wheat or oats), seeded with grass and clover. If less stock is kept the grass and clover may be kept but two years. If the small grains are more prominently grown, wheat may be grown two years in succession. If the land is not so well adapted to corn, there may be but one crop of this. Commonly, however, the second crop is fully as good as the first. While not considered so good practice, three or even more corn crops are not unfrequently taken in succession, on fertile prairie or alluvial soil. In this general rotation the manure is usually applied to the land while in grass, either as a top dressing for its benefit, or to be plowed under for the corn crop.

Where pasturage is the main feature, or where the land is thinner and not so well adapted to corn, the land may remain in grass several years, the clover usually mainly disappearing.

Over some considerable areas a four-course rotation, but with many modifications, is practiced. It may be: Corn; oats or fallow; wheat; clover and grass. In this case the manure will be applied to the fallow ground or the oat stubble for wheat.

Even in the almost exclusive grain-growing regions some benefit is found to result from alternating the corn and the small grain crops.

Double cropping is not common. Sometimes a crop of corn or sorghum or millet may be grown after wheat and removed in time for another wheat crop. As has been stated, the practice of sowing clover in the spring on the wheat or oats ground, whether the land is designed for wheat the next fall or is to be put in corn the next year, is growing in favor.

Clover alternated with some one grain or with the potato crop is an uncommon but successful rotation.

With a careful rotation, especially if clover have a prominent place in it, land of naturally fair quality, if well tilled, may be cropped for many years without showing much, if any, reduction in yield. Some intelligent farmers think that, with a good rotation and good tillage, the application of manure is unnecessary. It may be for a considerable number of years, but depreciation of fertility will finally come. Good tillage, a good rotation, and liberal manuring, combined, are the best security against ultimate loss.

CHAPTER VIII.

THE CHOICE AND IMPROVEMENT OF CROPS.

There is a large variety of crops grown on the farms of the United States. A very few, however, occupy most of the acreage. What is popularly called the grass crop—including many varieties of grasses and the clovers—grown for pasturage and hay, occupies the largest area and has the greatest value. Next to this come the three great cereals, corn, wheat and oats. The acreage in corn is about twice that in wheat and three times that in oats. Cotton comes next in acreage. Large as is the acreage in some other crops there is none which makes any considerable percentage of the total cultivated area. A million of acres is a very large tract of land, but it is insignificant when compared with the hundreds of millions of acres in the farms of the country.

There has been rapid increase in the cultivated acreage of the country and some changes in the proportion given to different crops, but there is little reason to believe that the time will soon come when grass, corn, wheat and oats will not be the leading crops of the country, at least so far as extent of acreage is concerned.

Almost every crop now grown on the farms of the United States had been grown to some extent before the revolutionary war. Improvements in methods of culture or in machinery for utilizing the crop have brought some crops into greater relative importance. This has been noticeably true of cotton, and it is

much to be hoped may be true of beets and sorghum for the manufacture of sugar.

The possibilities of crop production depend mainly on climate and soil. Of these the climate is the more important. Manuring, culture, or drainage may greatly modify the soil and make it fit for crops for which it was illy prepared. Plants, like animals, have great adaptability; they may become acclimated and do fairly well where neither soil nor climate is like that in their native land. Usually, however, it is unwise to attempt the growth of any crop which experience has shown to be illy adapted to the climate and soil of a given region; at least as a leading crop.

The profitableness of the growth of a given crop depends not only on the climate and soil, but very largely on the market facilities, and, so far as the individual farmer is concerned, largely on his tastes, experience and capital. The farming in many parts of this country has greatly changed, not because of soil exhaustion or changes of climate, but because of changes in the market demands. Usually, in regions recently settled, where land is low-priced and transportation facilities are poor, farmers devote themselves to grazing cattle or sheep or to the production of crops, like corn and wheat or cotton, which can be readily transported long distances. Where the soil and climate are favorable wheat has been a favorite crop with new settlers, because a considerable acreage can be grown with comparatively little expenditure of money or labor, and a money return can be secured more quickly than if stock-raising be selected as the chief business. As the land advances in value, especially near large cities, the production of crops

which give a larger money return for the acreage and of such as cannot be carried great distances without injury becomes more common. Thus supplying milk to large cities is now a chief business on farms formerly devoted to grain growing.

The general practice is usually the safest guide. There are many exceptions to this, but no safer rule can be given to one about commencing farming in a region with which he has little acquaintance than to follow the practice of the most successful farmers in the vicinity, at least in the beginning of his work. As stated, there are many exceptions. It not infrequently happens that the most profitable farming in a community is that by some one who has introduced a new industry, or sought to give a home supply of some article which has hitherto been brought from a distance. A man of special skill and intelligence may sometimes wisely work against peculiarities of climate and soil. It often happens that those who are first to see the probable value of a crop new to the region, or first to adapt their farming to changing conditions, are much more successful than their neighbors.

Specialties or General Farming.—For most farmers the production of several crops is safer and wiser than giving nearly exclusive attention to one crop. Here again there are many exceptions. A wisely selected specialty often gives much larger profits than come to the farmer who divides his efforts between several branches of farming. The specialty farmer ought to learn more about producing and disposing of his one crop than if he looked after several. He has a better opportunity of making a good reputation and of getting somewhat higher

prices. He may be able to produce more cheaply by a better use of machinery.

General farming usually enables the farmer to distribute his labor and that of his employes and teams to better advantage throughout the year. It gives the advantages of a rotation of crops, and, if stock feeding be a part of the system, of retaining much of the manurial value of the crops on the farm. It is something of a safeguard against poor yields and poor prices. It rarely happens that all the crops give poor yields and also bring low prices. This may happen with a specialty in any one locality.

The attempt to produce a little of each of a large variety of crops on any farm is almost always unwise. The safe rule is to give the chief attention to one or two or three crops, but not limit the farm work to these.

The tendency in farming, as in almost all classes of business, is toward specialization of effort and division of labor. This is wise, but it may be carried too far. It is not now wise for farmers to attempt to clothe themselves with the wool or cotton produced on their own farms or to produce all that they eat; but it is not the best management for the largest number of farmers in this country to buy any large part of the food of their teams or other live-stock on their farms.

For reasons which need not be discussed here, but largely because the feeding of farm animals on the farm is one of the best methods of preventing decrease of fertility, animal husbandry in some form should be a part of the system of management on the majority of the farms in the country. Meat, milk or wool is most cheaply produced where the animals get

most or all their food by grazing in good pastures. Hence liberal provision for grass or some of the clovers should be made on most stock farms. In most cases it is also best that the greater part of the grain or other food given them should also be produced on the farm. The by-products of manufactures are coming more and more in use, and it is well this is so. Oil cake or meal, whether of linseed or cottonseed, will doubtless become a still more popular food than it now is. Bran, etc., may often be purchased with profit, but corn and oats will long remain the chief grain food for farm animals. Wheat will probably long continue to be the great bread grain for civilized man. The great majority of the farmers north of thirty-five degrees or thirty-six degrees north latitude will do most wisely, so long as present conditions continue, to make some or all of these crops the chief product of their farms.

There are large areas in which minor crops may be more profitable than these great staples, and in very many neighborhoods a few farmers may do well to select some special line of work. Thus in the neighborhood in which this is written, large profits were formerly made on broom-corn. Now this crop is scarcely grown in this vicinity, but the presence of a large cordage manufactory makes the culture of hemp an especially profitable branch of farming, and a number of farms are almost exclusively devoted to this crop.

Cotton will certainly continue to be the chief farm crop of some Southern states, and it is probable the area in the Gulf states in which sugar cane is most largely grown will extend. It is believed, however, that more variety of crops, allowing some rotation, would be better in these regions.

Potato culture and the growing of what are called market garden crops, as well as fruit growing, are more profitable than ordinary grain growing in a good many localities; but important as these crops are they are still minor crops and engage the attention of but a comparatively small percentage of the farmers of the country.

Specific rules which shall be applicable to all parts of the country cannot be given. The great staple crops can safely be grown where soil and climate are adapted to them and where there are reasonable transportation facilities. When practicable a rotation is better than continuous growth of any crop, and it is very desirable to give a place in the rotation to clover or some plant of the same family. Generally the crops of which the larger part is retained on the farm are to be preferred. The growth of broom-corn, where only the brush is sold and this cut before the seed has matured, is less exhaustive to the soil than is the continued culture of Indian corn where the grain is sold. The order of cropping which will give employment during most of the year is ordinarily to be preferred.

Specialities which require most of intelligence and skill may give largest profits, with possibilities of large losses.

Improvement of Farm Crops.—Probably there is no grain, grass, fibre, or root crop cultivated in the United States which has not been greatly changed since it was a wild plant. In recent years many new varieties have been produced, differing in marked degrees from those formerly cultivated. Farmers generally do not actively interest themselves in the improve-

ment of their crops; are not always careful to maintain them in their present standard of excellence. Much can be done in this direction. It is often unnecessary to rely on specialists or to pay high prices for improved varieties. A frequent change of seed is not necessarily a good thing; certainly it is not necessary to obtain seed from distant parts of the country for a region where the soil and climate is well suited to the crop. If the region is not well adapted to the crop frequent new supplies of seed may be helpful or even essential. Probably no part of the world is better adapted to Indian corn than is much of the central Mississippi Valley. There would seem to be no good reason for changing seed of corn in this region. Much of this same region is not equally well suited for the oat crop. The climate is too dry and hot. The oats are much lighter than those produced in more moist and cool regions. Obtaining seed oats from regions where the crop does better is good business management.

Three methods of crop improvement are commonly used. These are selection, cultivation, and crossing. With some crops, as Indian corn, all these methods are easily practiced. With some, as with the small grains and grasses, crossing is more difficult. With plants, as with animals, the rule is that like produces like, or the offspring resembles the parent. Many things may cause variation but the tendency is toward almost exact reproduction. Persistent selection of seed from plants possessing any characteristic will tend to fix that characteristic until it will almost certainly be reproduced. Much less attention is paid to selection of most seeds than is given to selection in animal breeding, but like results may be expected to follow.

It is not alone the character of the seed but of the whole plant that may be affected by selection. Selection simply with reference to the size or shape or color of the seed is faulty. The character of the plant producing the seed should also be determined. Selection before or at the time of harvesting is wiser than selection from the granary. In this way the size, form, time of maturing, and prolificacy of the plant may be determined.

Good cultivation will tend to improve varieties; at least tend to prevent deterioration. Thick or thin seeding has a marked effect on the quantity of seed produced. The best varieties may become poor if given poor treatment.

The production of new varieties by cross-fertilization may unite good qualities of both or secure improvement. Sometimes greater vigor of plant or productiveness is thus secured. Occasional production of new varieties of potatoes from the seed seems almost essential. Sometimes a single plant of grain, grass, clover or other crop may, from some unknown cause, present some desirable quality in unusual degree. Selection of seed from such a plant is not "small business." It may prove a profitable step. Some widely famous varieties of grain had their origin in this way.

A definite idea of what is wanted, careful and persistent selection with reference to the possession of the desired qualities, and then good cultivation, is often a wiser method of getting good varieties of farm crops than purchasing new varieties from a distance and at high prices.

CHAPTER IX.

WHEAT.

History.—The cultivation of wheat is much older than the history of man. Very ancient monuments, much older than the Hebrew Scriptures, show its cultivation already established. The Egyptians and Greeks attributed its origin to mythical personages. The earliest lake dwellers of Western Switzerland cultivated a small grained variety of wheat as early as the stone age. The Chinese grew wheat 2,700 B. C., and considered it a direct gift from Heaven. Wheat is one of the species used in their annual ceremony of sowing five kinds of seeds. Chinese scholars believe it to be a native of their country.

The existence of different names for wheat in the most ancient languages confirms the belief in its great antiquity. It has been asserted that wheat has been found growing wild in Western Asia, but the evidence is not conclusive. The Euphrates valley is believed by De Candolle to be the principal habitation of the species in prehistoric times. So far as known wheat was not grown in America before its discovery by Columbus.

Its ease of cultivation; its adaptation to a climate favorable to the beginning of civilization; its quick and abundant return; its ease of preparation for use; its abundant supply of nutritious substance; possibly its rapid improvement under cultivation and the fact of its being paniferous, or possessing that special quality which adapts it above any other grain to the making of light bread, were probably some of the reasons

which caused primitive man to begin and continue its cultivation. In addition, its wide adaptation to different soils and climates has made it one of the principal foods of mankind.

Production.—The average wheat production of the world is from 1,500 to 1,700 million bushels annually. Europe produces annually about 1,200 million bushels; about 3.5 bushels per inhabitant.

The largest five wheat producing countries of Europe, are, in order of importance, France, Russia, Austro-Hungary, Spain and Italy. Germany and Great Britain were formerly more important wheat producers than at present. The United States and India are the only other large wheat producing countries.

The United States produces a large surplus of wheat annually, and must compete in the markets of the world with other nations. Europe is our foreign market. She requires nearly four bushels per inhabitant, or about a half-bushel per inhabitant more than she produces.

Each country of Europe, however, does not import equally and some export in considerable quantities. The principal importing countries are Great Britain, France, Belgium, Germany, Italy and the Netherlands. The average total net import of wheat of the various countries of Europe for the ten years, 1880 to 1889, was 203 million bushels annually. Half of this import went to Great Britain. During the same ten years, the average net export has been 88 million bushels, most of it coming from Russia and Roumania.

Outside of Europe the principal wheat exporting countries are the United States and India. Australasia, Canada, Algeria and Egypt export small quantities.

The wants of Great Britain control the wheat market of the world. Of the wheat consumed in Great Britain one-third to one-half is home grown. Fifty years ago only three per cent was imported. In that time the price has fallen thirty-five per cent, and the consumption has increased thirty-two per cent per inhabitant. The consumption per capita is given at 5.5 bushels. Other grains used increase the quantity to the equivalent of ten bushels of wheat per inhabitant.

The United States raises the most wheat of any nation on the globe. The following presents the essential statistics for the average of ten years, 1870-1879, and 1880-1889:

	1870-79.	1880-89.
Area, acres	25,000,000	37,000,000
Yield, bushels.....	312,000,000	450,000,000
Value, dollars	327,000,000	372,000,000
Value per bu., dollars.....	1.05	0.83
Yield per acre, bu.....	12.4	12.1
Value per acre, dollars.....	13.00	10.00

The yield during this decade increased forty-four per cent over that of the previous decade. The value of the crop increased only fourteen per cent. The value per bushel was twenty-two cents less during this decade than during the previous one, and the value per acre was three dollars less. The yield per acre has not materially decreased.

According to recent estimates forty-two per cent of the wheat grown in this country is consumed in the county in which it is grown. Of this eleven per cent is required for seed. About one-fourth of our crop is usually available for export. About one-third of the crop, therefore, is consumed in this country outside of the county in which it is grown.

While wheat is grown in every State in the Union

the greater part is raised in the Mississippi Valley. The progress of wheat-growing is steadily westward.

In 1849 the central line of production passed through Eastern Ohio; in 1859, through Eastern Indiana; in 1869, through Eastern Illinois; in 1879, through Central Illinois, and in 1889, the central line was on the western side of the Mississippi river. In 1849 only three per cent of the wheat was produced west of the Mississippi river. The fortieth parallel nearly divides the crop into northern and southern halves.

Wheat production has been stimulated by three prominent causes: 1. The possession of large areas of fresh lands, easily brought into cultivation; 2. The extension of railway construction, and 3. A period of several years of poor crops in Western Europe. The first cause is fast disappearing, and the second is becoming less important. The third is as uncertain as the seasons.

Structure.—The wheat plant belongs to that class of plants in which the first leaves of the embryo are alternate, technically known as monocotyledons. The family to which it belongs is characterized by having hollow stems with closed joints, alternate leaves with their sheathes split open on the side opposite the blade.

The flower of the wheat has three stamens, the anthers, which contain the pollen or fertilizing element, being suspended on thread like filaments. The stigma, which receives the pollen and conveys it to the ovary, or female element, is in two parts and is feathery. It is necessary for the ovary to be fertilized with the pollen before any seeds can be formed. It is believed that it is better for the ovary of a given

flower to receive the pollen of some other flower rather than its own. This is accomplished in the case of wheat and other cereals by the wind. At the proper season, this pollen may be seen floating in the wind over the wheat fields.

Whether varieties of wheat mix by natural methods when sown near together is one of the disputed questions. That they do not do so readily seems fairly well established. Wheat varieties may be crossed or

hybridized by conveying the pollen of one variety to the stigma of another by artificial means.

The ovary, stigma and stamens are enclosed in two chaffy parts called palets. The parts collectively constitute the flower of the wheat. Three or more of these flowers are enclosed by two more chaffy and harder parts called glumes.



FLOWER PARTS OF WHEAT.
(After Gray.)

This is called collectively a spikelet.

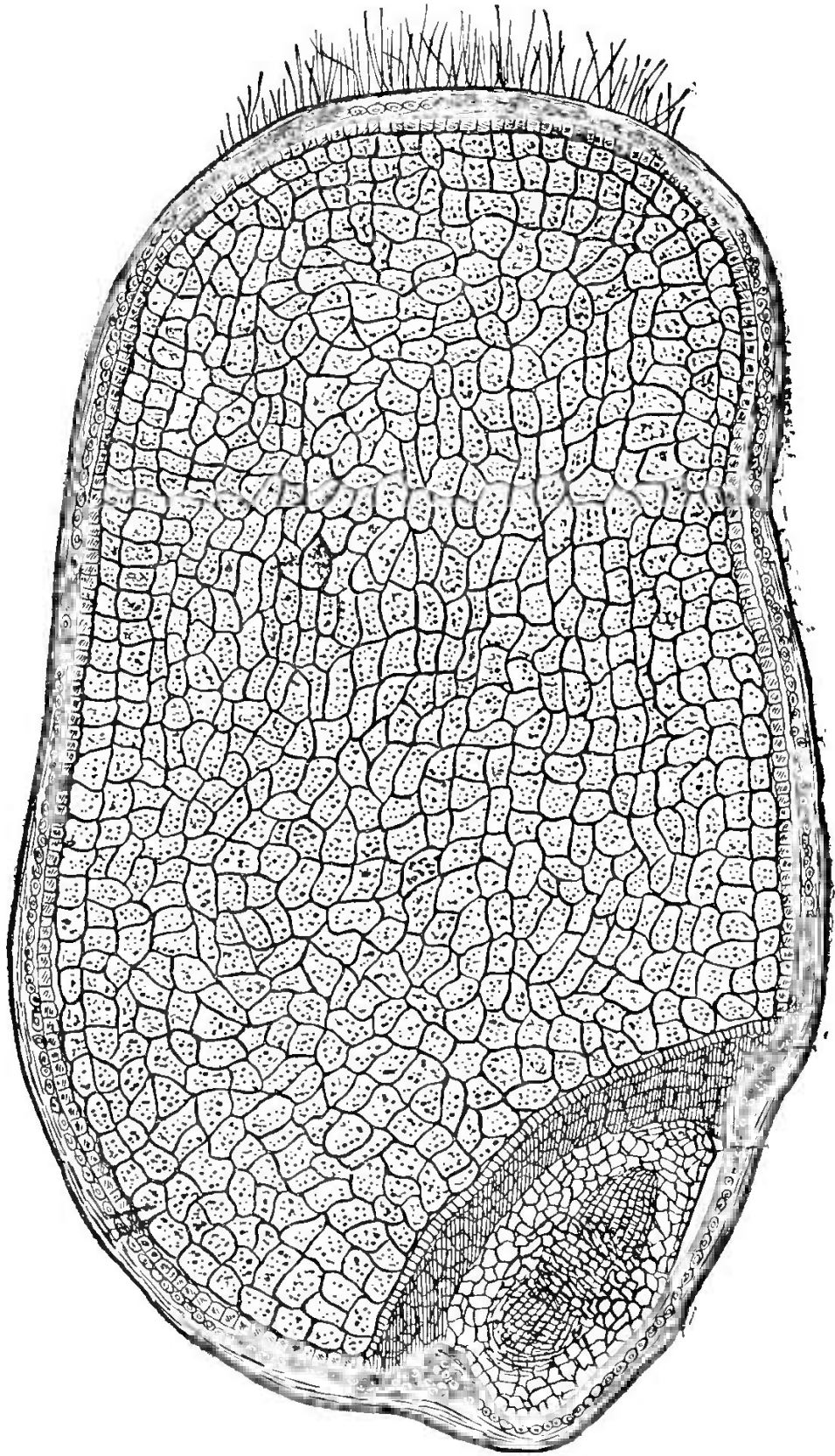
These spikelets in the grass family are arranged in two ways, viz.: On a more or less lengthened base, as in the oat, when the whole head is called a panicle, or joined directly to the stem as in wheat, when the head is called a spike. Several species of the grass family, including wheat, have the spikelets in a spike arranged alternately at the joints of a zigzag jointed stem, the joints being alternately excavated on the side next the spikelet. The reader should study a head of wheat in connection with this description.

In the genus *Triticum*, to which wheat belongs, there is but one spikelet at each joint and it is placed flatwise, usually on a single spike. We have in this country some wild species which are usually placed in this genus. They are perennial. Wheat is not only annual but the experiments of Lawes and Gilbert indicate that artificial cultivation is essential to its growth. Sir John Lawes is wont to say that if man should disappear from the earth wheat would follow him in three years.

The process of milling consists in separating that portion of the wheat berry which is desirable for bread-making from the undesirable portion, and reducing it to an impalpable powder.

The wheat berry is covered by a light, colorless, spongy envelope composed of cellulose, which is the principal ingredient in wood and straw. The envelope is about three per cent. of the entire berry and is almost, if not quite, indigestible. Botanically it is not a part of the seed proper, but is equivalent to the pod of the bean or the shell of the hickory nut.

Within this envelope is the testa, or true covering of the seed, which is finer but similar in structure, except instead of being colorless its cells are filled with two coloring matters, one a pale yellow and the other an orange yellow. These pigments give to the berry its color, which varies according to the relative abundance of the two. The testa is about two per cent. of the berry. It is the portion which gives millers so much trouble, as a surprisingly small amount makes the flour dark and the bread darker. The two envelopes described constitute the bran and together make about five per cent. of the wheat. The



LONGITUDINAL SECTION OF WHEAT BERRY.
(Highly magnified.)

bran of commerce contains about 75 per cent. of other materials; that is to say, 15 per cent. of the nutritive portion of wheat; otherwise bran would be practically valueless as a food for stock.

Within these envelopes, and next to them, is a row of irregular, cubical cells. This row of cells is supposed to be simply an expansion of the embryo and has been called the embryonic envelope. The cells are filled with phosphate of lime, and a solvent substance called cerealine, which assists in germination.

The body of the grain or endosperm consists of large thin-walled cells, filled mostly with starch but containing also gluten and other albuminous material. This is the portion from which flour is made and is 75 to 80 per cent. of the whole berry. In the modern processes of milling, besides the bran proper, the germ or embryo, the embryonic envelope and seven per cent. or more of the endosperm is separated from the remaining endosperm, the latter only being made into flour. About 70 per cent. of the berry is made into flour.

Chemical and Physical Properties.—In chemical composition wheat is very variable. It is probably more susceptible in this respect to surrounding conditions than any other grain.

The following may be given as the average of over 300 analyses of American wheat:

	Per Cent.	Pounds per ton.
Total dry matter.....	89.46	1789.2
Albuminoids.....	11.80	236.0
Crude fat.....	2.11	42.2
Nitrogen-free extract (starch, etc.).....	71.89	1437.8
Crude fibre.....	1.80	36.0
Ash.....	1.86	37.2

The spring wheats contain a somewhat larger percentage of albuminoids than the winter wheats. In individual instances there is considerable variation. Flour made from the hard spring wheats is richer in albuminoids than the winter wheats. The lightness of bread depends upon the per cent. of albuminoids, and it is for this reason that, with the modern process of milling, spring wheat makes the best flour.

High weight is almost always an evidence of high quality, but not always of large, plump, well-matured grains.

The hard spring wheat of the Northwest, which is small in size, and not well-matured in the sense of having a large, plump berry, is very heavy in its weight per bushel; while the large plump wheat of Oregon, which is very starchy, is light in weight. The weight of a bushel may vary from 55.5 to 65.5 pounds. In the majority of cases where trials have been made the weight varies with the percentage of albuminoids. Hence we find weight, together with the comparative uniformity of the kernels and cleanliness, fixes the grade of wheat. The shape rather than the size of the kernel affects the weight per bushel. Richardson found, as the result of nearly 400 determinations, that there were about an average of 12,000 kernels in a pound of wheat; in some samples there were less than 8,000, while in others 24,000 kernels to the pound. Obviously one bushel of seed in the one case would be equivalent to three bushels in the other.

The analyses of wheat given show that wheat contains 10 to 11 per cent. of water.

This represents the moisture in the samples as analyzed, often after they have stood in the dry-room of the laboratories. What percentage of water wheat

contains as it goes on the market cannot be stated, but it has been shown to vary largely from day to day with the varying conditions of the atmosphere. In California, where the atmosphere inland is very dry at harvest, this subject is a matter of considerable commercial importance. It is claimed that the moisture that this California wheat will absorb during a voyage from San Francisco to Liverpool will sometimes increase its weight enough to pay the entire cost of the freight. Wheat bought inland and kept in warehouses all the season would increase in a similar manner.

Experiments by Hilgard and O'Neil, of the University of California, indicated that wheat of the inland of California might increase twenty-five per cent in weight by the absorption of water when transported to a temperate climate, while a gain of five to fifteen per cent might be looked for with absolute certainty. A difference of nine per cent was observed in twenty-four hours. Brewer found a difference of from five to eight per cent between the water in wheat in a furnace heated room in February and the moist air of New Haven freely circulating in the same room in September. Richardson found that two days were sufficient to equalize the moisture in samples of flour which varied from less than eight to over thirteen per cent originally. Afterward the water in the samples fluctuated with the humidity of the air.

Wheat absorbs forty-five per cent of its weight of water in germinating. The lowest temperature at which wheat will germinate is forty-one degrees; the highest temperature one hundred and ten degrees; and the best temperature for the germination of wheat is about eighty-four degrees Fahrenheit.

CHAPTER X.

WHEAT.

Climate.—The yield and quality of wheat and hence its successful growth, agriculturally considered, depends mainly upon these six conditions: climate, soil, variety, method of cultivation, liability to disease, and attack of insect enemies.

The quality of wheat may be affected by the climate, as is evidenced by the difference between the hard spring wheats of Dakota and the soft winter wheats of Washington. Richardson found one sample from Dakota to contain eighteen per cent of albuminoids while one from Washington contained only 7.7 per cent of albuminoids. Differences exist elsewhere, but in a less marked degree. It has been shown that the climate of Colorado modifies the quality of wheat brought from other climates. Climate and soil, however, are intimately connected, so that it may be laid down as a rule that localities having widely different climate and soil produce their peculiar varieties and modify those which are brought to them. It is believed by some that the annual renewal of the seed from a desirable and favorable source often makes it possible to raise cereals where otherwise the climate and other unfavorable conditions would render their profitable cultivation impossible through reversion.

According to the tenth census of the United States seventy per cent of the wheat of the United States was grown where the average January temperature was

below freezing; eighty-five per cent was grown where the average July temperature was between seventy and eighty degrees and sixty-five per cent where the mean annual temperature was between forty-five and fifty-five degrees. We must be careful not to attach too much weight to this, as the soil, particularly its ease of cultivation, has greatly affected the distribution of wheat. However, although there are some noted exceptions, as California, Egypt and India, most of the wheat of the world grows in regions of cold winters.

The wheat plant for its best development needs to have its early growth in the cool part of the year. It is only early in its growth, during cool weather and slow growth, that wheat tillers. A long period of growth consequent upon cool weather gives it better opportunity to get sufficient plant growth. A cool, prolonged but not too wet spring is probably best.

According to the investigations of Lawes and Gilbert, there is a nitrifying agent in the soil which produces a supply of nitrates necessary to produce the crop. Suppose a maximum crop requires twenty-four pounds of nitrates besides those already formed in the soil, and throughout the growing season four pounds are produced per month. Six months of growth would be necessary to produce a maximum crop. If a warm growing season should force the crop to maturity in five months, it would not have enough food to produce a full crop. The loss of nitrates during wet seasons has been found to be greater and the amount taken up by the wheat smaller. On this account comparatively dry seasons should be favorable for the production of large crops of wheat.

Wheat of hot, sunny climates, with dry weather during the latter part of the growth, is brighter and makes a better quality of flour the world over. The United States is particularly favored in this respect.

In a country of cold winters it is better to have the ground covered continually with snow. Alternate freezing and thawing with the plant exposed to the wind is very destructive to wheat. Winter wheat kills in two ways, by being frozen to death and by being heaved out by alternate freezing and thawing. When the soil is bare, that about the roots will reach nearly the temperature of the air above, but if the soil is covered with a couple of inches of snow, the temperature of the soil will be little if any below the freezing point.

Soil and Manures.—The character of the soil affects the yield more than the quality of the wheat. Light clay soils are eminently adapted to wheat. A large proportion of the wheat is grown in this country on what is known geologically as drift soil, the controlling reasons being ease of cultivation and adaptation to the use of light machinery

In the United States very little manure, comparatively, has been applied directly to wheat land. In many places wheat is grown continuously without manure. Undoubtedly a change from this practice must take place eventually. Exporting over one hundred millions bushels annually, besides one-half the home consumption going to the cities to be lost, must be decreasing the fertility of the soil.

In many places wheat forms a part of a rotation of crops, stable manure being applied to the other crops, such as corn. In some places, although less frequent-

ly, stable manure is applied directly to the wheat, where wheat forms a part of the rotation. Clover is used in many places as a part of the rotation and with good results. In some localities, potatoes and wheat are grown alternately, large quantities of manure being applied to the potato crop. In some localities clover is sown with the wheat and then plowed under in August, another crop of wheat sown and clover sown again.

The drilling of a couple of hundred pounds of commercial fertilizers with the wheat is not an unusual practice in the Eastern States, and the quantity used seems to be increasing, which indicates that farmers believe that they are getting profitable returns. Commercial fertilizers are comparatively rarely sown with wheat in the Western States.

The Experiment Stations of New Jersey, Pennsylvania, Maryland, Ohio, Kentucky, Indiana and Illinois are among those which have made field tests with the various approved forms of commercial fertilizers for the production of wheat. The general result at these Stations has been that the increase in yield of wheat produced by the application of the various forms of commercial fertilizers has not given a profitable return for money invested, at the price of wheat and of fertilizers during the ten years 1880 to 1889. An increase in the price of wheat or a decrease in the price of fertilizers would tend to make their use profitable.

Of the three single ingredients usually considered valuable in commercial fertilizers, phosphoric acid has generally given the largest increase, and potash the least. A complete fertilizer—that is, one com-

posed of nitrogen, potash and phosphoric acid—has usually given the largest increase but at a more than corresponding cost. Usually, but not always, barnyard manure has given a large increase in yield; considered entirely as a waste product, it has been applied profitably. This does not preclude the possibility that it may be more profitably used on some other crops.

That commercial fertilizers have not been profitable in the instances given does not show that they would not be profitable on other soils and under other conditions, but the results indicate that it would be prudent for every farmer beginning the use of commercial fertilizers on wheat to apply them in a limited way and in such a manner as to make it evident whether their application was profitable on his soil.

While advocated by some, mulching wheat with straw or other material for the purpose of winter protection has not been generally practiced. The Ohio Experiment Station has been testing the question of mulching during the past decade, and has found no practical benefit from the use of a mulch. In severe seasons the benefit has been very slight, while in mild seasons the mulch has usually been harmful. A heavy mulch was more harmful than a light one. In exposed situations and localities where there is little snow upon the ground a light mulch is beneficial to the wheat. But where there is considerable snow and the temperature more uniform the mulch is pretty certain to do more injury than good.

Variety.—There are two cultivated forms of the genus *Triticum*. First, the form in which the palets

are freely removed when the grain is threshed. This is known as wheat. Second, the form in which the paleas adhere to the kernel, as they do in barley and oats. This form is known as spelt. According to Vilmorin, there are four forms, or, as some authors claim, species of wheat, and three forms of spelt, as follows:

1. Common wheat—*Triticum vulgare*, Villars; *Triticum hybernum* and *T. æstivum*, Linn.

2. Turgid or Egyptian wheat—*Triticum turgidum* and *T. compositum*, Linn.

3. Hard wheat—*Triticum durum*, Desfontaines.

4. Polish wheat—*Triticum polonicum*, Linn.

5. Spelt—*Triticum spelta*, Linn.

6. Starch wheat—*Triticum dicoccum*, Schrank; *Triticum amyleum*, Seringe.

7. One grained wheat—*Triticum monococcum*, Linn.

The Turgid or Egyptian wheat is known as the Wheat of Miracle or Wheat of Abundance, because of its branching spikes. It is said to be much cultivated in the valley of the Nile at the present time. Hard wheat has been long cultivated in Central Europe and Northern Africa. Polish wheat is chiefly cultivated in Eastern Europe and Northern Africa. Spelt is not now as commonly cultivated as formerly. It is chiefly cultivated in the mountain regions of Europe and Asia. Starch wheat is cultivated for its starch in Switzerland. It is said to be especially hardy. There seems to be reasonable evidence that the different forms of wheat are but races of one species, produced by long cultivation.

It will be noticed that common wheat has two Latin

names, *Triticum hybernum* and *Triticum aestivum*. Linnæus applied *T. hybernum* to winter wheat and *T. aestivum* to spring wheat. It has been shown, however, by direct experiment, that winter wheat may be changed to spring wheat and spring wheat to winter wheat. M. Mouries sowed winter wheat in the spring and out of one hundred plants four alone ripened seeds. These were sown and re-sown and in three years plants were reared which ripened all their seeds. Conversely, nearly all the plants raised from spring wheat sown in the autumn perished from the cold, but a few were saved and produced seed. In three years this spring variety was converted into a winter variety. This is a striking example of the climatic adaptability of wheat. It shows that a variety which possesses valuable characteristics, although lacking hardiness, may be worth attempting to grow until it becomes adapted to the climate.

The variety has very much to do with the successful culture of wheat in each individual instance. Except in the possible extra outlay for seed, it costs no more to raise twenty bushels from a good variety than ten bushels from a poor variety. If, on the other hand, the yield is increased by the use of fertilizers, or by better preparation of seed-bed, the increase is made at some expense, more or less considerable.

The question, What is the best variety? has never been answered. There is no best variety for the whole country. Not only do good varieties in one locality prove poor varieties in another, but often a variety which one year gives the largest yield of fifty varieties, sown the next year in the same locality is one of the poorest yielders.

Another reason which makes the comparative merits of varieties so confusing is that many names are given to the same variety. It is not unusual for old and well-known varieties to be put on the market with high-sounding names and extravagant praises. Probably the re-naming of old varieties is to some extent intentional deception, but doubtless much of it is through ignorance. A wheat raiser procures fresh seed from some source without knowing the name of it, and finds after growing it a year or two that it is better than that grown by his immediate neighbors. This leads to a local name, given either by the grower or the buyers. The better the variety and the more extensively it is grown, the larger the number of names it is likely to receive. Different varieties, also, although less frequently, sometimes have the same name.

There are varieties which for a given locality will do better during a series of years than will others. It is of great importance for wheat growers to discriminate between the good and the poor. It is not within the scope of this book to name even the varieties which are raised in this country, and it would be impossible to make out lists of desirable varieties for so large a country with any substantial accuracy.

What is a variety? The following are some of the characteristics which may be taken to constitute variety differences: color of berry, color of glumes, glumes bearded or smooth, growth of the straw, and time of ripening. If grown under like conditions probably the size of the berry when the differences are marked should be considered. With winter wheat the time of ripening is not a very important characteristic.

The first three characteristics are probably the most important and it will be seen that a classification according to these three characteristics would make eight groups, thus:—

Wheat....	{ Bearded..	{ Glumes white..	{ Berry red —1
			{ Berry white—2
		{ Glumes bronze.	{ Berry red —3
			{ Berry white—4
	{ Beardless.	{ Glumes white..	{ Berry red —5
			{ Berry white—6
		{ Glumes bronze.	{ Berry red —7
			{ Berry white—8

Different varieties coming in any one of these groups will usually resemble each other very closely and need to be subjected to a rigid test to determine their right to be called separate varieties. Varieties with red berries and white glumes without beards seem to be the most common. It has been pretty conclusively demonstrated that there is practically no difference in yield between red or white, or bearded or smooth wheat.

Starting with any good variety, the important thing is by cultivation and careful selection of seed to keep the variety from deteriorating and, if possible, to improve it. The evidence is universal that, for want of careful selection and proper cultivation, any pure variety of wheat will in a few years after its introduction become comparatively worthless. It is a popular belief among farmers that a variety “runs out,” becomes gradually poorer, when grown continuously on the same land or in the same locality for a number of years; and that a change of seed is essential—at least beneficial. While this is possible the effect of the change of seed must be slight as compared with intelligent, methodical selection. The benefit that a farmer usually derives from a change

of seed comes from the fact that he buys from some one who has taken more pains in growing and selecting his seed.

With wheat very little selection is practiced beyond occasionally grading the wheat and sowing the larger grains. While doubtless this is beneficial it is not the logical method. A large kernel may come from a head with a very few kernels, while a small kernel may come from a head with many kernels and much more weight of grain. The latter would be likely to produce much more wheat than the former. The logical method would be to use for seed the offspring of that seed which produced the largest progeny of best quality. If a plant produces five heads, each containing thirty to forty berries, and another produces but one head containing but twenty berries, the seed of the former will probably be more productive than the latter. The well known law that like produces like is true with plants as well as animals. Whether the law is equally available for purposes of improvement is not probably fully settled, but it is much more available than is usually recognized.

CHAPTER XI.

WHEAT.

Culture.—The ideal seed-bed for wheat, in the opinion of the majority of intelligent wheat raisers, is one that is compact below, being pulverized at the surface merely. When the soil is loose and open below, the spaces fill with water in the winter time and the freezing and thawing heave the plants and kill them. On the other hand, in times of drouth the soil dries out more completely down to the solid earth below and below the mass of the roots, to the injury of the plant, while, if the surface merely is pulverized, the soil immediately below, and that which is in contact with the bulk of the roots, remains moist.

Drilling wheat in the standing corn is practiced in some localities where there is a friable loam soil. In this case the soil has the proper surface pulverization from the cultivation of the corn, and is compact below. The wheat is sown by drawing a five-hoe drill between the rows of corn. Afterward, at the proper time, the corn is husked. In the winter or spring, when the ground and stalks are frozen, the stalks are broken off by drawing a heavy drag over the surface. In some cases the corn is cut and shocked before the proper time to sow the wheat and the wheat sown with the five-hoe drill between the rows of stubs. This method makes it possible to follow corn with winter wheat and the expense of putting in the wheat is small. It is thought also that the stalks are some protection to the wheat at times in

preventing the snow from drifting off the wheat. It is doubtful, however, whether the yield of wheat is so great as when a good seed-bed has been prepared by plowing.

Burning stubble when wheat follows small grain is sometimes advocated because it is possible to obtain a more compact and finer seed bed, and because it burns weed seeds, insect enemies and germs of plant diseases. Against the practice it is urged that organic matter and nitrogen are lost by burning. It would seem that the desirability of burning the stubble would depend upon the relative importance of these various elements in a given locality. There are some instances of very good results from burning stubble.

It is generally conceded to be good practice to plow as early as practicable after the previous crop has been removed, so that the soil may become compact before the seed is sown. Just before seeding the land should be thoroughly pulverized with some suitable implement. The kind of implement will depend upon the nature of the soil.

Both practice and experiment show that drilling is better practice in seeding winter wheat than sowing broadcast. The wheat is more uniformly distributed and covered and is sown at a more even depth. It is believed also to be less easily winter killed either by freezing or heaving. The drill makes little furrows in which the snow lodges and is prevented from being blown away. The amount of snow held in the furrows is sufficient to modify the temperature of the soil considerably. The wheat is less likely to be heaved out from freezing and thawing. The soil at the bottom of the furrow offers greater resistance to

the heaving than does that at the top of the ridge. The movement of the soil will take place at the point of least resistance, which will be at the top of the ridge, thus leaving the plant at the bottom of the furrow undisturbed. Just how much effect this has practically one year with another is not known, but in some trials where the furrows were obliterated by rolling the yield was not materially affected.

The time of sowing depends, of course, upon the locality. It is possible to sow later as we go south, and necessary to sow early as we go north. When sown too late the wheat has not sufficient vitality to stand the cold weather. When sown too early its growth is so rank and succulent as to be injured by freezing. In some localities, early sown wheat is subject to attack from the Hessian fly. This may be avoided by later sowing, especially if delayed until there is a slight frost, and also by sowing early some strips of wheat, where the Hessian flies will congregate and may be destroyed by plowing under the wheat.

Neither is there any best time for a given locality, as very much depends on the season prior to and after seeding. It may be said that as a general rule, although late sowing is often as good as early sowing, it is seldom better, while early sowing is often better than late sowing. On the fortieth parallel, at an altitude of 500 to 1000 feet, winter wheat should generally be sown between the first and twentieth of September. Doubtless the richer the soil, the later the seeding may be done with safety, as the rich soil would produce the growth needed in a shorter time. Spring wheat should be sown as early as the ground can be got in fit condition for seeding.

The depth of sowing will vary with the kind of soil, the moisture in it and the levelness and firmness of the seed-bed. It may be planted deeper in a sandy soil than in a clay soil. It is necessary to plant deeper in a dry than in a wet soil. An uneven and cloddy soil would require that some be planted deeper than is desirable in order that all may be covered. From one to three inches may be said to be the extremes at which wheat should be sown. It is reasonably well established that the nearer the seed approaches the former depth the better, under ordinary circumstances.

The quantity of wheat to be sown per acre will vary with the character of the soil, climate, time of planting, seed-bed, size, quality and variety of seed and method of seeding. If sown early less would be required than when sown late, because each plant would become larger, tiller more, and thus cover more ground. If the seed-bed is well prepared and the vitality of the seed good, a larger percentage of seeds will grow than if the seed-bed and seed are poor. A bushel of one variety may contain three times as many kernels as another. A variety which tillers profusely could be sown thinner than one which does not. If drilled a less quantity could be sown than if sown broadcast.

The yield will not be at all in proportion to the seed sown. The wheat plant adjusts itself to its surroundings. If sown thickly it tillers but little and produces but few heads per plant. If sown thinly it stools more and the heads are larger, often sufficiently to counterbalance the thin seeding.

In climates where the winters are uniformly mild

much thinner seeding may be practiced than where the winters are severe. The fact seems to be that when the winters are mild the plant largely adjusts itself to its surroundings, so that it makes but little difference how much seed is sown, but if the winter is severe and the wheat partly killed, if the wheat is sown thickly there may be still wheat enough left to raise a fair crop.

The Statistician estimates the average quantity of winter wheat sown as 13-8 bushels per acre, and of spring wheat $1\frac{1}{2}$ bushels per acre. Professor Brewer found by means of circular letters sent to representative farmers throughout the country that the amount sown in the middle Atlantic States was 7 to 9 pecks, in the Mississippi and Ohio Valleys 6 to 8 pecks, and in California 3 to 8 pecks, the smaller amount being used in the drier regions.

Winter wheat may be rolled in the spring, when there is much heaving of the soil, in order to pack the soil about the roots. The cost of thus smoothing the surface may often be repaid by the increased facility with which the crop can be harvested. When grass-seed is sown with the grain, rolling should never be neglected.

Wheat is sometimes harrowed in the spring but it is a practice that cannot be recommended. The cultivation of wheat, much as we cultivate corn in this country, is not unusual in England, although less usual than formerly. Cultivation of wheat has been tried in this country to a limited extent, but it has almost always been harmful rather than beneficial.

Harvesting.—The wheat harvest of the United States begins in Texas in the early part of May and

ends in Dakota and Washington in August. In California the harvest begins about June 1st and lasts till August 1st. Everywhere east of the great plains wheat is cut as soon as, or a little before, it is ripe, and the harvest extends on any one farm not longer than two or three weeks, the wheat being cut as fast as it is ready. In California, where there is no danger from storms, the harvest extends for many weeks after the wheat is ripe, some of it standing even ten weeks after it is ripe enough to cut.

The usual practice in the eastern half of the United States is to cut when the straw begins to turn yellow and the kernels in the dough, soft enough to be easily indented with the thumb nail and hard enough not to be easily crushed between the fingers.

Investigations indicate that there is a continuous increase of the plant during its growth until the plant is entirely ripe. There is a continuous increase in the weight of the kernel from the time it is formed until it is hard and dry. The increase in weight of kernel is most rapid up to the time when the kernel can be crushed between the thumb and finger. The increase seems to be decided and of economic importance up to the time when the kernels indent but do not crush under the pressure of the thumb nail. After that time the increase is slight.

It has been proven beyond question that at the earlier stages of seed formation a considerable transfer of material from the straw to the kernel may occur after cutting, if the wheat is placed in condition similar to the shocking and capping of bound sheaves. So far as getting the maximum yield is concerned, the results indicate that it is better to allow the wheat to

get nearly, if not entirely, ripe, but if it is necessary to cut at a much greener stage, shocking and capping would probably be beneficial. Of course there is always danger from over-ripe grain shelling out in harvesting, also danger from lodging.

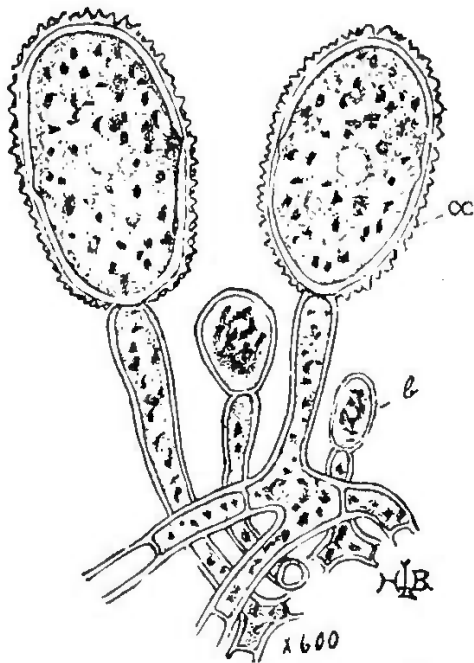
It has been found that, in general, there is a decrease in percentage of albuminoids, fibre and ash as the wheat becomes ripe. This is doubtless due to the starch or endosperm developing later in the growth of the wheat. The germ develops first, and later, when the endosperm develops, the percentage of albuminoids becomes less, although the actual amount may remain the same, or, as is probably the case, may increase. The higher per cent. of albuminoids in the spring wheats may be due to a less full development.

Plant Diseases.—Wheat is subject to three common diseases: rust, stinking smut or bunt and black smut.

Rust is caused by, or rather is, the general term for several species of fungi, the best known of which is called by botanists *Puccinia graminis*. The life history of this fungus is supposed to be about as follows: Certain forms of the plant grow in the leaves of the barbary plants and perhaps other plants. On the leaves of the barbary plant there appears in the spring certain orange-colored spots. These spots are composed of many spores which, getting upon the leaves of the wheat, in some way not well understood, enter through the breathing pores. The spores produce microscopic plants which grow within the wheat plant and upon its substance. A wheat plant infected with the rust plant has not only to support itself but also to support the rust plant. This it is more or less un-

able to do and the result is a lessened yield of wheat, very much in proportion to the vigor of the rust plant.

Anything which will favor the growth of the wheat, without favoring the growth of the rust plant in



Red rust spores of wheat rust.



Black rust spore of wheat rust.

a corresponding degree, enables the wheat plant to resist the ravages of the rust plant.

About the time the wheat is in the milk, elongated, orange colored spots appear upon the leaves and stems

of the wheat. This is the red rust of wheat and other cereals. These spots are one of the fruiting stages and are composed of spores (Uredspores) which reproduce themselves quickly, thus spreading the disease rapidly. About the time the kernels begin to harden or in about two weeks from the time the red rust appears, long black lines appear upon the leaves and stem. This is the black rust. These lines are composed of spores (Teleutospores) which live over winter and convey the disease to the barbary bushes. Red and black rust are different fruiting stages of the same plant. The red rust spores can produce the rust plant in the wheat directly but have not generally been supposed to stand freezing weather. The black rust spores live over winter but have not generally been supposed to cause the disease directly.

From this brief history it would seem that in order to prevent the disease it would only be necessary to eradicate the barbary bushes, upon which appear the first stage of the disease. This has been done in many places in England, where stringent laws on the subject have been enacted. On the other hand, however, there are, without doubt, in this country places where for a radius of fifty miles a barbary bush never grew and yet wheat and other cereals rust. It seems probable that there are other plants upon which the first stages develop—perhaps common weeds—or that it is not necessary for the plant to go through always all the stages of its development.

There is no known remedy against the disease. Moist, damp weather causing succulent growth when the wheat is developing the kernel, seems to be favorable to the growth of the rust. Damp weather is,

doubtless, favorable to the growth and distribution of the red spores, thus augmenting the trouble where it already exists. There is no such thing as a rust proof variety of wheat. Although in a given season



LOOSE SMUT OF WHEAT.

SMUT OF OATS.

some varieties rust more than others it cannot be said that the same will be true of the same varieties another year.

The wheat plant is infected by the rust after the

wheat germinates. The seed is not infected, and no treatment of it would be of any avail.

Black, or loose smut, is a disease affecting the kernel of wheat and other cereals and is caused by a microscopic plant of a somewhat different nature from rust, known as *Ustilago Tritici*.

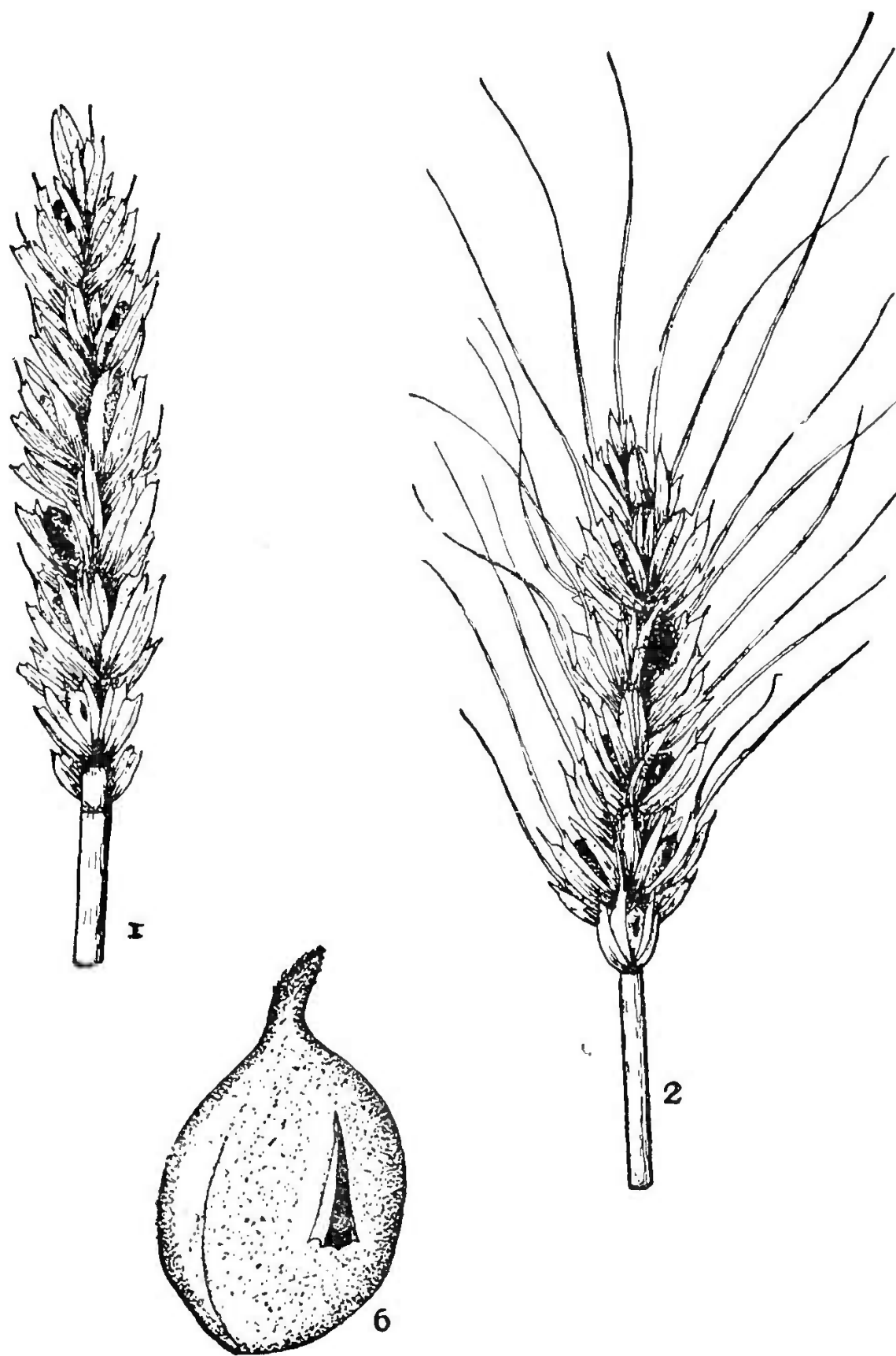
In black smut the whole kernel and even the chaffy parts are reduced to a black powder, as is commonly seen in oats. The black powder is the fruiting stage of the smut and is composed of myriads of spores. These spores are blown about by the wind and fall on the ground, when they are ready to infect a succeeding crop. More or less remain sticking to the uninfected berries, which when the seed is sown causes the disease again.

The remedy is obvious and complete. Sow on ground not previously infected and sow seed which has not come in contact with the smut, or sow with seed on which the smut has been killed.

The same methods which are employed in purifying smutty grains, in the case of stinking smut, given below, are recommended by some experimenters for this form of smut, but their efficacy is denied by others.

Stinking smut or bunt is caused by either of two fungi, *Tilletia foetens* and *T. tritici*, somewhat related to the loose smut above described. This form of smut instead of reducing the berry to a powder and blowing about is retained within the coat of the berry, often through all the processes of harvesting and marketing.

The infected kernels when ripe are more or less swollen and of a brownish color. As they are larger



STINKING SMUT OF WHEAT.

than the normal kernels of wheat they make the head somewhat larger in diameter, and the kernels can be seen more plainly. The kernels are filled with a rather dull, brownish powder, which has a very disagreeable and penetrating odor.

The disease is spread by the use of smutted seed and is to be prevented by sowing on clean ground and with seed free from smut spores.

The infected seed may be practically if not entirely freed from the disease. The methods used consist in soaking the seed in certain solutions, or simply in hot water. The most common solutions are a saturated solution of common salt and a five per cent solution of copper sulphate. The wheat should be placed in sacks or baskets and these put into the solution and allowed to stand twenty-four to thirty-six hours, when the wheat should be spread out to dry.

More recently the Danish investigator, Jensen, has introduced the method of soaking the wheat in water at the temperature of from 127 to 133 degrees Fahrenheit for five minutes. American experimenters recommend fifteen minutes.

CHAPTER XII.

INDIAN CORN.

History.—Indian corn, or maize, is pretty certainly of American origin. It has been introduced into Europe, Asia and Africa since the discovery of America. After its introduction into the old continent it spread very rapidly across Northern Africa and Southern Europe and across Asia into China. The rapidity with which it spread gave rise to disputes as to its origin and considerable confusion as to its name.

It has been known by the following curious names in Europe: Turkish corn, Italian corn, Roman wheat, Sicilian wheat, Indian wheat, Spanish wheat, Barbary wheat, Guinea and Egyptian wheat. These names were given it in various places on account of the country in which it was supposed to have originated. It simply indicates the country from which and through which it was introduced. The names, with the exception of Indian, are those of places bordering on the Mediterranean Sea. It seems to indicate that Indian corn was brought from America in vessels which sailed into the Mediterranean Sea and landed in the various countries indicated. The climate on both sides of the Mediterranean is fairly well adapted to the growth of Indian corn. The rapid introduction into these countries of so striking a plant and its spread therefrom is not a matter of surprise.

The word "corn" is used in Europe with the signification that the word "grain" is used in America. All

the cereal grains in the former countries are called corn, and Indian corn is called maize.

The records of the early voyagers prove that Indian corn was cultivated on the American continent from Maine to Chili at the time of its discovery. It was then the great bread plant of the New World. Numerous varieties of corn have been found in the ancient tombs of Mexico, Peru and New Mexico. These monuments are supposed to be two thousand years old. As there were many varieties at this time, the cultivation of corn must have been considerably more ancient, although not necessarily so ancient as that of wheat. There was a semi-civilized race of people in Peru, Mexico and even in New Mexico, who made considerable use of Indian corn, using it boiled and roasted when green, and grinding it and making it into bread when ripe.

Indian corn was the salvation of many of the early colonies, preventing the colonists and their stock from starving. The tame grasses had not been introduced, so that besides corn stover their stock had nothing but salt marsh hay.

The early settlers learned the cultivation of corn from the Indians. The James River settlers, under the tuition of the Indians, began to raise corn in 1608, and within three years they appeared to have as many as thirty acres under cultivation. The pilgrims found it in cultivation by the Indians on their arrival at Plymouth, and began its cultivation in 1621, manuring as the Indians did with fish.

“According to the manner of the Indians we manured our ground with herrings, or rather shads,

which we have in great abundance and take with ease at our doors.

You may see in one township a hundred acres together set with these fish, every acre taking a thousand of them, and an acre thus dressed will produce and yield as much corn as three acres without fish." In the Jamestown settlement they planted pumpkins and melons in the hill with the corn.

No wild type of the corn is known, so that its origin is as much unknown as that of wheat. Some have contended that the pod corn, in which each kernel is covered with a husk, was the original type of corn. It has been suggested that the original type of corn produced the kernels in the tassel as is sometimes seen, especially in suckers. The pod corn has a very marked tendency to produce kernels and fairly well formed ears in the tassel. The transition from kernels in the tassels, each covered with a husk, to kernels on an ear without husks on each kernel, is not difficult to imagine.

Production.—The Indian corn production of the world is not accurately known, but it is probably 2,800 to 3,000 million bushels, or about one-half more than that of wheat. Of this quantity the American continents raise three-fourths to four-fifths. Europe raises most of the remainder. There are five states in this country each of which raises more than any nation of the eastern continent. The largest corn-producing nations of Europe are Austro-Hungary, Italy and Russia. Other corn-producing countries are France, Spain, Portugal, Roumania, Algeria, Australia, Mexico and Canada. Great Britain and Ireland raise no Indian corn, except occasionally in gardens for table

use. There is not enough heat and sunshine during the growing season to mature the crop.

In the United States the corn crop occupies one-third the tillage area. There are 41 acres of corn raised for each 1,000 acres of superficial area as against 20 acres of wheat.

The average annual production of Indian corn in the United States for ten years, 1870-79, and for ten years, 1880-89, is given below:

	1870-9.	1880-9.
Area, acres.....	44,000,000	71,000,000
Yield, bushels.....	1,184,000,000	1,703,000,000
Value, dollars.....	505,000,000	669,000,000
Value per bushel, dollars. ...	0.43	0.39
Yield per acre, bushels.....	27.1	24.1
Value per acre, dollars.....	11.54	9.48

It is a curious fact that the increase in yield of corn during the past decade over that of the previous one has been in the same ratio as that of wheat; namely, 44 per cent, and that the total value of the crops has increased in nearly the same ratio as that of wheat, being but a fraction of a per cent less; namely, 13.3 per cent. The value per bushel has decreased four cents, and the yield per acre has decreased three bushels. The average gross value of an acre of corn has been less during both decades than that of wheat; while the production of wheat has increased between five and six times during the past fifty years, corn has increased between four and five times during the same interval.

The seven states—Ohio, Indiana, Illinois, Iowa, Missouri, Kansas and Nebraska, produce about two-thirds the crop of the United States, and are known as the corn surplus states, because they are practically

the only states which supply the commercial centers with corn. In most of the other states the corn is largely consumed where raised and need not be taken into consideration in the commerce of this crop, except as these states need more or less from the surplus states for consumption.

Very little, comparatively, of the corn raised in the United States is exported. Since 1870 the export has varied from 1 to 6.5 per cent and has averaged about four per cent. In 1889, up to that time, the year of our greatest crop, it was about five per cent. This very small proportion amounted to more than 100 million bushels.

The amount required for consumption is a very variable quantity, depending on price, other and cheaper feeding materials being largely used when the price is high. The average consumption for ten years past has been about 1,600 million bushels, or 28 bushels per head of population. This is the heaviest rate of consumption of any cereal by any people in the world. It is nearly twice as much, according to population, as the consumption of all the cereals in Europe.

The quantity of corn stover or stalks raised in the United States is never even approximately ascertained by the gatherers of crop statistics. The yield has been estimated from experimental evidence at about one and one-third pound of corn stalks for each pound of grain produced. On this basis there has been raised annually during ten years, 1880-89, 51 million tons of corn stover. The average annual production of hay during the same time has been about 42 million tons.

Use.—The chief use of the Indian corn crop is as

food for stock. It is, in connection with grass, the great pork and beef producing material of the United States. The fact that five-sixths of the crop is consumed within the county in which it is raised indicates that it is largely used for this purpose. Sir John B. Lawes once said that the natural food of the civilized hog was barley meal. If he had lived in America he would have said that ear-corn was the natural food of the civilized hog. The wonderful development of our pork industry is directly related to our corn crop. For the production of pork there is no single stock food equal to Indian corn.

While of secondary importance a considerable quantity of corn is used in the aggregate as food for man. Corn bread and hominy are common articles of food, especially among the colored population of the South.

The ratio of corn to wheat is greater in the South than in the North and there it makes a very considerable part of the diet of the colored people. Corn is suited to primitive methods. It can be ground for the purpose of making corn bread by very simple machinery, and hominy is made by soaking the corn in the lye of wood ashes, which removes the outer coat.

Some attempts have been made to bring Indian corn into more general use, especially among Europeans, by preparing a variety of attractive dishes from it. At present, however, it is used there as a human food only in limited quantities.

Corn preserved in its green state has become an article of considerable importance. There are extensive canning establishments in various parts of the country which use in the aggregate millions of bushels

of corn, mostly of the larger varieties of sweet corn. Glucose, starch, alcohol, whisky and malt liquors are also made from Indian corn.

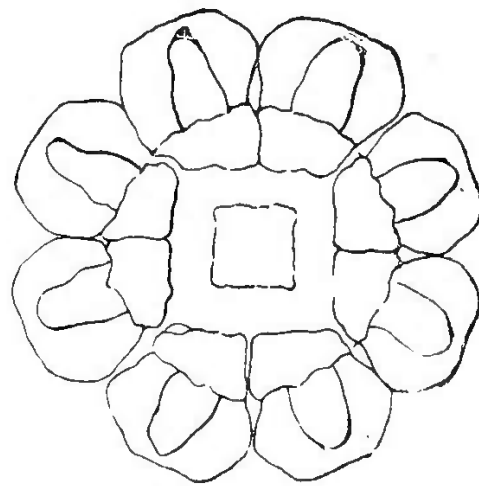
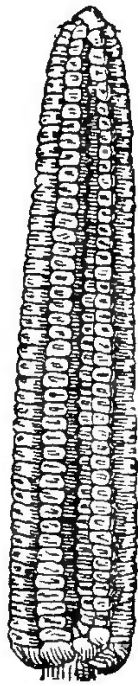
Formerly but very little use was made of the corn stalks other than to allow the cattle to roam in the fields after the corn was husked, and eat the ears which were missed and a few of the leaves. To-day a large part of the 51,000,000 tons of corn-stalks still go to waste. Their use is increasing, however, either as cured fodder or as ensilage.

Structure.—Indian corn, or maize, known botanically as *Zea mais*, belongs to the same family as wheat, oats, barley, timothy, etc., namely: the grass family. It is distinguished from most of the other plants of this family by its solid or pith-filled stems or stalks, by having the ovaries or female part of the flower on the side of the stem, and by its larger growth. The tassel bears the pollen or male part of the flower. The ovaries are arranged in pairs on the cob which, upon being fertilized by the pollen, develop into kernels. These pairs of ovaries are fertilized with such certainty that under normal conditions an odd number of rows never result. There are always 8, 10, 12, 14, etc., rows and never 9, 11, 13, 15, etc., rows.

Corn, like wheat, is wind fertilized: that is, the wind carries the pollen from the tassel to the silks (pistils) of the ear, frequently to ears of different stalks than that producing the pollen, so that the corn is naturally freely cross-fertilized. The pollen falling upon the silks, which is sometimes as much as a foot long, must, it is believed, grow down through the silk until it reaches the ovary before the ovary can develop into a kernel; at least one pollen grain, it is believed,

must grow down the length of each ovary that produces a kernel. Under the circumstances it is surprising that there are so few undeveloped ears.

The great quantity of pollen produced, and the ease with which it is carried in the wind, accounts for the readiness with which different varieties are cross-



EIGHT ROWED.

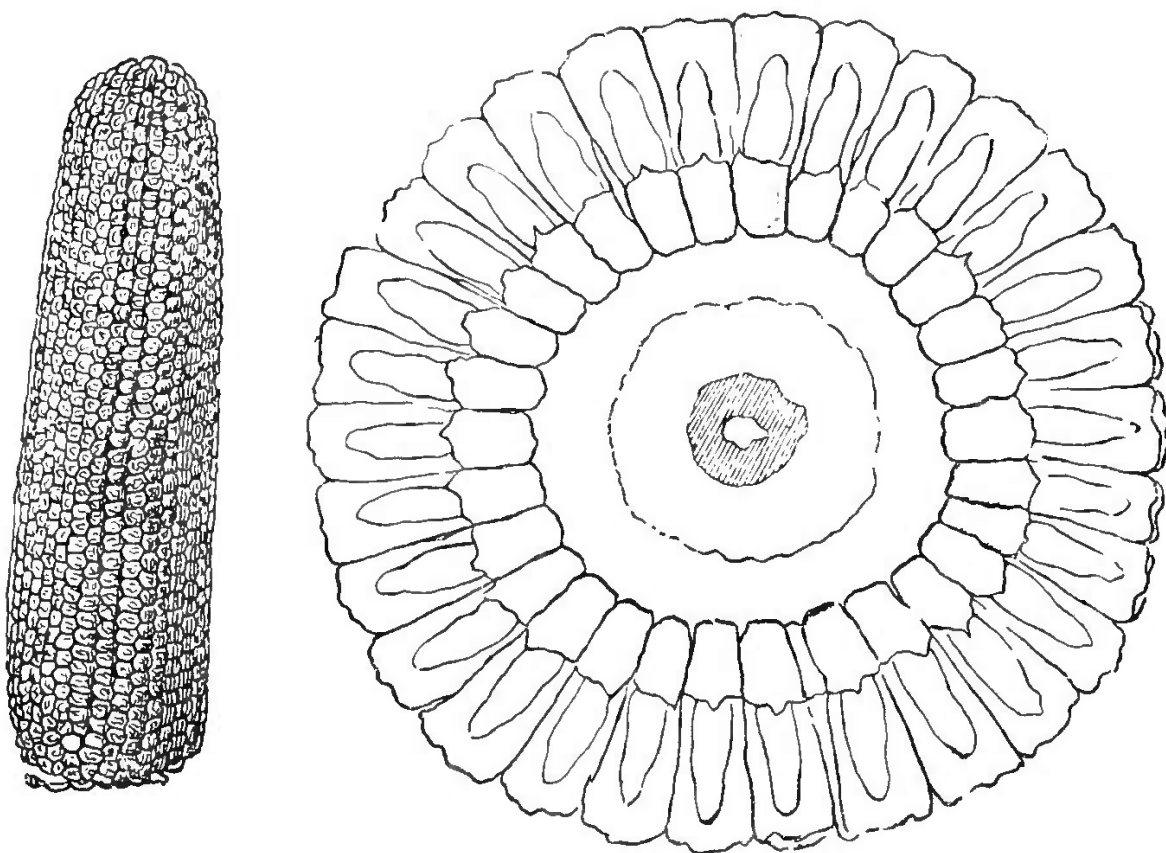
fertilized, or, as we say, mixed. In some cases the effect of the current cross is apparent; that is, the pollen of one variety so affects the ovary of the other variety as to be plainly visible in the developed kernel. The color is often af-

ected when yellow and white varieties are crossed. Where sweet corn is crossed with other varieties the current cross usually shows variation from the female type, the result often being unlike either parent. The general rule, however, is that the current cross causes but little, if any, variation from the female parent or variety producing the ear. Corn raised from the result of the current cross generally shows variation from the female parent. In some cases the variations are striking.

On account of the ease with which varieties cross it is difficult to grow several varieties on one farm, or in one neighborhood, and keep the varieties pure. It

is on this account, probably, that the corn of a given neighborhood tends to assume a common type. It is probable that the different plants of the same variety in a field cross each other freely, and the laws of breeding indicate that this is desirable. It has been proved, however, that the corn plant may be fertilized with its own pollen and produce a well developed ear.

Physical Structure.—The physical structure



THIRTY ROWED.

both of the whole plant and of the kernel is the most variable of our cereals. The plant may vary from two to twenty feet in height; a variation of from six to twelve feet is not uncommon. Along the Mississippi river, south of the 40th parallel, it is not unusual to see corn growing on which the ears are so high that a man of ordinary height can barely reach them, and some ears cannot be reached. In the northern latitudes of the United States, as in New

Flint corn contains less fibre than dent corn. The hardness of flint corn is due, as will be hereafter shown, to the denseness of the starch grains and not to the greater proportion of fibre.

The per cent of water in corn is extremely variable, being the only ingredient which varies sufficiently to be of practical moment. When corn has dried for a year in a crib it will contain under ordinary conditions from 10 to 11 per cent of water. But as it is husked it contains very much more.

For example, the Illinois Agricultural Experiment Station found, during 1888, 1889 and 1890, the average per cent of water in varieties of different maturities to be as follows:

	No. of varieties tested.	Ave. per cent of water.
Early maturing varieties.....	44	17.1
Medium maturing varieties.....	103	21.3
Late maturing varieties.....	45	26.4
Non-maturing varieties.....	23	36.8

On this basis, 1,000 bushels of medium maturing corn would lose, upon becoming thoroughly air-dried, a weight of water equivalent to one hundred and fifteen bushels of shelled corn. If this 1,000 bushels of shelled corn could be sold for fifty cents when gathered, it would be necessary to get fifty-seven cents a bushel when thoroughly air-dry in order to get the same amount for it.

Different varieties vary greatly in regard to the percentage of moisture which they contain. Two varieties of maturing corn have been grown the same season which contained 16 and 34 per cent of water respectively. In the former case 1,000 bushels of shelled corn when husked would make 945 bushels

when air-dry, while in the latter case 1,000 bushels would make only 740 bushels when air-dry. In the first it would take 70 pounds of ears as husked to make a bushel of air-dry shelled corn, while in the last instance it would take 97 pounds of ears to make a bushel of air-dry corn. The weight of corn as husked does not, therefore, indicate accurately its food value.

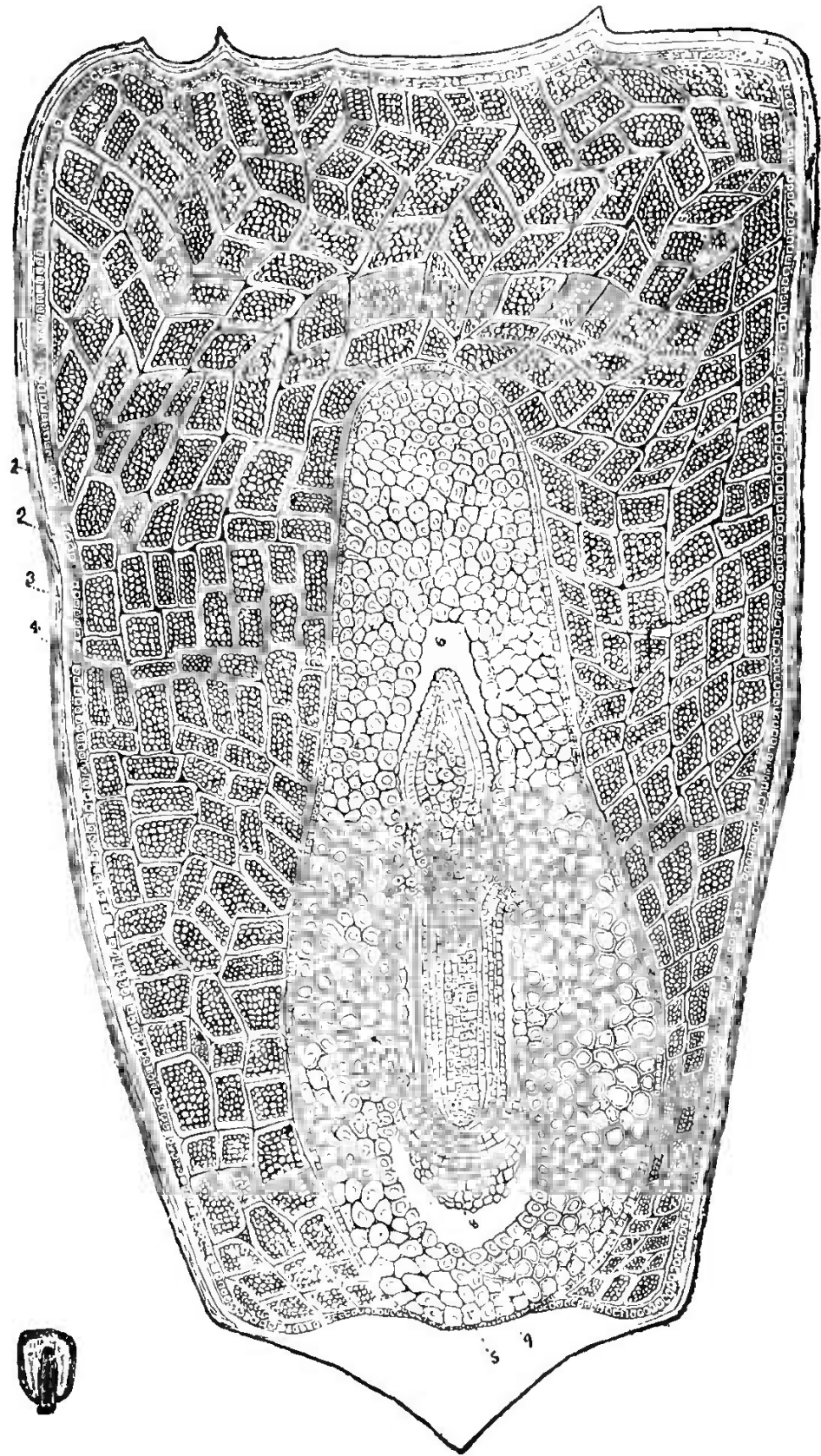
CHAPTER XIII.

INDIAN CORN.

Varieties.—The structure of the corn kernel is in general like that of the wheat kernel. There is the outer covering which corresponds to the pod of the pea or edible part of the cherry. Inside there is the testa or true seed coat, which contains the coloring matter and gives the kernel its color. Inside the testa is the row of irregular cubical cells, the so-called embryonic envelope. These cells are not so large as in the wheat. Inside this row of cells is the germ or embryo and the endosperm. The endosperm consists of thin walled cells of cellulose packed full of starch grains and very little nitrogenous material. In sweet corn, instead of the cells of the endosperm being packed full of starch grains, the latter are changed to glucose, and the shrinking caused by the transformation makes the sweet corn kernel wrinkled.

Apart from pod corn, there are five types or classes of Indian corn. The differences in these types are variations in the shape of the kernel and in the arrangement of the starch cells of the endosperm, except in the sweet corn, where, as just explained, it is a modification of structure.

If a kernel of dent corn is split open through its longest two diameters, the endosperm will be seen to consist of two parts. In the central part, the endosperm will appear white, while on each side it is glossy. An examination with a microscope will show the structure to be the same in both. The difference



is due to difference in compactness of the starch grains, just as the more compact crystals of ice produce a glossy appearance, while the crystals of snow, being less compact and containing more air, more perfectly reflect the light, and thus produce a white appearance.

Dr. Sturtevant first pointed out the relation between the interior arrangement of the kernels and the types of corn, which he called agricultural species, and gave Latin names to them. He has not been followed by other writers.

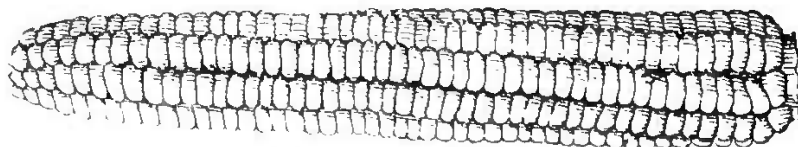
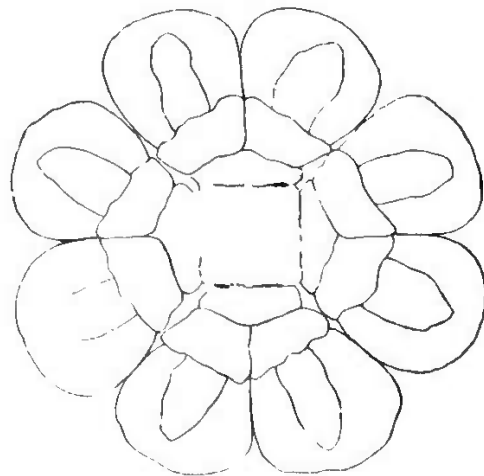
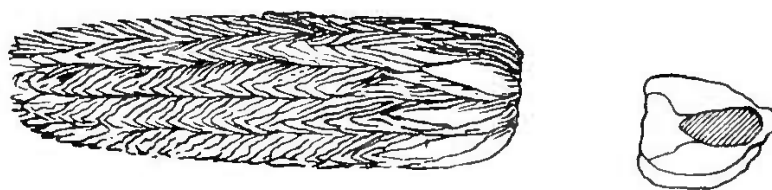
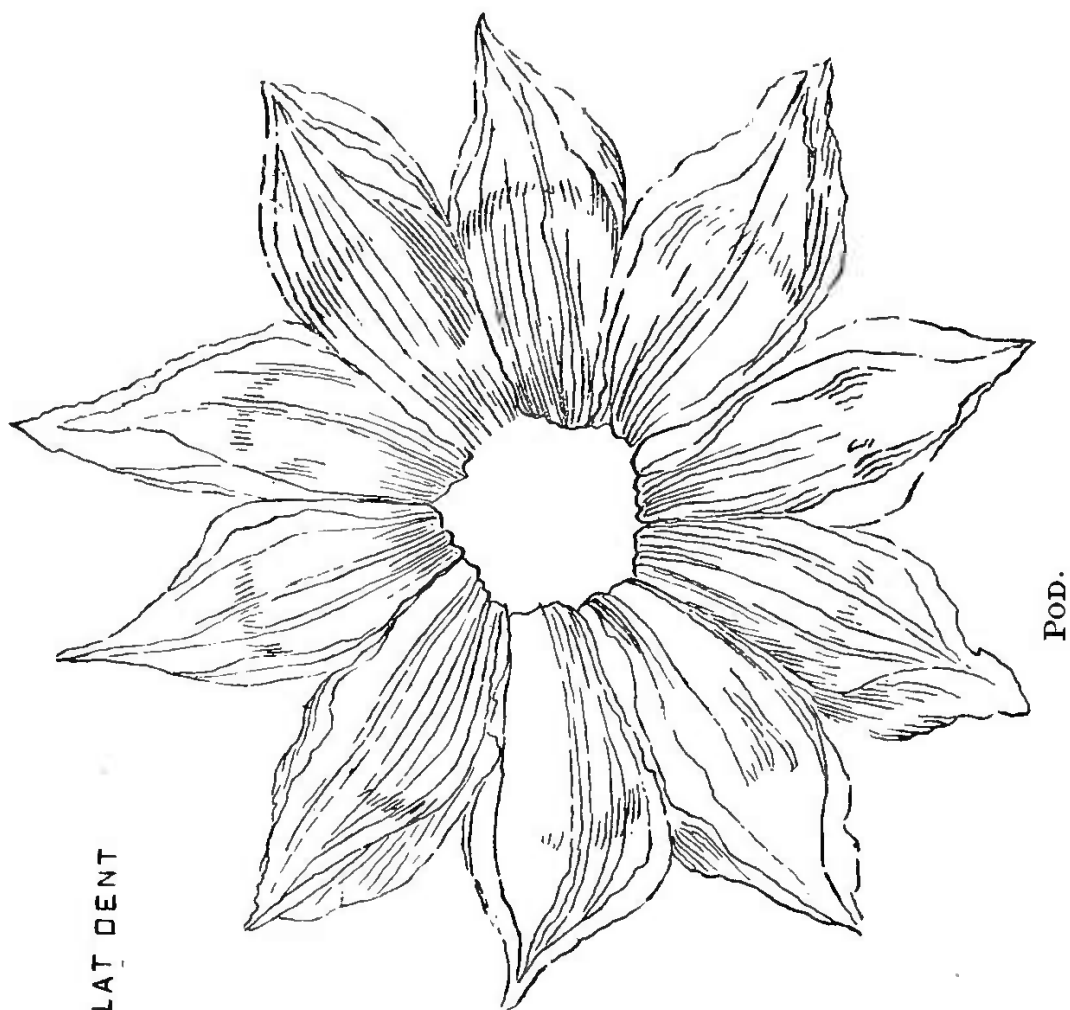
The types of corn are as follows:

1. Dent corn is that type in which the split kernel shows the germ, the glossy starch on each side and the white starch extending to the top of the kernel. The kernel is indented on the top, evidently because the softer starch shrinks in the center, while the denser starch on the sides holds the sides in a straight line. The kernels of dent corn are more or less wedge-shaped.

2. Flint corn is that type in which the split kernel shows the germ, the white starch and the glossy starch surrounding. The surrounding dense starch prevents the kernels from indenting. The kernels are hard, smooth and more or less oval.

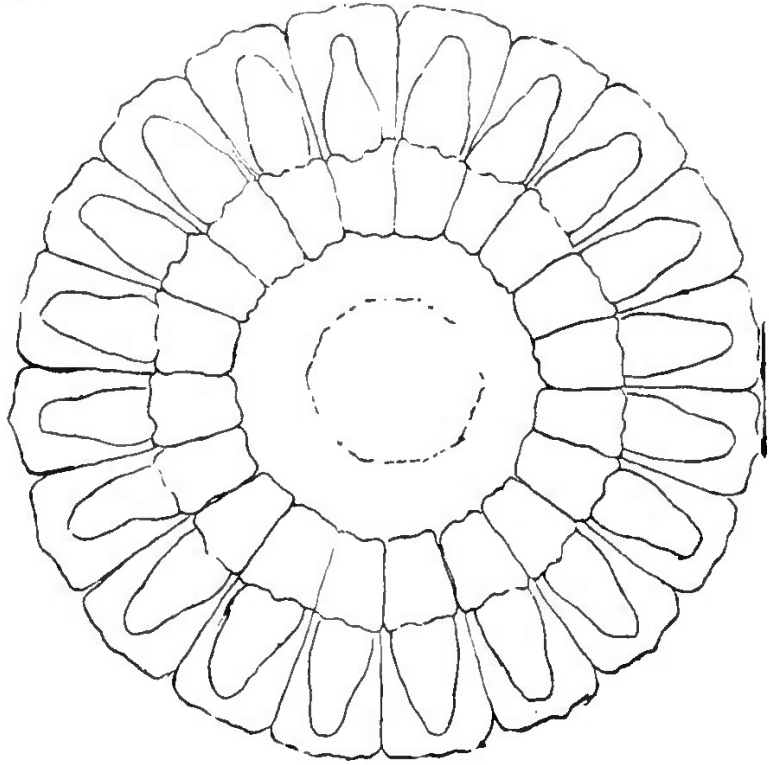
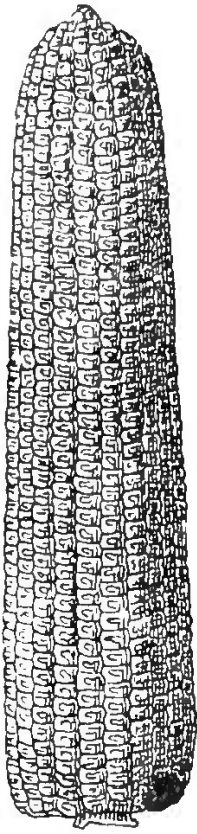
3. Pop corn is that type in which all, or almost all, the endosperm or starch is glossy. The kernel is an elongated oval in outline and extremely hard.

4. Soft corn is that type in which the endosperm is entirely white. The shape of the kernel is similar to that of the flint corn, and the starch grains in the endosperm being loosely arranged the kernel is easily crushed.



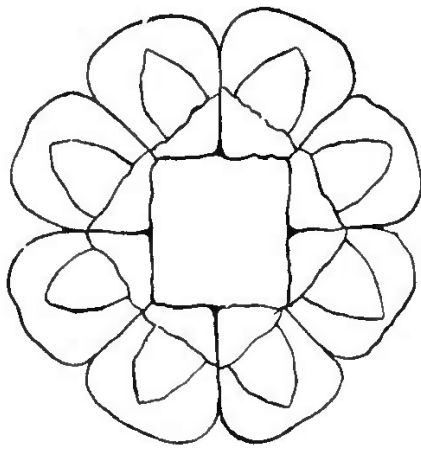
TYPES OF INDIAN CORN.

ILLINOIS YELLOW



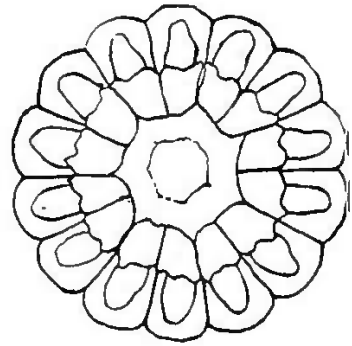
DENT.

RED RIVER

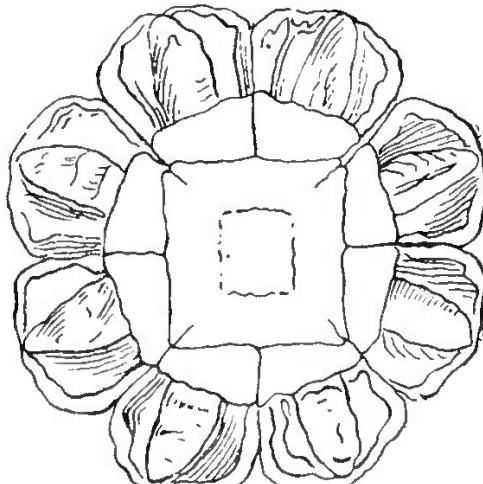
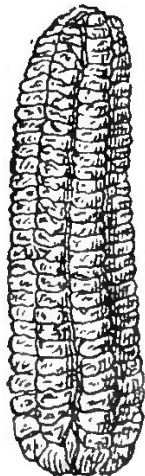


SOFT.

WHITE PEARL



POP.



5. Sweet corn is that type in which the endosperm is translucent and horny in appearance, the starch having been more or less reduced to glucose. The kernels are wedge-shaped and usually very much wrinkled.

Almost all the field corn of the United States, comparatively speaking, is of the dent type. Flint corn requires a smaller number of days to mature a crop and hence it is used in the more northern latitudes and at higher altitudes. It is the common field crop of New England. Each of these types has its place, but wherever the common varieties of dent corn will ripen flint corn is not usually desirable.

For example, at the Pennsylvania Agricultural Experiment Station eleven varieties of flint corn and fifteen varieties of dent corn have been tested from one to three years. The altitude is 1,200 feet; the season, therefore, is comparatively cool and short, and not especially adapted to the growth of dent varieties. The following table gives the yield of dry matter in pounds from ears and stover.

	Flint.	Dent.
Ears	1,750	3,012
Stover.....	1,691	3,258
Total	3,441	6,270

Soft corn is grown to some extent by the Indians. It can be made into meal rather readily by crude methods and it is said also to be eaten whole by the Indians. It is also known as "squaw corn." The Brazilian flour corn is of this type.

The ease with which varieties of corn mix, the extreme variability within certain limits, and the ease with which any type may be obtained within these

limits by careful selection, results in infinite varieties of corn, many of which are much alike. Every locality has its peculiar varieties, some of which] are usually well adapted to the surrounding conditions.

There seems to be good evidence for believing that for any given locality a medium maturing variety will yield more bushels of dry corn than an earlier or a later maturing variety. The later maturing variety will often yield a greater weight when husked, but the extra quantity of water contained may, and often does, more than counterbalance the increased weight. The danger of injury from frost is also greater. It is, probably, a good rule to plant varieties which will ripen ten days before the usual date at which killing frosts occur.

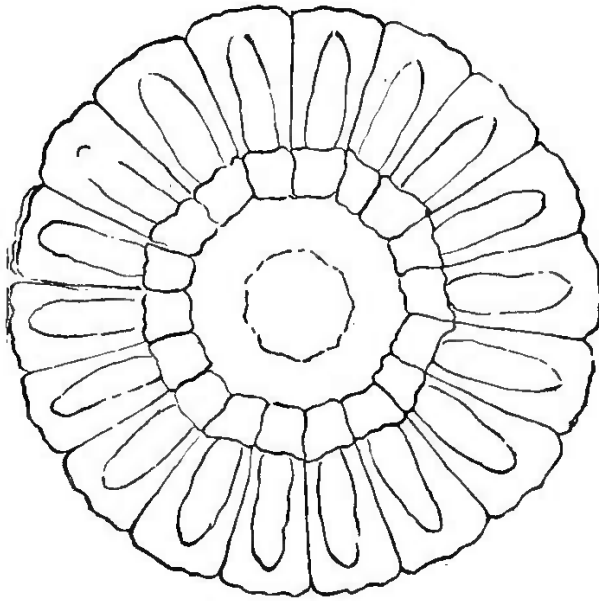
A good ear of dent corn should be as nearly cylindrical as may be, so that it may hold the largest amount of corn in proportion to the size of the junction with the stalk. Ears that taper rapidly also have usually less corn in proportion to the cob. Both the tip and butt should be well filled.

A good sized ear is eight to nine inches long and from six and one-half to seven inches in circumference at two-fifths its length from the butt. Ten inches is rather long for an ear of dent corn, while seven inches is a good length for smaller varieties. It is a good ear that weighs three-fourths of a pound. It takes about 100 good ears to make a bushel of shelled corn.

A good size for the circumference of the cob is from three and two-thirds to four and one-third inches. The cob should be neither too large nor too small. It is evident that of two ears of equal size and com-

pactness the one with the small cob will contain the most corn.

A large cob is not especially objectionable, however, if it is surrounded by a correspondingly larger supply



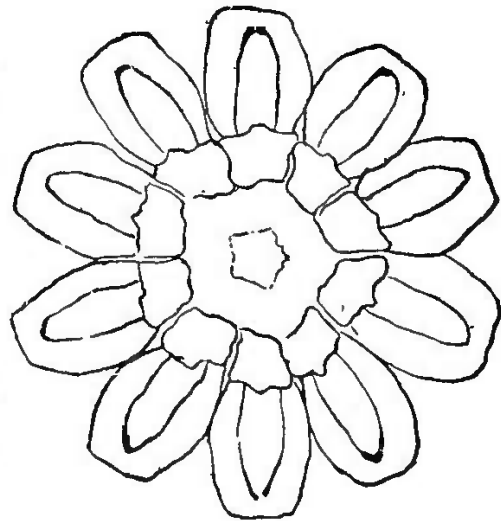
Space between rows well filled.

of corn. Although ears with small cobs usually contain the larger proportion of corn the total yield is often less. In a good ear the shelled corn will occupy the same space as the ear before it is shelled. It is a good relationship where the length of the kernel is

half that of the diameter of the cob.

On an ear of dent corn there should be but little space between the rows of kernels and they should be solidly and compactly placed.

To this end the kernel should be as nearly wedge-shaped as possible. An average sized dent kernel is five-eighths of an inch wide. A smooth ear is pleasanter to husk, although there are some excellent varieties whose ears are rough. The kernels which cause rough ears are usually longer but somewhat less compact than those causing smooth rows.



Space between rows not well filled.

There is no evidence that color affects the yield. White varieties are more common in the southern portion and the yellow varieties are more common in the northern portions of the United States.

Of two stalks bearing the same quantity of corn the smaller stalk is to be preferred, where grain is the principal object sought. The larger the stalks the more food material necessary to produce them, the more ground is shaded, and, consequently, a less number can be raised per acre. In some localities the ear may be too high on the stalk to be easily husked. The stalks are also more easily blown down. Four feet above the ground is a good height for the ears of medium sized varieties of dent corn.

Two-eared varieties of dent corn have not been commonly grown, and it has not been satisfactorily shown in what way it is easier for a stalk of corn to elaborate the material for two ears of corn than it would be to produce the same corn on one ear. As ordinarily harvested varieties bearing but one ear on a stalk are to be preferred, unless the two or more eared varieties yield an appreciably larger quantity of corn.

A varying percentage of the stalks of a field are barren—do not bear any ears. The percentage of barren stalks on a given soil varies with the thickness of planting and the season. Barrenness does not seem to be a variety characteristic.

Starting with a good variety for a given neighborhood it is important to maintain its excellence and to improve it by continued and careful selection. The most important thing is to select good ears according to the standards just given. The next thing is to give

due consideration to the stalk upon which it grew. It is very much better to select the ears for seed in advance of the general husking, when it can be done leisurely and carefully, and before there has been any hard freezing. In the more northern latitude thorough drying by hanging in an airy place or by artificial heat is almost necessary to obtain good seed. In more southern latitudes storing in narrow cribs is all that is essential.

The vitality of the seed is injured by freezing before the kernels are thoroughly dry. It is the water in the kernel that freezes and thereby destroys the tissue. The vitality may be preserved in two ways: 1: by thoroughly drying; or, 2: by not subjecting to a low temperature. The former is the only generally feasible method. If the corn is first thoroughly dried it does not matter how low a temperature it is subjected to.

It is hardly needful to state that the vitality of all seed corn should be carefully tested before using it. The vitality may be injured and the seed still grow. The seed should not only sprout but it should sprout strongly. The less the percentage of seeds sprouting the less the vital power. For illustration: the Illinois Agricultural Experimental Station found in the case of sweet corn that where 95 per cent of the seed grew in the green-house but 75 per cent of the seed which grew in the green-house grew in the field, while where 52 per cent grew in the green-house test only 55 per cent of those which grew in the green-house grew in the field.

Climate.—The corn plant is the most variable, according to the climate to which it is adapted, of

any of our farm crops. The differences in size between the corn of northern and southern latitudes has already been mentioned. These differences existed when the country was discovered, and we have no evidence that varieties have been modified in modern times by climate alone.

Differences in the number of days required to mature a variety exist similar to the differences in size. The smaller varieties require less and the larger more time. The time may vary, at least, from 90 to 150 days in different parts of the country.

In general it may be said that as we go north or south of a given latitude, a variety becomes one day later or earlier for each ten miles of travel. That is to say, a variety which ripens two weeks before a killing frost in a given locality, would only barely ripen if taken 140 miles farther north, the altitude remaining the same. Care should be taken, therefore, in selecting new varieties, to get them from the same latitude. If obtained from much farther north they may ripen too early, and consequently be too small. If obtained from much farther south they may not ripen.

Professor Brewer shows that nearly nine-tenths of the crop of 1879 was grown where the July temperature is between 70 and 80 degrees Fahrenheit.

Rain-fall affects the yield of corn more directly than does the temperature, while the temperature more directly affects the maturity of the crop. The best condition for the growth of corn is comparatively heavy rains at considerable intervals, with clear weather in the meantime. Twenty inches of rain-fall are desirable during the five corn-growing months: May, June, July, August and September.

Soil and Manure.—A large proportion of the Indian corn crop is grown on the drift soil to which it is so well adapted. For its best growth Indian corn requires a soil that is easily drained and does not bake during drouth. The water table should be some distance below the surface, say at least three feet, but the capillary attraction should be such as to bring the water up freely during the period of fastest growth.

The corn plant uses large quantities of water during its growth, especially during July and August, and unless the physical conditions of the soil with reference to soil and water are the best it is apt to suffer from a lack of water, or, in other words, from drouth.

A large supply of humus increases the capillary power of the soil and it is probably one reason why stable manure is generally found beneficial.

The corn plant requires a fertile soil and throughout the region where the bulk of the crop is grown it is planted on the most fertile soil. Stable manure is more frequently applied to land to be put into corn than to any other. Grass and clover are usually followed by corn. Throughout the main corn belt a good rotation is corn two years, oats or wheat one year, timothy and clover three years. In some localities in the eastern states the rotation is: corn, oats, wheat and clover with timothy, each one year, the stable manure being applied to the wheat.

The use of stable manure, and the rotation of crops in connection with stock raising, are the chief means of keeping the land in good condition to grow corn. Generally speaking, commercial fertilizers have not been profitably applied to corn. This is almost sweepingly true west of the Allegheny Mountains.

CHAPTER XIV.

INDIAN CORN.

Culture.—The time and depth at which to prepare the seed-bed will vary with the soil, climate, the particular season and, in some instances, with the previous crop grown on the land. In general, fall plowing is advisable. When plowing in the spring there is a practice, which seems to be a good one, of plowing immediately before planting. The land is plowed, immediately dragged and rolled, and then harrowed and planted while the surface is still fresh and moist. When the plowing is done earlier in the spring the surface becomes hard and it requires more labor to get a good seed-bed than when the plowing is done later. It is a question of labor merely. The main point is to get a deep, well pulverized seed-bed. The more well directed labor there is put on the seed-bed before planting the better.

Corn will sprout at 47 degrees Fahrenheit. It will grow and produce chlorophyll at 54 degrees Fahrenheit. It will grow more readily as the temperature increases up to, at least, 80 Fahrenheit; but Sachs gives 115 degrees Fahrenheit as the highest temperature at which corn will sprout. The soil should be at least 60 degrees Fahrenheit at the depth of planting before the corn is planted. But it is not enough to consult the thermometer. The almanac should also be consulted. A change in the weather may follow even after the temperature of the soil is at 60 degrees Fahrenheit. The old Indian sign, which

is to plant corn when the leaves of oak trees are as big as a squirrel's ear, is not much at fault. There is fairly good evidence that in the main corn belt there is a period of three or four weeks within which the time of planting does not materially affect the yield. Very early planting, however, has been found to require more cultivation to keep the land free of weeds. Through the main corn belt from the 10th to the 20th of May is the usual time of planting. Where corn is planted on old sod-land the corn should be planted later to avoid cut worms and allied insects.

Experiments have shown that there is little difference in the yield, whether the seed is from the butt, middle or tip of the ear. The tip kernels being smaller have less food material to supply the developing plant. Beyond this there seems to be no reason why they should not produce plants which would yield as abundantly as kernels from any other part of the ear. The kernel does not reproduce itself but the ear from which it was taken. In practice it is found better not to use tip and butt kernels, especially the former, in order that the planting with the ordinary planters may be more regularly done.

Corn may be planted from one to four inches deep. In exceptionally dry seasons, planting six inches deep has been known to give better results than shallow planting, but usually one inch deep is better than deeper so far as the growth of the plant is concerned. When planted by machinery it is usually necessary to plant somewhat deeper in order that all the corn may be covered. Hence the desirability of a uniform seed-bed. Where it is the practice to harrow the land after planting the corn, it is probably

better to plant deeper than one inch so as not to move or drag out the hills. The depth of planting has merely to do with the plants getting properly started. If the corn sprouts and comes up equally well, no difference in yield need be expected on account of the depth of planting.

The depth of the roots is not materially affected by the depth of planting. When a kernel sprouts, three or four roots are produced at the kernel. No matter what depth the kernel is planted the second whorl of roots, or the crown roots, are produced at about an inch from the surface, varying somewhat, probably, with the nature of the soil. The deeper the kernel is planted the greater the distance between the first two whorls of roots. The stem between these points is usually about one-sixteenth of an inch in diameter, while above the crown, in plants 15 inches high, the stem is about three-eighths by five-eighths of an inch in diameter. The roots at the kernel die in a few weeks, so that the roots which ultimately nourish the plant grow at the same distance from the surface without reference to the depth at which the kernel is planted. Nothing is gained, therefore, by deep planting, unless necessitated by the dryness of the soil. It only requires of the plant extra force and time to reach a position where the roots which eventually nourish the plant will grow.

The thickness of planting depends upon the soil, climate and variety. In some of the southern states corn is planted in hills five feet apart and one stalk produced per hill. In the New England states corn may be planted three feet apart and three stalks raised per hill.

In one experiment at the Georgia Experiment Station a larger yield of dent corn was obtained where 2,184 stalks were raised per acre than by the thicker planting. In another experiment, at the Connecticut Experiment Station, a larger yield of dent corn was obtained with 21,780 stalks per acre than by thicker or thinner planting. In other words, the best results with dent corn were obtained in Connecticut, with ten times as thick planting as in Georgia. Experiments indicate that for the main belt, at the rate of three or four stalks per hill, at a distance of 42 to 44 inches apart each way, is the most desirable for the production of grain. Planting too thickly reduces the yield both by reducing the size of the ears raised and by reducing the number of ears raised in proportion to the number of stalks. If the largest quantity of material is desired, stalks included, experience seems to indicate that from one-half to as much more seed should be planted as where the grain is the principal object. Of course, in any given locality the larger-growing varieties need to be planted thinner and the smaller varieties thicker to get the best results.

The Indian method of planting was to plant four kernels in hills four feet each way. This method they taught the colonists. The usual method in the eastern states is to plant in drills. In the surplus corn states the practice is divided, but the larger part is planted in hills. The chief reason why corn is planted in drills in the eastern states is that on account of the unevenness of the surface and the comparative smallness of the field, the check rowing planters do not readily check straight cross rows,

and that while a one-horse machine which will drill corn rapidly enough for eastern requirements can be bought for from \$10 to \$12, a two-horse corn planter, such as is found economical in the larger and more level fields of Ohio, Mississippi and Missouri valleys, would cost from \$30 to \$40. The difference in method is one of economical farm management rather than any difference in the growth of the corn.

Experiments show that it makes little, if any, difference whether the corn is planted in hills or drills so long as the land is kept equally free of weeds. It is only a question, therefore, by which method the corn can be raised at the least cost, and, at the same time given equally effective cultivation.

The key-note to the cultivation of corn is to keep the land as free as possible from any growing vegetation, except the corn, and to do it with the least possible disturbance of the roots. Much less stirring of the soil after the corn is planted is necessary or even desirable than has been formerly supposed.

Cultivation does two things: it stirs the soil and kills the weeds. These are entirely separate things, although doing the former accomplishes the latter.

In the chapter on weeds the way in which weeds may be injurious is discussed and it is shown that probably the principal damage that ordinary weeds do in a corn field is in exhausting the water from the soil.

Stirring the soil admits the air more freely, so that more plant food may, perhaps, be made available. It also loosens the earth so that the roots may penetrate it more freely. These things are, doubtless, important, but if we stir the soil to a depth that will benefit the roots in these ways, we mutilate them. It has

been shown that, in the ordinary prairie drift soil, a large proportion of the roots are between two and five inches deep at a point where they are likely to be disturbed by cultivation, and that by far the larger portion of these are between two and four inches deep.

It has also been clearly demonstrated that, by cutting off these roots to the depth of four inches, at six inches from the center of the hill the yield of corn is decreased in a marked degree. The decrease in yield may vary from one-eighth to one-third the crop, and a decrease of one-sixth to one-fourth the crop may be expected.

Cultivating with an ordinary cultivator does not prune the roots so completely as may be done by direct methods, so that as much injury from deep cultivation as from root pruning need not be expected, but that the injury is often considerable has been shown in many places. The following table shows the average yield of corn during three years at the Illinois Experiment Station from deep and shallow cultivated plats, and from a plat receiving no cultivation after the corn was planted but having the weeds removed by scraping the surface with a hoe:

Kind of Cultivation.	Av. bu. per acre dur. 3 yrs
Shallow, average 3 plats	82
Deep, average 3 plats	74
None, one plat	79

The practice of shallow cultivation is becoming much more common than formerly, machinery having been perfected for this purpose, and now many farmers never cultivate their corn over two inches deep.

Stirring a soil dries out the portion that is stirred

but keeps the water in the soil below the stirred portion. If two inches of cut straw are spread upon the surface of the soil, the evaporation will be checked for obvious reasons. Two inches of pulverized soil acts in much the same manner, although much less effectively, as direct experiment has shown. Indeed, the saving of moisture by surface cultivation will depend very largely upon the nature of the weather. If this pulverized surface is frequently moistened by rains, the evaporation from the stirred portion may be greater than the evaporation that is thereby checked from the soil below. On the other hand, if the surface is kept loose more of the water which falls upon it will pass into the soil and less will run off than upon a hard surface.

In any case the evaporation that is checked by the stirring of the surface is small compared with the quantity of water taken from the soil by an ordinary growth of weeds. The killing of weeds is much more important, therefore, in conserving moisture than is stirring the soil. That this is true is indicated by the fact that, on certain soils, at least, good crops of corn can be raised without any stirring of the soil, provided the land is kept thoroughly free of weeds.

In ordinary practice it is essential to stir the soil in order to kill the weeds. It may be laid down as a rule, therefore, that the soil should not be stirred deeper than is essential to a thorough eradication of the weeds. There seems to be pretty good evidence that the cultivation need not be more frequent than is necessary for their complete destruction.

Harvesting.—When the corn is grown for the grain, it is not harvested until entirely ripe and

growth has ceased, usually for a considerable time. Experiments show that the weight of dry matter is increased in the corn up to the time it is perfectly ripe. Indian corn is our only cereal crop in which the harvesting is done almost exclusively by hand. At least two hundred billion ears are separately handled annually.

When harvesting for fodder the practice is to cut when the ears begin to dent or glaze, and lower leaves begin to get dry. Although less total dry matter is harvested than if allowed to ripen, the assumption is that the fodder is more digestible and more palatable than when riper.

Plant Diseases.—The most common and generally known plant disease to which the corn is subject is corn smut. (*Ustilago Maydis.*) The black sooty mass which is familiar to every one is composed of myriads of microscopic spores which spread the disease. These spores are supposed to germinate and penetrate the corn plant when it is small and the smut plant grows inside the corn plant, the former feeding upon the latter. The part which we see coming upon the plant so conspicuously during August is merely the fruiting part of the plant.

Methods of prevention are not well understood. Sowing with seed and upon land which is free from the spores of the disease should apparently accomplish the object. Seed corn being hand selected is less likely to have the spores of corn smut upon it, than oats, for example, are to have oat smut upon them. Rotation of crops might be expected to rid the land of the spores. Stable manure, especially where corn fodder is fed, may be expected to contain an

abundance of the spores. None of the preventives suggested, however, have been effectual. The disease is much worse some seasons than others.

Corn smut is not an active poison, as it has been fed to cattle in numerous instances in large quantities for a considerable period of time without apparent injury.

Corn, like other cereals and grains, is subject to rust, although it does not seem to be materially injured thereby. Besides this there is known to exist in Illinois, and is supposed to exist in other western states, a bacterial disease of corn, which is known not only to do considerable damage to corn in some localities, but it is also supposed that the germ which causes the disease in the corn is able to cause a sudden and fatal disease in cattle. This is known as the corn-stalk disease. The first indication of the disease is the dwarfed condition of the young plants. This commonly occurs in spots of various sizes, and is found in rich places, rather than in those of poorer quality. The young diseased plants, besides being smaller than the healthy ones, are uniformly yellowish in color, the lowest leaves showing worst. Affected plants are easily pulled from the ground on account of the death of the lower roots. The inner tissue of the lower part of the stalk has a uniform dark color, while on the surface there are brownish corroded spots. After midsummer the leaf sheaths become spotted with various sized patches of a watery brown, half-rotten in appearance, which are most conspicuous from the inner surface. The ears are, at least occasionally, affected. Internally, in the worst stage, the whole ear is reduced to a moist state

of corruption. Very often these ears subsequently become mouldy, penetrated through and through by a close, very white, felt-like fungus. These mouldy ears are, in certain seasons, very numerous, and are readily recognized by the husker.

No remedy is known. There appears to be in a considerable number of cases more injury on land which has been planted with corn the preceding year.

CHAPTER XV.

OATS.

History.—While the origin of the cultivation of wheat can be traced with some probability to a warm climate and that of rye to a cold climate, oats we find occupying an intermediate position. They were not cultivated by the ancient Egyptians or the Hebrews as was wheat. Neither the ancient Greeks nor the ancient Romans cultivated them. They were likewise unknown to the ancient Chinese or the people of India.

All evidence points to eastern temperate Europe, and possibly Tartary, in western Asia, as the probable place of their first cultivation. They were cultivated by the prehistoric inhabitants of central Europe, but did not appear, it is believed, until long after wheat and barley. Hence they were less important in the early history of our race than either of the last-named crops or rye. When central and northern Europe became civilized the cultivation of oats became vastly more important, becoming in some of the cool, moist climates north the most important cereal used for man's food. In Scotland it occupies one-third the land in cultivated crops, excluding land in pastures and meadows. In Ireland it constitutes one-half of all the grain and green crops.

Production.—Oats stand third in acreage and value of product and second in number of bushels of the cereals of the United States. The annual pro-

duction for the two decades, 1870-79 and 1880-89 is given below:

	1870-79.	1880-89.
Area, acres,	11,000,000	22,000,000
Yield, bushels	314,000,000	584,000,000
Value, dollars,	111,000,000	181,000,000
Value, per bushel, dollars.....	0.35	0.31
Yield, per acre, bushels,.....	28.4	26.6
Value per acres, dollars,.....	10.00	8.22

While the increase in the yield of wheat and corn during the last decade over the previous one was 44 per cent, the increase in the yield of oats has been 86 per cent. The area sown to this crop has doubled. This is the largest increase of any of our cereal crops. The total value of the crops has increased 63 per cent. The value per bushel has decreased four cents and the yield per acre less than two bushels. The average value of an acre of oats is less than any other of our more important cereal crops. Oats occupy about one-eighth of the tillage area of the United States.

The principal oat-raising states are New York, Pennsylvania, Ohio, Michigan, Indiana, Wisconsin, Illinois, Minnesota, Iowa, Missouri, Kansas and Nebraska. These twelve states raise over four-fifths of the crop. The only other important oat-raising state is Texas. New York raises more oats than any other cereal.

We export very few oats, usually less than half a million bushels annually. In 1889, however, we exported ten million pounds of oatmeal.

The proportion of straw may vary from one to three and one-half pounds of straw for each pound of grain. Probably two pounds of straw for each pound

of grain would be a fair average. This would make the average yield of oat straw in the United States about seven-eighths of a ton per acre. The total yield of oat straw annually during the past decade would be 18 million tons, or a little less than one-half the yield of hay.

Structure.—The oats plant (*Avena sativa*) is distinguished from wheat and barley by the heads being in panicles instead of in spikes. The spikelets, containing two or more grains, are joined to the stem by an elongated base instead of being directly joined to it.

It differs from wheat and rye and agrees with barley in that usually the kernel is enclosed within the palets, which are not removed in the ordinary methods of thrashing. The comparatively large glumes are thin and membranous. The lower pallet usually has an awn of more or less length, according to the variety and conditions under which it is grown.

Use.—Oats have become the greatest of all grain foods for horses. In this country oats are used in connection with and interchangeable with corn. If one is more plentiful, and, therefore, cheaper than the other, it is used more abundantly. So in considering the possibility of a rise or fall in price of either we must ascertain the combined yield of the two cereals.

In the United States, oatmeal was formerly but sparingly used. Its consumption has increased enormously in recent years, its use having become thoroughly diffused in a moderate way throughout the country. It is manufactured in many places.

Oat straw is preferred to wheat or rye straw as food

for cattle, and for bedding. It is less valuable than rye straw for the manufacture of paper, and than wheat straw also, although some paper mills are said to prefer it to wheat straw.

In the south, where it is difficult to grow our tame grasses, oats are frequently cut green for hay.

Composition.—It would be reasonable to suppose, that as oats deteriorate so readily and are apparently so easily influenced by their surroundings, great variations would be found in their chemical composition under different climatic conditions.

Analyses show that there is very little variation in the kernel itself, that is, the residue after the palets or hulls are removed. Taking the kernel alone, oats have a considerably larger per cent of albuminoids and fat than any other of our cereals. Taking the whole berry as we feed it to our stock, oats differ from corn principally in having a larger per cent of crude fiber at the expense of the starch.

As prepared for human food it is the most nutritious of our cereals. It is especially adapted to people living in northern climates or those who have plenty of out-door exercise. It is said that in eastern Scotland the unmarried plowmen lived solely on oatmeal and milk, except in the winter, when they sometimes got potatoes. They were allowed seventeen and one-half pounds of oatmeal weekly, and three to four pints of milk daily. This formed their sole diet with no other cooking than boiling water stirred into the meal. These men were strong and healthy. The witty Dr. Johnson sarcastically remarked: "Oats is a grain fed to horses in England, but eaten by men in Scotland." "Yes," said a Scotchman, "and I have noticed that

they grow the best of horses in England and the best of men in Scotland.”

The quality of oats depends principally upon the proportion of hull to kernel. The per cent of hull will vary in different varieties from at least 20 to 45 per cent. The per cent of hull will depend both upon the variety and upon the conditions of growth. American varieties contain on an average about 30 per cent of hull and 70 per cent of kernel. About 50 pounds of oatmeal are made from 100 pounds of oats.

While at first thought it is a matter of some surprise, it has been pretty satisfactorily demonstrated that those varieties with long, slender, light berries and light weight per bushel contain an appreciably larger per cent of kernel than those varieties with short, plump, heavy berries and heavy weight per bushel. In other words, those varieties which sell best on the market or take the premiums at exhibitions have the least food value.

Oats may vary in weight from 25 to 50 pounds per bushel, the lighter weights being found in the more southern climates. Richardson found the average weight per bushel of 166 varieties gathered from the various sections of the United States to be 37 pounds.

Climate.—Oats are naturally adapted to a cooler climate than wheat, barley or corn. The climate needs to be both cool and moist. Oats grow fairly well in the south, where, while warm, it is moist, but in California, where both warm and dry, oats do poorly. Oats grow to perfection in the cool, moist climate of Scotland, Norway and Sweden. It is from these countries that we get our new varieties as a rule. It is on account of the adaptability of the

oat plant to a cool, moist climate that early sowing is found especially advantageous. It is curious that while the cultivated oat does poorly in California the wild species, *Avena fatua*, L., should become an abundant and valuable wild pasture grass in that state.

The physical properties of oats seem to be readily affected by climate. The southern varieties are larger, less plump, often of a dirty dun color, with long-awns. Of course there are all degrees of plumpness, from the very short, plump, smooth berries of the more northern climate to the long, slender, long awned southern varieties. The fact that short, plump, smooth, heavy berries have the largest market value has led to the importation of varieties from Scotland, Norway and Sweden. Probably more new varieties of oats are imported and distributed by seedsmen than of any other cereal.

Soil.—The character of the soil upon which oats are sown is of less importance probably than with any other crop. Almost any tillable soil will bring a fair crop of oats. It is on this account and because oats are liable to lodge on very fertile soil, that they are sown on the poorer soils and on soils in the most exhausted state of fertility. In the American systems of rotation they usually follow corn. Fertilizers are seldom applied to this crop, both because they grow too rank and because it usually pays better to apply the manure to some other crop. Oats respond, however, very readily to an application of manure where applied when needed.

Varieties.—Oats may be classified according to their date of ripening, according to the color and

shape of the berry, and upon the way in which the spikelets are arranged on the stem. In some varieties, the spikelets are distributed on all sides of the stem and are spreading. Other varieties produce the spikelets on one side of the stem and are not spreading, but are erect and close against the stem. The former may be said to be varieties with open panicles, and the latter varieties with closed panicles. The latter



VARIETY WITH
CLOSED PANICLE.



VARIETY WITH OPEN
PANICLE.

are also known as side oats. These two types of oats have been considered distinct species by some writers. There are, however, all degrees of variation between the varieties with open and closed panicles.

There is still another type of oats in which the palets or hulls are removed upon thrashing, and there only remains the hullless kernels. These are called

hulless oats, and are the so-called Bohemian oats. This kind is usually considered a distinct species *Avena nuda*, L. It is not generally raised, as the yield is considerably less than of the varieties in which the palets or hulls are not thrashed off. One reason, of course, why the yield is less is because the palets or hulls go into the straw instead of with the grain.

Experiments seem to indicate that there is no material difference in yield between varieties with open or closed panicles, between varieties of different color, or between varieties having short, plump berries and those having long, slender berries, and consequently between varieties of different weights per bushel.

In America there are more early maturing varieties with short, plump, white berries and open panicles than any other kind, such as White Swede, Early Lackawanna, Canada White, White Bonanza, White Victoria, Welcome, Clydesdale, Hopetown, White Wonder, Prize Cluster, Badger Queen, White Belgian, Hargett's White and Centennial. There is little practical difference in the varieties named. They have the advantage over later maturing varieties, in that their growth and maturity are during the cooler portion of the season, and also because they may often be harvested so as to avoid storms which injure the late varieties. In some localities early maturing varieties are desirable in order that they may be harvested in time to prepare for the succeeding crop. There is a difference of about two weeks in the market varieties of this country. Early varieties also usually have shorter stems and are, therefore, less likely to lodge.

Culture.—It is not customary to prepare the seed-

bed so deeply for oats as for wheat, rye, barley or corn. In the eastern states the land is usually plowed. In the western states many acres are sown on corn land without plowing. The oats are sown broadcast on the unprepared land and covered with a corn cultivator, disc harrow or similar implement. Sometimes the corn-stalk land is cultivated once before sowing the oats and then cultivated once or twice afterward. Good crops are grown in this way, but very much depends upon the nature of the soil and something upon the season. When the soil is naturally compact plowing is better. Some times oats are sown on the uncultivated surface and the land shallowly plowed.

Unless the land is plowed oats must, of course, be sown broadcast. On plowed land the practice is divided, but broadcasting is probably the most general, the controlling reason being that they can be somewhat more cheaply sown in this way, than if the drill is used.

In the south fall and winter varieties are sown. In some localities in the south oats are sown in November, December, January and February during the same season. The bulk of the crop in this country, however, is from spring seeding. Oats should be sown as early in the spring as possible. Experiments indicate that there is a marked decrease both in the yield and the weight per bushel when the seeding is delayed. With corn, the time of planting, within four or five weeks, any season is not especially important. Such a difference in the time of sowing oats may make the difference between success and failure.

The depth of sowing, between one to four inches, does not seem to be important. The same principles apply here as with corn and wheat.

The yield within certain limits is not materially modified by the thickness of planting. The oat plant, like the wheat plant, has the ability to adapt itself to its surroundings, so that where it is thinly planted it stools more than when thickly planted. On some soils, at least, the thinly sown oats are later in maturing and the proportion of straw is greater. No definite rule can be laid down, but sowing from two to three bushels according to circumstances may be taken as a safe guide. The number of berries in a pound of oats has been found to vary with different varieties from about 11,000 to about 30,000.

The oat plant is generally exceptionally free from insect enemies and plant diseases. It is subject to rust in a way similar to wheat, and for which, as in wheat, there is no known remedy. It is subject to the loose smut, similar to that described under wheat. This is much more common and destructive on oats than on wheat. The same treatment is efficacious.

CHAPTER XVI.

BARLEY AND RYE.

History of Barley.—The culture of barley is very ancient. Both it and wheat were cultivated before we have any history of man. In ancient Egypt it was used as food for man and beast, and also made into beer. It was the chief bread plant of all those nations from which we derive our civilization. Barley continued to be the chief bread plant of continental Europe down to the sixteenth century. The introduction and wide cultivation of potatoes and the rapid development of the growth of wheat has brought about a decline in the use of barley. Barley was used to some extent by both man and beast in the early colonies of this country.

Production.—Barley is the fourth cereal crop in the extent of its production in the United States. It is much less important, however, than either wheat, corn or oats. The acreage of wheat is about one-half, that of oats less than one-third, and that of barley only about one-thirtieth that of corn. The average yield of barley during the past decade was 22 bushels per acre. From 35 to 40 bushels per acre may be considered a fairly good yield. Fifty bushels per acre is not extraordinary. The average price during past decade has been 59 cents per bushel, a decrease of 15 cents from previous decade.

The average annual value per acre of wheat, corn, oats and barley during the past decade has been: wheat, \$9.97; corn, \$9.48; oats, \$8.22; barley, \$12.79.

The significance of these figures may be illustrated by assuming the cost of raising either an acre of wheat or barley at eight dollars. On this basis the profit from an acre of wheat would be \$1.97, while from an acre of barley it would be \$4.79.

Practical experience has demonstrated that barley is a paying crop in regions to which it is adapted, but the distribution of barley is very peculiar. It is a maxim that like causes produce like effects. Here is an example of unlike causes producing like effects. A few years ago California and New York were the largest two barley-producing states. The large production in California is due to the fact that the climate is favorable for barley and not favorable for the production of corn and oats, nor for the ordinary cultivated tame grasses. Barley is the forage crop of California. In New York the climate is not especially adapted to barley, and is well enough adapted to oats, corn and tame grasses. The partial failure of the wheat crop from the ravages of the Hessian fly, the competition of the western wheat-raising states and probably the demand for barley for malting purposes, are some of the causes which have led to the increased acreage in New York. On the other hand, New York produced in 1888 sixteen times as much barley as Pennsylvania, although the two states are otherwise much alike in their cereal production.

Seven states raised six-sevenths of the crop in 1888, the order of the greatest yield being: California, Wisconsin, Minnesota, New York, Dakota (north and south), Iowa and Nebraska.

Our average annual import since 1870 has been eight million bushels or about one-fifth of our annual

production. The imported barley comes almost entirely from Canada.

Structure.—Barley agrees with oats in having the palets adherent. The hull is somewhat different in texture from that of the oat and has a long barbed awn or beard, which makes barley a very disagreeable crop to handle. The hull is very closely attached to the kernel and is not so easily removed as in case of oats. The hull may form from 12 to 18 per cent of the berry, 15 per cent being about an average.

Use.—Barley is very little used in this country as an article of human food, and then only as pearl barley. It is largely used as a stock food and for malting purposes. Except on the Pacific Slope its use as a stock food is not general as compared with corn or oats. In Europe it takes the place largely which Indian corn does in America. It is also used for malting purposes, and on the continent, especially in the southern part, is used as a human food.

Composition.—Barley differs from Indian corn principally in having a less per cent of fat. Oats contain about three times as much crude fibre as barley, yet it is essential to grind barley before feeding it, while it is not necessary to grind oats. Otherwise, as compared to oats, it has less fat and more starch, the starch taking the place of the extra crude fibre in the oats.

The highest priced barley is used for malting purposes. For this use barley should be mealy instead of glossy, light in color, and have a low percentage of albuminoids. As sold in the market, however, the grade depends upon its plumpness, its weight and its color, the latter two being the most important. The

greater the weight and the lighter the color, the higher the grade. The best barley for feeding purposes is the poorest for malting. As the price is fixed by the demand for malting, the best feeding barley is the lowest in price. The price varies more with the grade than is the case with any other cereal.

The weight per bushel depends much upon the thoroughness with which the beards are removed. To accomplish this the grain is often run through the thrashing machine a second time. So important is the weight that at elevators where much barley is shipped special machinery is used for thoroughly scouring and cleaning it. The legal weight in most states is 48 pounds. The color is darkened by rains or heavy dews after the barley is ripe. To produce a high grade of barley it is important to get it dry and in stack as soon as possible after cutting it.

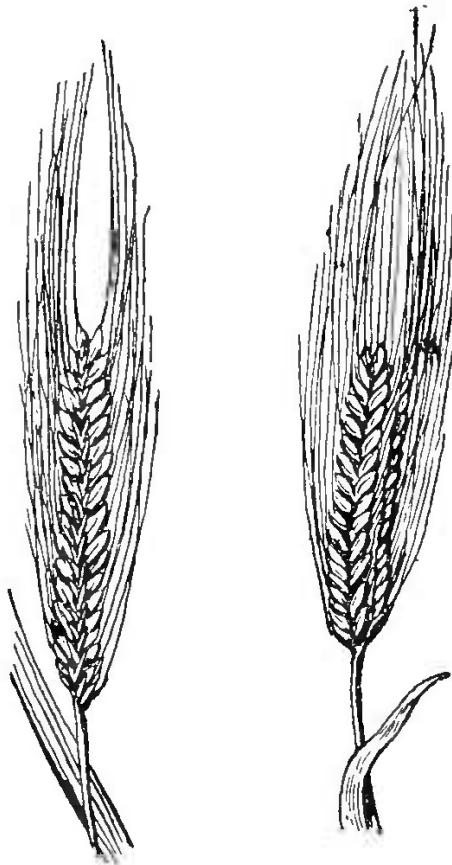
Climate.—Barley is successfully cultivated in a wider range of climate than any other cereal. It is cultivated from Iceland to semi-tropical California. Although an important crop in Norway and Sweden, it was formerly the bread plant of the people bordering on the Mediterranean Sea. It is said to grow at the extreme north where the soil only melts a few inches deep. It seems, however, to be best adapted to a warm, dry climate.

Professor Brewer shows that the greatest production of barley is with a smaller amount of annual rainfall, and also a smaller amount of rainfall during the growing season, than in the case of any other cereal. An abundance of rain, however, does not deter it from successful growth.

Soil.—Whether the peculiar distribution of barley

in the United States is in any way dependent upon the soil has not, and possibly cannot be satisfactorily ascertained. The general impression is that the nature of the soil makes more difference with barley than with our other cereal crops. English experience would indicate that rather sandy and well drained soils are better than clay soils or soils not well drained.

It needs a fertile soil and will stand liberal manuring. There is good reason for believing that if stable manure is applied directly to barley it should be well rotted. It is probably better, however to apply the manure to a previous crop, such as corn or wheat. The roots of barley grow near the surface of the soil, and although they

TWO-ROWED
BARLEY.SIX-ROWED
BARLEY.

grow rapidly they are comparatively feeble and short-lived. The fertilizing ingredients, therefore, need to be in a soluble condition. Barley is considered an exhaustive crop.

Varieties.—There are at least, four types of barley which are somewhat distinct, and have been considered species. The four types, with the botanical names given them, are as follows:

1. Two-rowed barley, *Hordeum distichon*, L.
2. Four-rowed barley, *Hordeum vulgare*, L.
3. Six-rowed barley, *Hordeum hexastichon*, L.
4. Naked barley, *Hordeum distichon nudum*, L.

It is the six-rowed type that is generally raised in this country. In England the two-rowed type is principally used for malting, the six-rowed being used there for grinding and feeding. The two-rowed type has been found to yield more malt-extract than the six-rowed. The leading six-rowed varieties are Mansbury, Scotch and Imperial. The hullless or naked barley is grown only for feed. It does not seem so prolific as varieties with hulls.

Culture.—The seed-bed should be deeply and thoroughly pulverized. To this end the land should be plowed fairly deep. A well prepared seed-bed is essential for barley.

Barley is sown in the fall in Europe along the Mediterranean sea, but in America practically only spring barley is sown. The temperature required for the germination of barley is about the same as that of wheat. The barley plant when young, however, is rather more susceptible to cold than wheat. A light frost just after it is up is likely to injure it. In the spring wheat regions barley is generally sown after wheat is sown and before oats are sown.

Two bushels is the usual quantity of seed sown per acre. It is generally sown broadcast, although some raisers prefer to use the drill.

Harvesting.—Formerly the barley crop was usually cut with a self-rake reaper, and laid off in small gavels or in continuous swaths. These were allowed to dry a day or so, as required, and then raked together, or, more usually, placed in piles by hand with large wooden, four-tined forks. The aim was to get the barley dry as quickly as possible, so that it might be subject as little as possible to the rains and dews

before reaching the stack. The severity of the beards and the shortness of the straw made it almost impossible to bind by hand. With the self-binder it is the easiest and pleasantest of our cereal crops to bind. The shocking is now the most unpleasant operation.

Barley of as good color cannot be obtained when the sheaves are bound as when they are left open, chiefly because it is necessary to allow it to be longer exposed to the weather before stacking. For malting purposes, especially, barley should be thoroughly ripe so that all the kernels will germinate at the same time.

The barley plant is generally rather free from attacks of plant diseases and insect enemies.

RYE.

The cultivation of rye is not nearly so ancient as that of wheat and barley. It was unknown to the ancient Egyptians. The ancient Greeks did not know it. Its introduction into the Roman Empire was hardly earlier than the Christian era. The origin of its cultivation is supposed to be Northeastern Europe.

Within modern times rye was formerly a more important crop. Even as late as the middle of the present century rye was said to have formed the principal sustenance of, at least, one-third the population of Europe, this one-third inhabiting the northern half of Europe, barley taking its place in the countries nearer the Mediterranean. It was usually sown with wheat and is yet to a large extent mixed with wheat in grinding, and the [resulting flour is called *meslin*. The mixture of corn and rye for bread was common in New England. Relatively rye was formerly much more important in England and the United States.

Production.—The amount grown in the world is

yet very large. It has been estimated at about 1,200 million bushels, or about three-fifths that of wheat. One-half this quantity is raised in Russia, while about five-sixths of all the rye raised in the world is raised in Russia, Germany and Austro-Hungary. Russia raises more rye than the United States does wheat. In France and England it now holds a subordinate position.

The average annual acreage in the United States during the past decade has been only about two million, or a trifle less than that of barley, with an average yield per acre of 12 bushels, at 62 cents per bushel, making the least average value per acre of any of our cereals, considering the grain only. Pennsylvania, New York and New Jersey raise over one-fourth this quantity, while Illinois, Wisconsin, Kansas, Iowa and Nebraska raise about one-half the crop. In the eastern states especially the straw is an important item in its culture. Near the large cities it is put to various uses which are made of straw, particularly where long, straight, unbroken straw is needed. The manufacture of paper from rye straw is also an important item, a paper mill becoming the center of its culture for this purpose. A ton of straw is an ordinary yield per acre, and ten dollars is a common price per ton in eastern paper mills.

The use of the grain is confined almost entirely to the making of bread and spirituous liquors. Fifteen to 20 bushels per acre is a fair, and 20 to 30 a good crop, for most parts of the country.

In the western states rye is frequently grown where winter wheat is a precarious crop, as it is an advantageous distribution of labor to sow a fall crop,

and even where wheat is grown somewhat the fact that it ripens before wheat lengthens the grain harvest, which is often desirable. As a soiling crop and as a crop for green-manuring it has been highly esteemed. Indeed, in any thorough system of soiling it is almost an essential as furnishing green food until clover is large enough to cut. While there is evidence which tends to show that the yield of green rye used as a soiling crop is not so great as that of medium red clover, and that it is less rich in albuminoids, yet in practice it has been found very satisfactory. This is especially true in the production of milk for city delivery, where it is important that the milk be acceptable to the taste. There are many ways in which rye may form and does form an important, although subordinate part, of a system of mixed husbandry.

Composition.—Analyses show that rye in the kernels is less nutritious than wheat, and that the difference in their respective flour is still greater. Rye bran is much richer in albuminoids than wheat bran. Coarse rye bread is more nutritious than fine rye bread. Fine rye bread is less nutritious than fine white bread. On the European continent, where coarse rye bread is largely eaten, it has always been considered more nutritious than wheat bread.

Rye is not so variable as wheat in chemical composition and is not very susceptible to climatic conditions. In structure it is more like wheat than any other cultivated plant.

Climate.—Rye is a very hardy plant. It stands severe winters better than wheat. It is naturally a plant of cold climate, just as barley is one of comparatively warm climate.

There is only one species of rye (*Secale cereale*) and not many recognized varieties. There are both spring and winter varieties, the latter being sown almost exclusively.

Soil.—Rye is adapted to light, sandy soil. It will thrive on much poorer soils than wheat, corn or barley. This is so well recognized that the expression, “it is too poor to grow rye,” is used to indicate extreme poverty of the soil. Professor Brewer says that the feeling that poor soil and the growth of rye are connected, prevents many farmers raising it for purely sentimental reasons. Such a sentiment in the west has not been observed although a similar sentiment seems to exist in parts of Pennsylvania with reference to buckwheat.

Culture.—The same principles apply to the preparation of seed-bed and the seeding of rye as in the case of winter wheat. Ordinarily, where both wheat and rye are sown, the rye is sown first. One and one-half to two bushels are sown, preferably drilled, per acre. It may be sown in standing corn and used for pasturage and afterward plowed under for green manure. It should not be sown until the corn is sufficiently matured to allow access of the sun. If sown earlier the shade of the corn retards its growth so that no advantage is derived from the earlier sowing.

Plant Diseases.—Rye is not particularly subject to insect attacks but is subject to a plant disease which needs special mention. Ergot, known also as spurred or horned rye, is readily recognized by the very much enlarged and changed appearance of the kernel, caused by the growth of the fruiting spores. Rye containing ergot should not be fed to animals or eaten

by persons, because of the serious effect which may follow from such use. Rye containing ergot should not be sown and land producing ergot should be used for some other crop.

CHAPTER XVII.

GRASSES.

History.—The cultivation of wheat, corn, oats, barley and rye is very ancient; that of wheat and barley perhaps antedating the others. The sowing of grass and forage crops is of comparatively recent origin.

Permanent pastures have existed for many centuries, in the civilized countries, but the custom of sowing grass seed to produce pasturage and hay is scarcely a hundred years old. The lack of any cultivated grasses was one of the difficulties that the early colonists had to contend with in this country.

The introduction of red clover into England did not take place till 1633; that of white or Dutch clover, not till 1700. Of the natural grasses our well known timothy was first brought into cultivation in this country, and it was not cultivated in England until 1760. The culture of orchard grass was first introduced into England from Virginia in 1764. There is no evidence of any systematic or artificial cultivation of grasses there until the introduction of perennial rye grass in 1677, and no other variety of grass-seed appeared to have been sown for many years, not, indeed till toward the close of the last century, upon the introduction of timothy and orchard grass.*

The average weight of cattle and sheep sold in 1710 in Smithfield Market, which in many senses bears the same relation to England as the Chicago Stock-Yard market does to America, was: beeves

*"A Hundred Years Progress," U. S. Dept. of Agr., 1872, p. 277.

370 lb., calves 50 lb., sheep 23 lb., lambs 18 lb. That the improvement in grass culture has in a large measure made possible the wonderful improvement in stock since that time cannot be doubted.

Production.—Grass is not only the greatest of all our crops, but the greatest source of wealth of any single crop. There were 35 million acres of hay harvested annually during the past decade against 37 million acres of wheat. The average value of an acre of wheat was \$9.97, while the value of an acre of hay was \$11.09, so that the total value of the hay crop was 389 million dollars, against 372 million dollars for wheat.

Eleven per cent of the total farm area, or about 60 million acres, was in permanent pastures and meadows. This is exclusive of pastures and meadows in rotation, of woodland pastures or ranches beyond the western border of the pioneer homesteader.

In 1890 there were 53 million cattle and 44 million sheep. If we do not consider the horses, mules and swine and allow one acre of pasture for each animal of the ox-kind of whatever age, and one acre for five sheep of any age, we would have 62 million acres of pasturage.

It is probably entirely within bounds to say that there are as many acres of grass land for pasturage and hay, exclusive of ranches, as there are of corn and oats raised annually.

A large proportion of the land devoted to pasturage is, for one reason or another, not well adapted to tillage crops. The land is either too uneven or too stony to be easily tilled, or is broken by streams, or more or less covered with trees.

In the west large areas are grazed in advance of approaching cultivation, or in regions where the rainfall has not been considered sufficient for successful cereal production. The native grasses of the plains produce a nutritious diet, although often scanty as compared with the grass produced in cultivated regions. It has not been uncommon for a rancher to control 25 acres for each head of cattle that he raised.

Permanent pastures are not the rule in this country on land capable of easy tillage. Occasionally, but not often, there will be found a piece of tillable land in the older settled regions which has never been broken, but has been constantly in pasture since it was in prairie grasses, tame grasses having supplanted the wild ones. As a matter of convenience also, such as proximity to farm buildings, land is kept more or less permanently in pasture. The rule in this country, however, is to make the grass on the tillable lands a part of a more or less systematic rotation of crops.

In England it is quite the reverse. There are many pastures in that country which have been down so long that there is no record of the date of seeding. The land was once cultivated, however, as is shown by the furrow marks which still remain. There they consider that the pastures improve from century to century.

The acreage of permanent pasturage has increased considerably in Great Britain during the past quarter of a century, while the acreage of grain crops has been diminished.

Manure.—The value of grass crops, besides their intrinsic worth as a crop, is in maintaining the fer-

tility of the soil. There is a Flemish proverb, "No grass, no cattle; no cattle, no manure; no manure, no crops." Constant pasturage by cattle not otherwise fed may slowly reduce the fertility of the soil. A crop of hay will remove more of the "precious" elements than will the grain of a crop of wheat. Selling hay has not been considered by many, therefore, as good farm practice. Of late years, however, the practice of selling hay has been looked on with more favor, both because it has been relatively more profitable than grain crops, and because it has not been found in practice to be harder on land than selling grain crops. The fact is it is not what a crop takes off the soil but what it leaves in the soil when it is taken off that determines whether it depletes the fertility of the soil.

Probably there is no way, considering the expense involved, of so profitably manuring land as by top-dressing grass lands. Stable manure has been applied to pasture and to meadows as a top-dressing with good results, applying it lightly, say ten loads per acre. It does not seem to injure materially the palatability of the pasture grass. With hay crops, there is danger, if not well spread, of getting the manure raked up with the subsequent crop of hay.

Fattening animals on pasture, or feeding grain food to milch cows while on pasture, increases the fertility of the soil by returning more to it than is taken from it. Although the manure is not as well distributed as if the land was top-dressed, there is no expense for spreading.

Experiments have been made by Lawes and Gilbert which show that different kinds of fertilizers favor

different grasses and clovers. They find that the most complex herbage occurs on unmanured lands; that potash and phosphoric acid increase the proportion of leguminous plants; nitrogen and yard manure increase the proportion of grasses proper. The yield of hay was increased more by the use of yard manure and nitrogen than by the use of mineral fertilizers.

It is evident that if different kinds of fertilizers favor different pasture plants, the character, as well as the quantity of the pasturage, may be affected by the kinds of food fed to the stock which feed upon it. The kinds and purposes for which the stock are used may affect the character of the pasture for a similar reason.

Seeding.—The usual method of sowing grass seed (using the term in its general and not its botanical sense), is to sow with grain crops. Undoubtedly this is good practice for most regions. Usually no crop of hay can be harvested the first year. If sown alone the land is not sufficiently shaded by the grass to prevent the growth of weeds, which it is necessary to mow at considerable expense. The crop of hay the succeeding year is no better than if grain had been sown with the crop the preceding year. This is especially true of our leading hay crops, timothy, medium red clover, mammoth red clover and red top. A crop of grain, also, is obtained at little additional expense.

In some regions, however, timothy sown alone in fall will produce a fair crop of hay the following season. When sown with wheat, it produces so much hay as to interfere with the harvesting of the crop, as well as materially reduce the yield of wheat. In such regions the custom is to sow the timothy alone.

These localities are the exception rather than the rule. Generally the practice of sowing the grass seed with the grain crop is based on sound business principles.

The desirability of sowing two or more kinds of grass seed together must depend largely upon the adaptability of the grasses to the locality and the purpose for which the crop is grown.

The plants should mature at about the same time. It may be laid down as a rule, that for hay it does not pay to grow one plant with another when it is not in itself adapted to the conditions under which it is grown when sown alone. If it does not pay to sow alone it will not pay to sow with another crop. The introduction of such a plant reduces the yield, by occupying land which could have been more profitably occupied by a plant adapted to the conditions existing there. In this respect it is a weed. It is a plant out of place.

Roots never fully occupy the soil. Those of different plants occupy different portions of it. The roots of timothy grow near the surface. Clover roots grow deeper. Thus to a certain extent they do not interfere with each other. When medium red clover is sown with timothy the former usually dies after the second crop, leaving the decaying roots and stems to furnish their acquired fertility to the timothy and succeeding crops. The holes left by the decaying roots may perhaps in some cases improve the mechanical condition of the soil.

In some localities timothy does not reach its best development until it has been down two or three years. In the meantime the clover may occupy

a portion of the ground with no serious ultimate disadvantage apparently to the timothy.

The seeding with a miscellaneous mixture of grass seeds of varieties of little or no value when sown alone, has neither practical nor experimental evidence in this country to commend it. The seeding of limited quantities of several varieties merely to add variety may be justifiable.

For pasturage several varieties may be desirable in order to furnish a succession of herbage throughout the season. The chief difficulty in America is to find varieties adapted to our soil and climate which will do this.

The time of seeding will depend largely upon the climate and the variety and will be discussed under varieties.

Grass seeds must not be sown so deeply as cereals. The smaller the seeds the shallower they must be sown. They have less starch with which to support the plant until it is up. The plant is so much more delicate that it cannot overcome the resistance of the soil. These facts make a well-prepared seed-bed or a great waste of seed imperative.

Much seed is sown without any covering, although a light covering is generally advantageous. Probably better average results would be obtained with deeper covering than is usually practiced, if the seed-bed is carefully prepared. In continued moist, rainy weather the covering is not important.

The great difficulty in securing a stand is from the drying of the surface soil just when the seeds are sprouting and the plants are becoming established. The seeds being so near the surface the soil may in a few days become dry enough to kill the plants.

The quantity of seed that it has been found necessary in practice to sow is very much more than is theoretically necessary for a perfect stand. In field culture only a small portion of the seeds sown produce mature plants.

This may be illustrated by giving the number of seeds per square foot where a given number of pounds are sown per acre. Many more might be given but the following list will suffice:

Name.	Lbs. seed sown per acre.	No. seeds per sq. foot.
Timothy	15	490
Red top	30	2850
Orchard grass.....	35	370
Kentucky blue grass.....	40	2000
Meadow foxtail.....	40	915
Fall meadow oat grass.....	40	140
Meadow fescue.....	30	190
Sheep's fescue.....	30	540
Sweet vernal grass.....	30	440
Perennial rye grass.....	60	335
Italian rye grass.....	60	380
Medium red clover.....	10	85
Mammoth red clover.....	10	75
Alsike clover.....	10	150
White clover.....	10	200
Alfalfa	10	55

The rate of seeding timothy varies from nine to fifteen pounds per acre, thus making from 300 to 500 seeds to the square foot. The rate of seeding clover may vary from six to ten pounds, making from 50 to 85 seeds per square foot. This quantity has not been found too much in practice.

This of course, shows the crudeness of the present method of seeding. The greater delicacy of the smaller seeds is also well illustrated. This is, in part,

due to the great lack of vitality of the smaller seeds. Many of the smaller seeds sold are incapable of growing under the most favorable conditions.

Harvesting.—The proper time to harvest hay is manifestly when the largest quantity of the best quality can be secured, provided the expense is not thereby increased. The quantity may be sacrificed to improve quality. Quality may be sacrificed to increase the yield or to decrease expense in harvesting. The expense and risk of securing timothy may be greater if it is cut early, as it requires more handling and longer exposure in curing than if cut late.

If hay is to be marketed it is important to distinguish between food value and market value. A ton of early cut hay may contain more nutrients than a ton of late cut hay. As a food for milch cows the former would doubtless be better than the latter. Yet the later cut timothy hay may have the higher market value.

Growth signifies an increase of weight. A crop of grass increases in weight of dry substance until it is ripe. There may be a greater loss in weight in the matured plant from the loss of seed, in the case of timothy, or in the loss of leaves and finer parts in the case of clover, than if cut earlier. When ripe the hay is practically straw.

A summary of experiments made in this country shows that there is an appreciable increase of yield of the true grasses from the period of full bloom until seeds are formed. There is an increase of all the food nutrients, but the increase is most marked in the crude fibre, starch, sugar and allied substances. With timothy, orchard grass and meadow fescue an increase

has been found in some instances of one-fourth, from the period of full bloom until seeds were formed.

With the clovers, there has been found a decrease in all the nutrients, with the exception of crude fibre, in which there is sometimes an appreciable increase. The loss of the leaves and finer parts in handling while curing is sometimes sufficient to render the clover hay well nigh worthless. There is both a loss of weight and loss in quality.

A farmer with 150 acres of hay to harvest cannot harvest it all at the theoretically best time. If he sells part of his hay it is prudent to sell the later cut hay. It has less food value pound for pound, especially for growing stock and milch cows. In many localities it has a greater market value. In such cases it is usually intended for matured horses, for which purpose it is better suited.

The aim in curing a fodder crop is to preserve the nutrient elements with the least loss, and in as digestible and palatable a form as may be. In practice, it is desired to secure bright clean hay.

The quality may be reduced by the direct washing and dissolving by rains; by bleaching, through the alternate wetting by rains and dews, just as linen is bleached; by becoming musty through heating or fermentation, or by the loss of the more delicate and more valuable parts, as the leaves, when the hay is too thoroughly dried.

As before indicated the latter is an important reason why the quality of clover is improved by curing in shocks. When it is spread thinly on the ground the leaves become dry much sooner than the stems, and every time the clover is handled the leaves are

broken off and lost. If, on the other hand, the clover is put in shocks before the leaves become dry, the stems and leaves transpire or evaporate the water through the leaves, much as they do when the plant is growing. The moisture of the stems passes off through the leaves. This is the sweating of hay. The water collects on the outer surface of the stems and leaves, because it is imprisoned there by the surrounding material.

It is not feasible in many places, however, to cure hay in the shock, on account of the extra labor necessary. Much hay is now put in the barn or stack on the day after it is cut. Hay rakes, loaders and forks make it possible to do this with but little hand labor, while if put in shock much hand work is necessary.

On the other hand, where only a limited quantity is to be handled, it is often more convenient and more economical to put the hay in shock. The method of handling hay depends much upon circumstances, the main element being the cost of a given method under given conditions.

Other things equal, the less the hay is handled the better the quality, as at every movement some of the finer parts may be lost.

CHAPTER XVIII.

GRASSES.

Varieties.—Probably not one farmer in a thousand east of the one-hundredth meridian in the United States knows any other cultivated grass by name than Timothy, Red top and Kentucky blue grass, or any other clover than medium red clover and white clover. Fortunate is the farmer who has no need to know any other.

There are considerable areas of the United States, however, in which none of these thrive particularly well, notably the South Atlantic and Gulf States, and much of that vast area west of the one-hundredth meridian.

Probably in no other country are the cultivated grasses and clovers grown in such purity as in the United States. Yet a considerable part of herbage of this country consists of native grasses and forage plants.

The herbage of the ranges is composed of a large number of species of grasses and grass-like plants. These grasses have the common characteristics of growing in a dry climate and producing a nutritious herbage which retains its nutritious qualities when dried standing. This is probably in part due to the climate rather than to the kind of grasses. Fermentive and putrefactive changes of all kind take place less rapidly than in a moist climate.

The most common grasses of this character on the Great Plains are Grama or Mesquite grass (*Boute-*

lous oligostachya), Buffalo grass (*Buchloe dactyloides*), and the bunch grasses of which those belonging to the genus *Stipa* and to the genus *Oryzopsis* are leading types. *Koeleria cristata*, *Deschampsia*

Coespitosa, and several species of the genus *Festuca* are widely diffused.

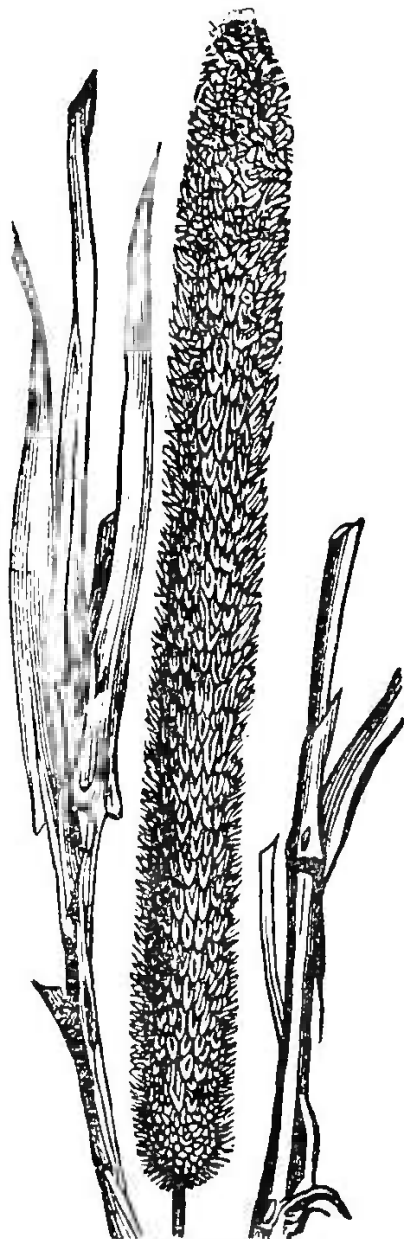
Blue joint (*Calamagrostis canadensis*) is one of the best and most productive on moist soils and in cool climates.

There is space for only a brief description of some of the better known cultivated species.

Timothy.—Herd's grass, meadow cat's-tail grass, are common names given to the grass plant known botanically as *Phleum pratense*, L. The most common name is Timothy.

Timothy is widely distributed. It is universally admitted, however, that timothy was first brought into cultivation in this country. As the story goes, Timothy Hanson, of Maryland, first introduced the plant from England in 1720.

About forty years later Peter Wynch took seed of it from Virginia to England. Its cultivation began there. It is claimed also that a man named Herd found it growing wild in a swamp in New Hampshire as early as 1700 and began its cultivation.



TIMOTHY.

Timothy is not adapted to swamp lands. The reason for the name cat's-tail grass is sufficiently obvious from the appearance of the head or spike.

Nowhere in the world is timothy so well and favorably known as in America. It is pre-eminently the hay plant of the grass family in the United States. No other plant in the grass family compares with it in extent of production for hay. North of the Gulf states it is almost exclusively the hay of commerce in the eastern half of the United States. Red top and clover hay is of course, sold to some extent, but the amount is small as compared with timothy.

The great popularity of timothy as a hay crop is due to the very satisfactory reason that it produces an abundance of hay of good quality over a large territory, and on a considerable variety of soils. It is easily and cheaply grown and the hay can be harvested cheaply and with comparatively small risk to quality. The fact that it can usually be put into the barn or stack so soon after it is cut makes it possible to handle it with a minimum amount of labor, and decreases the risk of having the hay spoiled during inclement weather,

It takes from nine to fifteen pounds of timothy seed to sow an acre, while with most of the other grasses grown for hay from thirty to forty pounds are required with present method of seeding. As timothy often produces from six to ten bushels of seed per acre, the price per bushel is moderate. The price of a bushel of timothy and a bushel of orchard grass seed is about the same, say \$1.50 per bushel. One-third of a bushel, or fifteen pounds of timothy, would

be as good a seeding as two and one-half bushels, or 35 pounds, of orchard grass. In other words, the cost of seed to sow an acre of orchard grass would be seven and one-half times as great as to seed an acre of timothy.

Timothy produces but one crop in a season, and does not produce much aftermath. It often grows very little for a couple of months after the crop is harvested. In dry, hot seasons the lack of vegetation, especially when mown close to the ground, causes the plant to be injured. It is better, therefore, where such danger exists, to mow rather high.

Timothy does not start to grow early in the spring, which, coupled with the last mentioned feature, and the fact that if not cropped closely it becomes coarse and woody, makes it less desirable for pasturage than some other grasses. In some localities it does not seem to be strictly perennial. That is, it disappears without being replaced by other grasses when constantly pastured. In England, Sutton says, the only objection to it for a rotation is the trouble of getting rid of it when the meadow is broken up.

Timothy is what is called a late grass, being ready to cut in July. This is a great advantage for this country as it can be much more easily cured and with so much less risk of injury to quality than if it was cut in June, both because it cures more quickly and because there are in general a less number of days of rain-fall in July than in June.

It has been customary to recommend that timothy should be cut in bloom or just passed bloom. The following table gives the yield per acre of the dry matter or water-free substance of timothy cut at dif-

ferent dates as determined by three experiment stations:

	Connecticut.	Illinois.	Pennsylvania.
Well headed out.....	2,750
Full bloom.....	3,300	3,285	2,585
Out of bloom.....	3 115	3,425
Seed in dough.....	4,010
Seed nearly ripe.....	3,615	4,065	3,065

There was not only an increase in the total weight of dry substance in each instance, but there was in general also an increase of each of the food nutrients, although the percentage of nitrogenous matter decreased as the plant became ripe.

Data with reference to the digestibility of timothy at different stages of maturity are meagre, but the indications are that the digestibility does not decrease to any great extent up to the time the seed is in the dough. Practical experience shows that for horses, at least, the palatability is not materially decreased.

The indication is, therefore, that the cutting of timothy may be safely postponed until after it is well past bloom. All things considered, probably when the seeds are in the dough would be the best time to mow timothy.

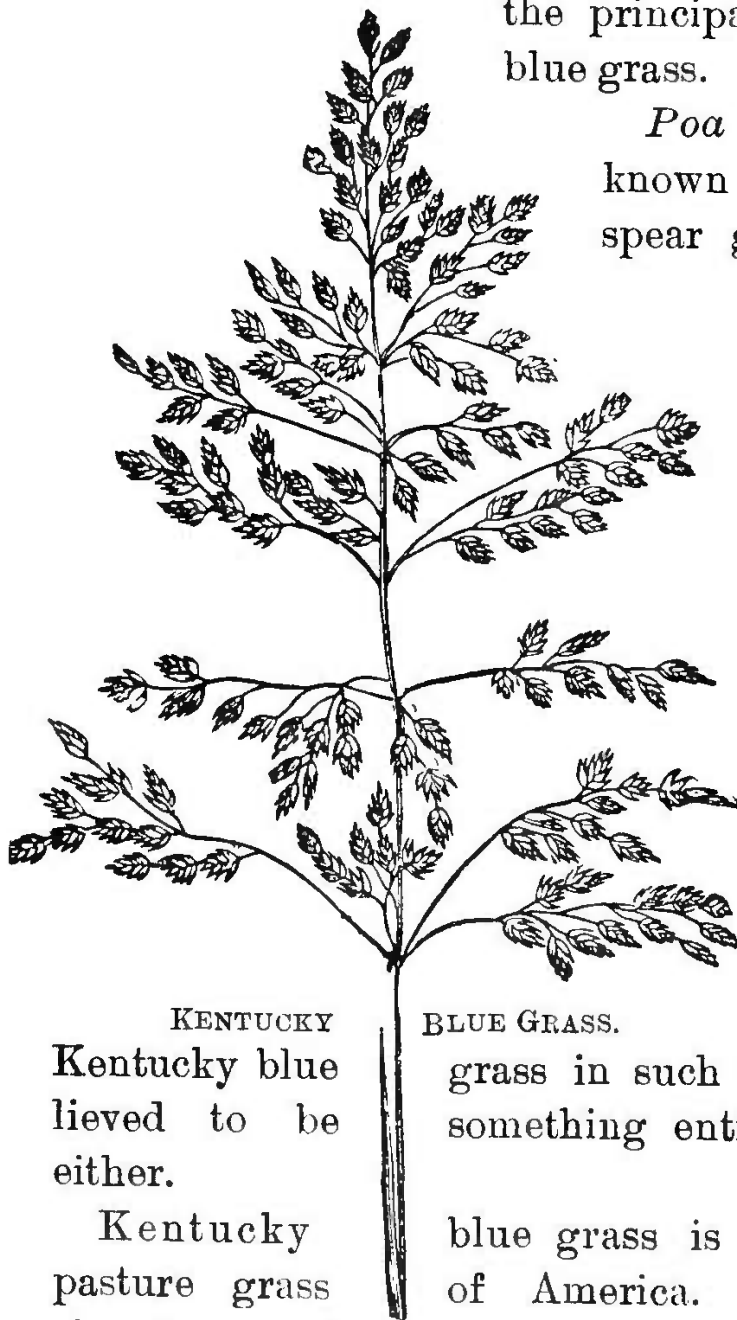
Timothy may be sown either in the fall or in the spring with any small grain that is sown at the time. A good stand will be obtained oftener, probably, by sowing in the fall. The seed should be well covered, and probably more deeply than is the general practice. Sowing the seed in front of the hoes of the wheat drill brings good average results in some localities.

Probably rye is the best and oats the poorest crop with which to sow timothy. In some localities it is

sown alone in the autumn and a crop harvested the following summer.

Kentucky Blue Grass—(*Poa pratensis*, L.) There is a large number of species of *Poa* which grow more or less abundantly in this country, but the principal one is Kentucky blue grass.

Poa pratensis is also known as June grass, spear grass, green grass, smooth stalked meadow grass and blue grass. In some localities wire grass (*Poa compressa*) is known as blue grass, and Kentucky blue grass is known as green grass. This gives rise to much confusion and misunderstanding,



KENTUCKY
Kentucky blue
grass is be-
lieved to be
either.

Kentucky
pasture grass
abundance of
a wide territory.
It makes a compact sod. The
leaves are fine, succulent, palatable and nutritious.
It is one of the earliest grasses to start in the spring
and one of the latest to grow in the fall.

BLUE GRASS.
grass in such regions being be-
something entirely different from

blue grass is pre-eminently the
of America. It produces an
pasturage of the best quality over
a wide territory. It makes a compact sod. The
leaves are fine, succulent, palatable and nutritious.
It is one of the earliest grasses to start in the spring
and one of the latest to grow in the fall.

In the more temperate climates it makes excellent winter pasture by keeping stock off it a while in the fall. When thus dried standing it is a formidable rival in nutritive qualities of the grasses of the arid regions.

Its greatest fault is a lack of supply of good pasturage during July and August. During hot, dry periods, the growth almost, if not entirely, ceases. The return of wet weather brings the apparently dead grass to life again, and it continues its growth until late in the fall.

It stands a large amount of tramping and very close pasturage without injury. On lawns the close and frequent cutting is an apparent improvement. As a lawn grass it is unexcelled.

The plant throws up seed stalks, usually about two feet high but varying greatly under different conditions. It ripens seed in June. The quantity of hay produced is small although of excellent quality. It is seldom cut for hay.

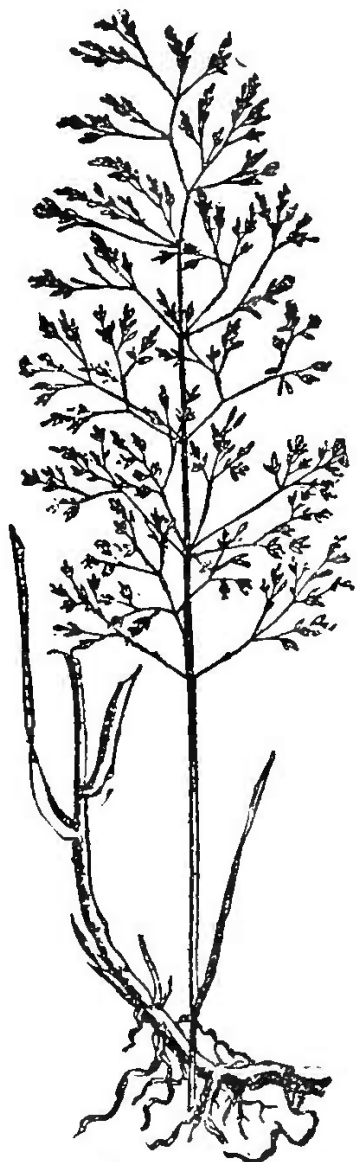
The plant not only reproduces by seed, but spreads by underground root stalks. It often takes possession of the soil when the land is put in pasture. Probably few of the blue grass pastures have been artificially seeded.

For commercial purposes the seed is obtained by stripping the heads with hand or horse machines made for the purpose. The heads thus obtained are dried in sheds and afterward cleaned by improved machinery.

Commercial seed is frequently poor, either because it is stripped when too green or is allowed to heat after stripping. It is easier to strip and clean when gathered green.

There are fourteen pounds of Kentucky blue grass seed in a bushel. Two and one-half bushels per acre or about 2,000 seeds per square foot has not been found too much to sow of commercial seed when it is sown alone. Seed of good quality should require

much less. It is probably better to sow a small quantity, say one-half bushel, with other grasses. The blue grass will spread gradually and take possession of the ground. Even when sown alone it takes possession of the soil slowly and requires several years to produce a compact sod.



RED TOP.

Red Top.—The plants of the genus *Agrostis* seem quite variable and there is some dispute as to the proper classification of the cultivated species. Beal recognizes three, although in the case of two of them he says the specific difference is questionable. However that may be, what is known to botanists as *Agrostis Vulgaris*, With., is commonly called red top and is the species generally cultivated. It is also known in some places as Herd's

grass, Burden's grass, summer dew grass, fine top, fine bent, bent, Rhode Island bent, and furze top.

As a hay crop it is next to timothy in importance among the true grasses in this country. It often, perhaps usually, forms a large part of the herbage of

permanent meadows. It is widely distributed. It bears its seed in a panicle, and thus has a superficial resemblance to Kentucky blue grass. The general observer may distinguish it from the latter by the purple color of the panicle and the smaller and more numerous spikelets. It does not grow as tall as timothy, but rather taller than Kentucky blue grass. It ripens about the same time as timothy. It is adapted to low, moist lands and is usually grown on the poorer lands of this sort.

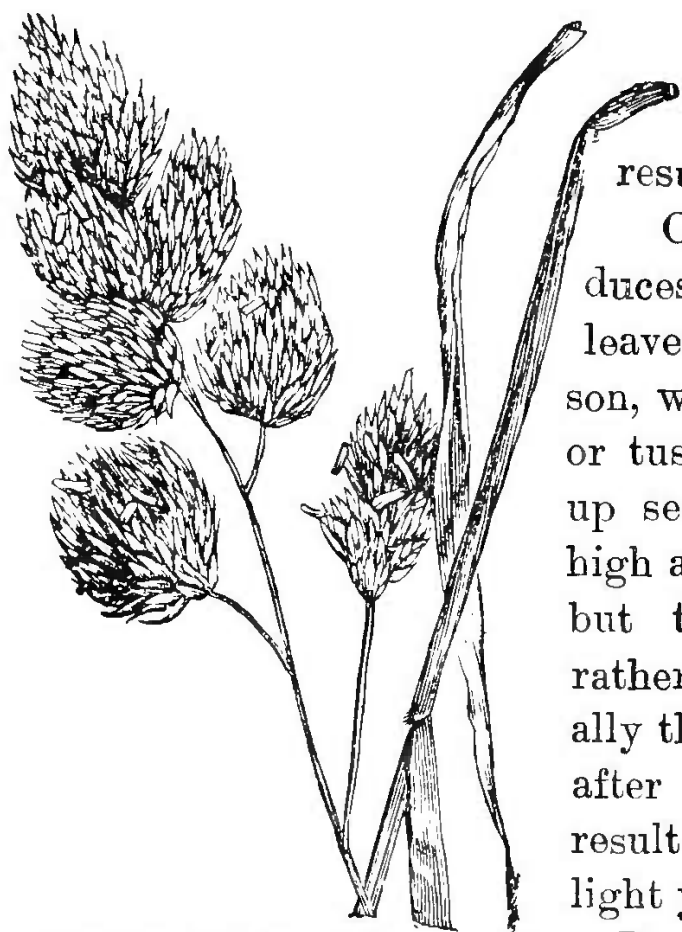
It produces a fairly good quantity of hay, but the quality is not considered as good as timothy. Buyers are not favorably disposed toward it. In some places where it grows readily farmers take the precaution to keep it out of their timothy meadows, because even a little of it reduces the market value of the hay.

It makes fair pasturage. It produces a better sod and more pasture, probably, on suitable soils, than timothy, although the plants do not take possession of the soil so quickly. As a pasture grass it is more important where Kentucky blue grass is not adapted.

There are ten pounds of red top seed per bushel. Two to three bushels are recommended for seeding. This is from two to three thousand seeds per square foot. The seeds are extremely small and are apt to have poor vitality.

Orchard Grass or rough cock's foot (*Dactylis glomerta*, L.) is a much praised but little cultivated grass in this country. It has been cultivated in this country, at least since 1764, when we are told it was brought into notice in England by its re-introduction from America. While it has been cultivated in this country more or less since that time, it has not been

known commercially and is so little grown that but few farmers know it. If it was especially adapted to the conditions of our agriculture it would seem that its cultivation would have been universal by this time. The fact that it has zealous advocates may indicate that there are special conditions of soil and climate



ORCHARD GRASS.—(After Vasey.)

It ripens about the time of medium red clover, and hence is better in this respect for mixing with medium red clover than is timothy. The abundance of leaves, however, has a repressing influence on the clover so that less clover is produced than when the same amount of seed is sown with timothy. It starts up with marvelous rapidity after a crop is removed and is not easily affected by drought.

Judged by analyses the quality of the hay is

over limited areas in which it produces favorable results.

Orchard grass produces an abundance of leaves early in the season, which are in bunches or tussocks. It throws up seed culms about as high as those of timothy, but they are produced rather sparingly, especially the first few years after being sown. The result is a comparatively light yield.

superior to timothy. The hay has the reputation of being less readily eaten by stock, although it is claimed this may be remedied by cutting it earlier. For pasture it does not take the place of Kentucky blue grass, timothy or red top.

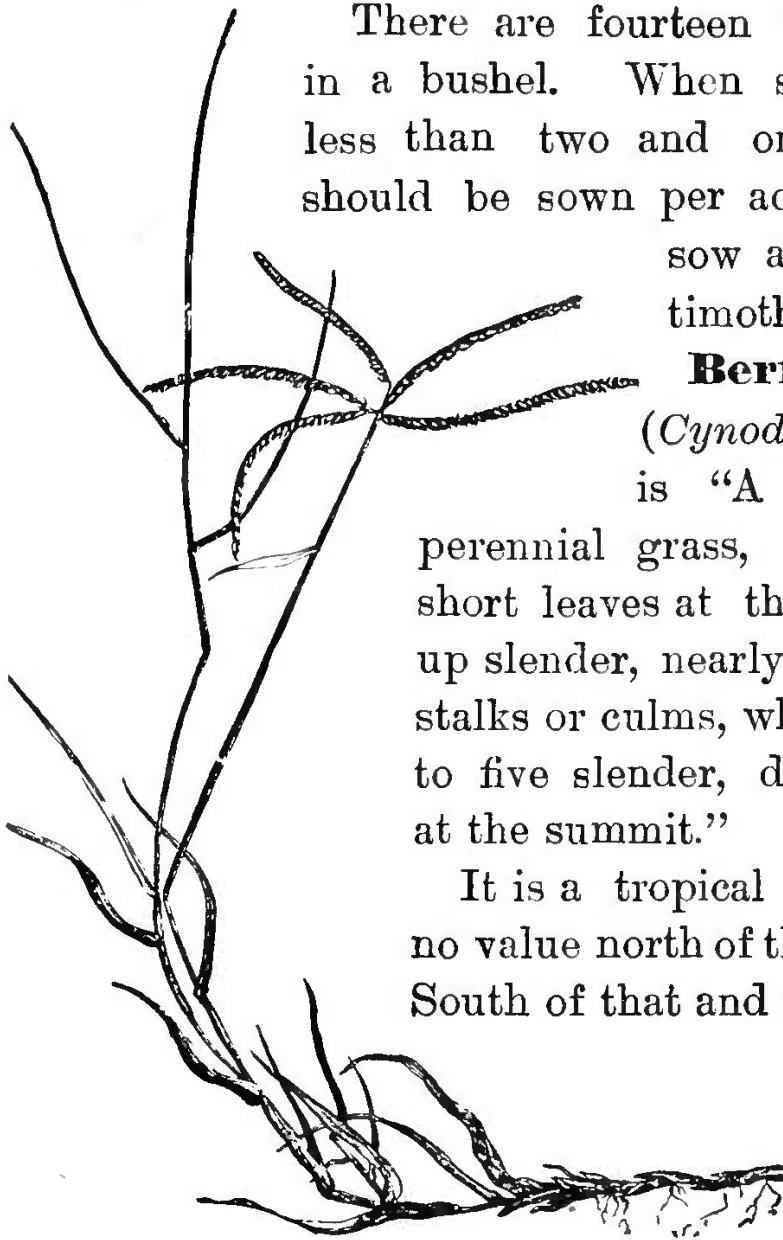
There are fourteen pounds of seed in a bushel. When sown alone not less than two and one-half bushels should be sown per acre. Otherwise sow as in the case of timothy.

Bermuda Grass

(*Cynodon Dactylon*)

is "A low, creeping perennial grass, with abundant short leaves at the base, sending up slender, nearly leafless, flower stalks or culms, which have three to five slender, diverging spikes at the summit."

It is a tropical plant, and has no value north of the 37th parallel. South of that and especially south of the 35th parallel it is a most valuable grass, both for hay and pasture.



BERMUDA GRASS.—(After Vasey.)

It has been avoided by farmers because the roots take such a strong hold upon the soil as to make the land generally unsuited to a rotation.

It spreads by its rooting stems, but does not generally produce seed in this country. It is usually

propagated by cutting up the rooting stems in a feed cutter and sowing broadcast and plowing in, or planting in rows or hills like potatoes. It stands the hottest weather and the severest drought and makes its best growth during the summer months. The tops are easily killed by frost.

Fescues.—There are many species of the genus *Festuca*. Taller fescue, (*Festuca elatior*, L.) and meadow fescue (*Festuca pratensis* Huds,) are for practical purposes very similar. The former grows somewhat taller and coarser.

The manner of growth is very much like Kentucky blue grass. They produce a compact sod. They start to grow early in the spring and ripen their seeds in June. Their seed culms, however, are considerably taller and look more like chess than Kentucky blue grass. They yield a rather larger quantity of hay. The hay is of good quality. They deserve a trial wherever timothy and Kentucky blue grass are not well adapted.

Sheep fescue (*Festuca ovina*, L.) is a small, low growing plant which makes a compact sod and is very much prized in Great Britain for pasturing sheep, especially on the poorer soils. Vasey says it and several other species of *festuca* form a part of the vegetation on the ranges.

Rye Grasses.—The perennial rye grass (*Lolium perenne*) and the Italian rye grass (*Lolium Italicum*) are much used in England both for hay and pasturage, the former being the oldest and best known and the most highly esteemed. *Lolium perenne* was the first grass gathered separately for agricultural purposes.

In this country, while they have been repeatedly

tested they have not been much used and do not seem adapted to our agricultural conditions. They make an abundant growth the same season the seed is sown, and are good varieties to sow where this is desirable. The yields the succeeding seasons are apt to be poor, as the plants do not seem to be permanent in this country.

Sixty pounds of seed per acre are required. The seed should be sown very much like oats, only perhaps not as deeply covered, and should not be sown with a grain crop. Where it is desirable to get a piece of land into pasture at once it might be advisable to sow permanent rye grass in place of the grain crop, sowing also the other desired grasses.

Tall Meadow Oat Grass (*Arrhenatherum avenaceum* Beauv) is one of the earliest grasses to start in the spring. It is a tall growing grass. It may grow five feet high.

The stems are rather coarse and appear woody. It will produce a large yield of hay. There is considerable difference of opinion as to its quality, but the weight of evidence seems to be that it is of poor quality. The hay is apt to be bitter.

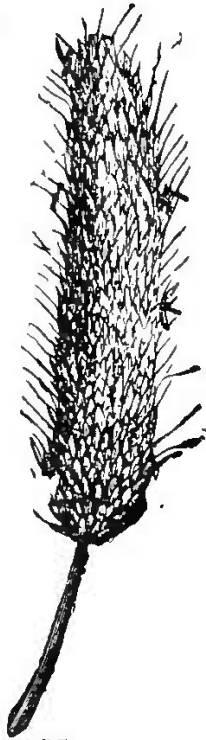
Beal states that he has raised this grass on rather light sandy soil at Lansing, Michigan, for twelve or more years and thinks that the reason for the conflicting opinion is, that it is adapted to the hotter, drier climates, while the finer succulent grasses thrive better in a moist climate such as England. Sutton



PERENNIAL
RYE GRASS.
(After Vasey.)

considers it superior to Italian rye grass. It is much grown in France under the name of ray grass.

Forty pounds of seed may be sown per acre under the same conditions as timothy. The seeds are com-



MEADOW
FOX-TAIL.
(After Vasey.)

paratively large and should be well covered. It is not always strictly perennial. It will probably never be widely used in this country.

Meadow Fox tail (*Alopecurus pratensis*) is the only cultivated grass that it is at all possible to mistake for timothy. It matures fully a month earlier, the seed clumps are not so tall, and the spikes or heads are not so long.

It is one of the earliest grasses to start in the spring and it produces an abundant aftermath. The seed is expensive, generally of poor vitality, with which it is difficult to obtain a stand.

In Great Britain it is highly prized for pasturage. It is the Kentucky blue grass of England. It is seldom seen growing in this country.

CHAPTER XIX.

CLOVERS.

Use.—The clovers are of vast importance to our agriculture. They are important as a part of a whole:

1. They help to balance our food ration. The great bulk of our agricultural productions in the United States, either in grain or coarse fodder, are from plants belonging to the grass family. These plants produce an abundance of starch and other heat-forming substances, but are relatively deficient in albuminoids or muscle-forming foods.

The clovers and other plants belonging to the pulse or clover family produce in the whole plant, as well as in the seed, a large percentage of the albuminoids. Feeding these tends to correct the otherwise one-sided ration. It is desirable to feed growing cattle clover hay with Indian corn, for the same reason that we eat meat with potatoes. Too much clover hay or too much meat would be undesirable.

The following table, giving the number of pounds of the different nutrients which may be found in a ton, will show the contrast between the grass and clover families:

	GRASS FAMILY.		CLOVER FAMILY.	
	Corn.	Timothy Hay.	Pea Meal.	Clover Hay.
Total dry matter	1554	1524	1791	1449
Albuminoids.....	184	100	405	228
Crude fat.....	95	63	24	103
Starch, etc.	1212	751	1022	609
Fibre.....	36	512	287	389
Ash.....	27	100	53	120

2. A ton of clover hay contains more nitrogen than does a ton of timothy hay, or corn fodder, or even a ton of corn or oats. Nitrogen being the most expensive of the "precious" elements, the manure produced from clover hay is more valuable than that produced from the other food material.

3. A crop of clover leaves in and on the soil a larger quantity of vegetation than does the cereal crops. This organic matter contains a large quantity of the precious elements, which become available with the decay of the vegetation. The land is thus in a more suitable condition to grow a succeeding crop than if the crop had not been grown. Grass crops also leave a considerable quantity of vegetation behind them, sometimes a greater quantity than the clover plant, but usually not so rich in the precious elements.

4. It seems to be satisfactorily determined that through the agency of the clover plant the free but inert nitrogen, which constitutes about four-fifths of the atmosphere, may be converted into active nitrogen; that is, it may become combined with oxygen.

The virgin fertility of the soil was largely due to the nitrogen combined with organic matter. This fertility has been collected through countless ages. The clover plant is an agency through which this fertility may be in a measure maintained. The clover plant is only the indirect source of this beneficent property. The direct power of converting atmospheric nitrogen into an available form for plant food lies in certain low organized plants called microbes or bacteria, which are found in the root tubercles of clover plants. These tubercles are characteristic of the plants of the clover family.

5. The organic matter which is left in the soil also improves the mechanical condition of most soils. There are soils which contain all the fertilizing ingredients necessary to a fertile soil, but which do not produce because of their mechanical or physical condition. Probably the most important single physical property is that with reference to the retention and passage of water in the soil. The decay of vegetable matter modifies this property to a considerable extent.

Varieties.—The true clovers (*Trifolium*), including possibly one or two other similarly growing plants, are more important agriculturally in this country than the large number of other valuable plants of the clover family, because they are adapted to general and profitable culture over a wide range of territory. A brief description of the more important is given.

Red Clover (*Trifolium pratense*, L.) is also known as broad clover, broad leaved clover, common clover and meadow trefoil, and also as medium red clover, to distinguish it from mammoth red clover.

It was one of the earliest forage plants to be brought into systematic cultivation, having been introduced into England in 1633 or about half a century before perennial rye grass.

Red clover is a plant of temperate climate. It is widely diffused through Europe. It is successfully cultivated throughout the United States east of the one hundredth meridian and north of the Gulf states. In this region it is cultivated for hay almost to the exclusion of the other clovers and similar forage plants. Where it is grown successfully it is not replaced by any other clover or similar plants, unless,

under some circumstances, the closely allied species, mammoth clover.

The plant is described by some as a biennial and by others as a perennial of a few years' duration. The plant varies considerably in this and other respects in different localities. It is usual when timothy and clover are sown together for the first crop to be largely clover; the second year about half and half clover and timothy, and third year largely, if not quite wholly, timothy. This is particularly the case when sown with spring grain. If timothy is sown with the fall grain it is somewhat more predominant from the first.

Red clover is easily affected by drought. It does not thrive on wet, undrained land. It grows on soils of all states of fertility except the poorest. The fertility of the soil may be correctly ascertained by the appearance of the clover plant, assuming a proper quantity of rain-fall. It is not entirely hardy, especially on poorly drained land.

Red clover produces two crops annually, one in June and one in August. The second crop varies in quantity with the season, the rain-fall being the controlling element. Frequently the second crop does not pay for cutting. It is wise to be able to pasture the aftermath of clover meadows. In some localities the second crop is considered with disfavor; in others it is used with good results. Probably the second crop is usually cut when too ripe.

The first crop usually contains very little seed. The second crop is frequently cut for seed. The quantity varies greatly. Frequently only half a bushel, occasionally eight to ten bushels per acre, is

obtained. Red clover requires the agency of some insect to produce seed. This is usually the bumble bee. There are few bumble bees abroad when the first crop is in bloom. The pollen of one flower is placed on the stigma of another flower by them as they visit the flowers for nectar. The purpose of the brightly colored flowers is to attract insects for the purpose of cross-fertilizing the plants.

Darwin aptly says that the beef supply of England depends upon the old maids. The beef supply depends upon the clover, the clover depends upon clover seed, clover seed depends upon bumble bees, bumble bees upon field mice, field mice upon cats. Old maids keep cats. Beal says that it is not improbable that the time will come when queen bumble bees will be reared, bought and sold for their benefit to the crop of clover seed. It is doubtful whether honey bees aid materially in fertilizing medium and mammoth clover. They do help to fertilize white and alsike clover.

Red clover should be sown in the spring. The young plants do not usually withstand the winter when sown in the fall. If sown with spring grain the seed should be covered with the harrow. Even in fall grain, the ground may be harrowed with a light harrow without injury to the grain and to the benefit of the clover. Rolling is usually advisable.

Good judgment is required as to the time of sowing. Much depends on the season. The young plants may be killed by a sharp freeze, or by a dry spell of a few days duration, particularly if the seed has not been well covered.

In general drought is most to be feared. Hence early sowing is usually advisable. Sowing on a late

snow often gives good results. The seeds sink into the liquid mud produced by the melting snow.

The quantity of seed varies largely with the locality. Ten pounds per acre, or about 85 seeds per square foot, may be given as about the average when sown alone. Twice the quantity is said to be sown in some localities. When sown with timothy or other grass seed six pounds will usually suffice.

Mammoth Clover has generally been considered a distinct species under the Latin name *Trifolium medium*. Sutton denies that *Trifolium medium* or zig-zag clover has ever been known in commerce and states that the cow grass of England is but a perennial variety of medium red clover.

It is distinguished from red clover by its larger and coarser growth and by its ripening three to five weeks later. Typical specimens have less hairy stems, narrower and more pointed leaves, and more conical and darker colored heads, which may be raised on short stalks. These distinctions are not well maintained.

Mammoth clover ripens about the time of timothy, and is, therefore, in this respect more suitable for sowing with timothy than is medium red clover. When medium red clover is sown with timothy the crop can not be harvested when they are both in the best condition. The danger is that the crop will be harvested when the clover is too mature and before the timothy has reached its proper growth. With mammoth clover the best condition of each can be obtained. Clover can generally be more readily cured in July than in June, both on account of the greater heat and drier atmosphere.

Mammoth clover usually yields but one crop in a season. It produces seed plentifully in this country. The seed can not be distinguished from that of medium red clover. One crop of mammoth clover may not yield as much as two crops of medium clover. The one crop of the former may be more economical than the two crops of the latter.

Mammoth clover grows rather coarse on rich soils. The quality of the hay is in such cases not so good as that of medium red clover. It is best adapted to relatively poor soils. Its deep roots and coarse growth gives it a large manurial value.

White Clover (*Trifolium repens*) holds the same relation to Kentucky blue grass as red clover does to timothy. It is suitable for pasture only. For pasture it is, in connection with Kentucky blue grass, unexcelled. It is not largely sown but finds its way into pastures which are suited to it. It is very uneven in its distribution, even in the same field, and grows very unequally in different seasons. It needs warmth and moisture but stands drought better than red clover.

It seeds freely. The seed may remain in the soil several years. The seed is supposed to make horses slobber on account of their acid nature, a characteristic common to all clover seeds. There are about twice as many seeds in a pound as of red clover. It roots readily from its creeping stems. It is perennial. It is frequently called Dutch clover because it was first brought into cultivation in the Netherlands.

Alsike or Swedish Clover (*Trifolium hybridum*) is a finer, smaller clover than medium red clover, with blossoms of small reddish white heads. In

growth it is about half-way between medium red clover and white clover. It does not produce as much hay as the former, and is not as suitable for pasture as the latter. The hay is of excellent quality. It often does not have strong enough possession of the land to prevent the growth of weeds. There is very little aftermath. It is more sensitive to drought, than

red clover. It is better adapted to damp soils than the latter.

Where it is strictly perennial it would be desirable for pasturage, but it is frequently not enduring.

As grown in this country it matures about the time of red clover. The seed is only about half as large as red clover. More plants



ALSIKE CLOVER—(After Vasey.)

may be advantageously grown on the same area.

Although it has no such wide adaptation as red clover there are probably limited areas where it is worthy of cultivation.

Crimson Clover (*Trifolium incarnatum*) is cultivated in France, Germany and Belgium. It is a native of Southern Europe and hence of a warm

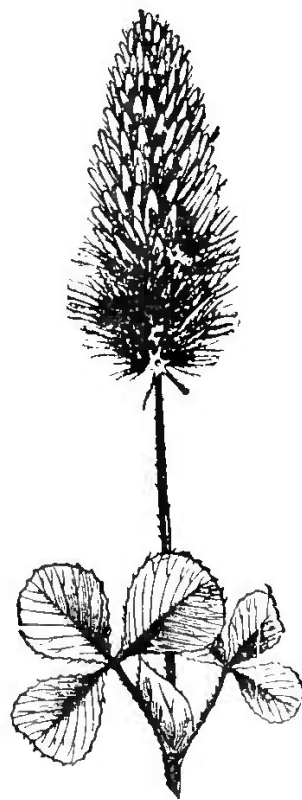
climate. It is an erect annual plant, growing about two feet high and has large, showy heads about two inches long. The flowers vary in color but are generally a bright crimson.

Crimson clover is not new to this country, but it has recently been brought into prominence by being recommended as a soiling crop. For this purpose it is sown alone in August or September and harvested in the following May. Vasey says it deserves a trial in the dry climates of the West.

Alfalfa or lucerne (*Medicago sativa*) has probably been used for hay longer than any other cultivated plant. The ancient Greeks and Romans used it. It is now cultivated in Southern Europe.

It was introduced into North America under the French name, lucerne, by the first colonists. It was tried over and over again in the New England and Atlantic states during the 150 years that elapsed prior to the Revolution. It was finally abandoned. Darlington wrote in 1859 that alfalfa could not be profitably grown where red clover was successful. Later experience has not disproved this assertion. Each has its place.

It was introduced into South America under the Spanish name, alfalfa, where it now grows wild extensively. It was introduced into California from Chili and has become the principal forage crop of the Pacific and Rocky Mountain states. Six tons of hay



CRIMSON CLOVER.
(After Vasey.)

per acre during a season is not infrequently reported.

This history of the plant is a fair indication of its adaptability. It is particularly adapted to warm, dry climates and dry soils with deep, porous sub-soils. The sub-soil is more important than the surface soil.

The roots grow deep. Sixteen feet deep has been reported on trustworthy authority. The compact, yellow clay sub-soil which underlies much of the middle, northern and Atlantic states is fatal to the successful growth of alfalfa. It is only "waging a fruitless war against nature to attempt to grow it."

It is not as hardy as red clover. It stands drought excellently and is adapted to irrigation. Much of it in the West is grown in this way.

It should be sown in the spring after all danger from spring frosts are past. When sown broadcast the best results are obtained by sowing on well prepared land without grain, grass or other forage plants. Weeds are inclined to appear. Planting in drills 12 to 18 inches apart is, therefore, sometimes recommended.

Ten to twenty pounds of seed may be sown per acre; less if in drills than if broadcast; less if for seed than for hay. The seeds are rather large. Twenty pounds per acre is equivalent to about 100 seeds per square foot. The seed does not grow so uniformly well as red clover.

Alfalfa is strictly perennial and is, therefore, adapted to both permanent meadows and pastures. It does not stand grazing so well as the true clovers or the grasses. In Great Britain, it is used chiefly for soiling. In moist climates it is difficult to cure, and the leaves are apt to be lost in drying.



ALFALFA.—(After Vasey.)

Common Yellow Clover or Trefoil, (*Medicago lupulina*) grows about 12 inches high and is in bloom in May. The heads are a small cluster of yellow blossoms. The leaves are small and the stalks small, resembling white clover in its manner of growth.

It is too small for a hay crop. In Great Britain it is considered desirable for pasture. It is biennial but



BUR CLOVER.

(After Vasey.)

seeds so plentifully as to make it practically permanent. Common trefoil occupies the northern part of Europe while alfalfa occupies the southern part.

It grows readily in this country and is worthy of a trial for early pasturage. It would probably not produce much summer pasturage, as it does not stand heat and drought well.

Bur Clover (*Medicago denticulata*) is an annual, native of the Mediterranean region, which has become widely distributed in California and somewhat in the southern states and is considered of great value.

It only grows in a mild climate. It is sown in the fall, growing during the winter months and ripening in the spring. Another crop may be grown on the the same land during the summer, and the seed left in the soil will produce a crop of clover during the succeeding winter months.

The seed is produced in pods or burs which cause trouble by getting into the wool of sheep.

Japan Clover (*Lespedeza striata*) is an annual which was introduced into the south Atlantic states

from China about 1850. It re-seeds on the same ground year after year, and has not been sown much artificially. It is highly prized for pasture in the South, but is not suited to northern climate. It is somewhat cut for hay also on the lowlands. It seems to have been spread by the war, the seed having been carried from place to place in the hay and by the horses. It was not much known before that time.

CHAPTER XX.

SILAGE AND FORAGE CROPS.

Soiling, or the system of feeding farm animals green food in stables or yards instead of allowing them to go to pastures, has never become common in the United States. Farmers have generally believed the cost of the additional labor made necessary, more than equaled the gain from this system. Partial soiling is common, and there is an increasingly large acreage devoted annually to the growth of crops to be used in the early spring, during summer drouths, or when the pastures begin to fail in the autumn. There is now a large area devoted to growing crops to be stored in silos. This system of preserving fodders is extending year by year, more especially among dairy farmers.

Maize.—Indian corn is easily first among the crops grown for ensilage in this country, and is very largely grown for feeding during the summer and early autumn. No crop gives a larger return of nutritious and palatable food. It is easily cultivated and is well adapted to a large part of the United States. One of the great wastes in our system of farming has been in the general failure to at all fully utilize the stalks and leaves of the corn crop when it has been grown for the grain. The proportion of the crop which is being well cared for in this respect is steadily increasing.

What has been said about soil, climate and cultivation in the chapters given to corn as a grain crop, ap-

plies almost equally well to it as a silage crop. There is, however, much difference of opinion and practice concerning varieties, thickness of planting and time of harvesting, when the crop is to be used for summer feeding or put into the silo. Formerly broadcast sowing of the crop was not uncommon, as much as three or four bushels of seed being sometimes used per acre. With fertile soil a large yield was received in this way, but the stalks did not have so good development as when planted in rows, and the crop cultivated. At present the more common practice is to plant in rows three to four feet apart, and at the rate of one kernel every four or even six inches in the row.

The kind of stock to which the crop is to be fed, and the time at which it is to be used, have much to do with determining the thickness of planting. If to be fed to supplement the pasturage in the summer or to dairy cattle liberally supplied with grains, comparatively thick planting is often preferred. If to be fed in the autumn to hogs or to fattening cattle or to be put into the silo for feeding to beef cattle, thinner planting is advisable. It is believed the greatest food value is received if the crop be not planted so thick as to prevent the formation and development of small ears.

The quantity of dry matter in the plant and its total food value increases until it has nearly reached maturity. There is some loss in palatability, possibly some in digestibility and danger of considerable loss from the falling of the leaves, if the crop is allowed to mature before cutting. If the fodder is to be kept in shocks or stacks it is better to leave it until the

kernels have become fairly hardened. If to be put into the silo it may be cut at a somewhat earlier stage. Ensilage is best preserved if the crop is cut when it has neither a great nor small percentage of water in it.

The young and rapidly growing corn-stalks have very little dry matter in them. In experiments at the Illinois Agricultural Experiment Station it was found that when the stalks of a medium sized dent variety had reached half the total height they had but one-fourteenth as much dry matter as when fully matured, and when they were in full tassel only about one-third as much. Early cutting involves a considerable loss of possible feeding value of the crop, but gives a very palatable food, often produced more cheaply than any other crop of equal value.

The larger varieties of sweet corn are sometimes grown as a fodder crop. They have the advantages of early maturity and of greater palatability than the ordinary field corn varieties. The chief objection is that the yield is relatively small. They may be planted more thickly in the rows and with the rows closer together than when larger varieties are used. Many growers of corn for ensilage prefer the large, late maturing varieties grown as field corn in some of the Southern states. On fertile land and with good culture enormous yields are secured. The stalks are sweeter than those of the medium sized dent varieties. An objection is that a longer season is required for maturing and there is danger of injury from frost in Northern states if the crop is not cut until the ears have somewhat matured. Many farmers prefer to use the larger varieties of field corn adapted to

their region. There is considerable difference in these in adaptation to use as fodder crops. Those with the largest number of joints and greatest percentage of leaves should be selected.

In some cases a crop of corn may be grown for cutting green or for ensilage, on ground which has produced a crop of wheat, rye or barley. If there is sufficient moisture in the soil to permit germination and fairly vigorous growth of the young plants a fair yield may be secured, but there is not often sufficient time to allow the crop to mature.

Large as is the yield of good food from a well managed crop of corn grown for soiling or ensilage, it is probably generally over-estimated. Reports of yields of 20 or 25 tons per acre are commonly made and in some cases are correct. But these are much above average results, even under favorable conditions. For the country at large 15 tons per acre is a good crop in fields of fair extent.

Sorghum.—The sweet sorghum has been highly recommended as a crop for soiling or for ensilage and is grown to some extent for these purposes. Except in regions with deficient rain-fall it is not the equal of Indian corn. The yield is not greater, and in the great corn-growing regions the culture is rather more costly because of the slower growth of the young plants, often making hand hoeing necessary to free the hills of weeds. The crop is more difficult to cure for use as dry fodder, and in most cases the ensilage made from it has not been so satisfactory as that from corn.

Good results have been had when sorghum has been grown in Western Kansas, Nebraska and other

regions with fertile soil but not abundant rain-fall. It is there sometimes grown as a cultivated crop, and sometimes sown broadcast, harvested with a mowing machine and treated as a coarse hay crop, often being left in the fields in large shocks until needed for use.

In parts of the country where the winters are mild and growth commences early in spring, the practice of sowing the seed in the autumn has been recommended, thus securing an earlier growth.

Several varieties of the non-saccharine sorghums have been grown, to some extent, as fodder crops in different parts of the United States for years. They are known by many names. There are several varieties of Durra, spelled also in three or four other ways. Some of these are grown in enormous quantities in Africa, India and China, where the seeds are a staple food of multitudes of men.

Under such names as Millo maize, Guinea corn, Egyptian corn, Jerusalem corn, different varieties of these non-saccharine sorghums have been introduced, and extravagantly praised, both as seed and fodder-producing plants. No one of them has come into common or continued use in this country, except in some of the Western States, in parts where the rain-fall is not always sufficient for the safe culture of corn. For such regions they promise to be very valuable. The yield of the seed, which is a valuable food for any class of stock, is often equal to that of corn in the same region, and the fodder is valuable. They are sometimes sown broadcast, and treated as a hay crop, or may be planted in drills and cul-

tivated. When cut early for summer feeding, some varieties will give a second crop.

Millet.—Several varieties of millet are grown to a limited extent as hay crops or for a soiling crop. There is much confusion as to the common names. Hungarian grass (*Setaria Italica*) is probably the most generally known. The German millet is larger and coarser in stalk and leaf, and requires a longer time to come to maturity, but yields more abundantly. Some varieties have been cultivated for centuries in Europe and in parts of Asia. They were brought to this country at a comparatively early period and have been generally tried. In no part of the older settled portions of the country are they largely grown and it is not probable they will ever increase much in popularity for these regions.

The crop is so well adapted to hot climates and withstands drought so well that it is probable the larger varieties will be somewhat largely grown on the western plains, where they are now cultivated to a fair extent. They are worthy of attention as minor crops in the great grain-growing regions, especially where the soil is light and well drained. The crop is not well adapted to heavy clay or wet soils, nor to a cold climate. It should not be sown until the soil has become warm. With a very moderate supply of moisture it grows rapidly. In from six to ten weeks after sowing the crop may be harvested. On good soil from three to five tons per acre may be cut.

The seeds are nutritious, but sometimes not well digested when fed to cattle or horses. There is a largely unfounded prejudice against feeding the crop. Sometimes excessive feeding has produced bad

results and probably the short, stiff hairs or bristles so abundant about the heads may cause injury in some cases. If cut before the seeds have ripened hay of good quality is secured.

A recommendation of millet is that it may often be grown as a "catch crop," following a crop of wheat or one of rye which has been grown for pasturage or soiling. The millet may be removed in time for a fall sown crop of grain. Millet also does well sown on prairie sod when first broken.

If sown for hay from half a bushel to one bushel per acre may be sown. If the grain is the chief consideration from one to two pecks per acre will give better results than thicker seeding.

Rye.—Rye, which has been treated of as a grain crop, is a favorite crop in some regions for soiling and also to be used for fall, autumn and early spring pasturage. It does well on almost any soil, is little liable to injury by freezing and thawing in winter, often makes a good growth in the fall, giving good pasturage for four or six weeks, and is among the very first of soiling crops to be ready for cutting in the spring, or it may be pastured for a time in the spring and give a fair yield of grain.

Comfrey.—The prickly comfrey (*Symphytum asperinum*) has been brought to this country from Europe more than once, and introduced with extravagant praise. It has not come into more than the rarest use and it is not probable it will become generally popular. It is a coarse growing, fleshy stalked, broad, coarse leaved plant, producing large crops. It is very hardy, of easy cultivation and perennial. On the grounds of the Illinois Experiment Station neg-

lected plants make a vigorous growth annually although growing in a thick blue grass sod.

Farm animals usually do not like the plant, rarely eating it voluntarily until accustomed to its use by having it mixed with other food. It is believed there are more valuable plants for cultivation by farmers in this country. It is not suited for pasturage and not especially for ensilage.

It is readily grown from small slips from the roots. These may be planted in rows far enough apart to permit cultivation, for the first year, at least.

Rape.—Rape (*Brassica napus*) is a plant of the turnip kind, but has not the enlarged root of the edible turnips, and is grown for its seeds and stalk and leaves. It is prized in parts of Great Britain and the continent of Europe, and is well spoken of in reports from the Ontario Agricultural College. It has been tried to a limited extent in the United States but has not come into practical culture. It is, probably, much better adapted to a cool and moist climate than to one with hot and dry summers. It grows rapidly, can be sown in the very late spring or early summer, either broadcast or, better, in drill rows and cultivated. The crop can be cut and fed at the stables or used for the pasturage of sheep or calves. Cattle like it well but injure the crop by trampling it. The crop is not injured by moderate frosts. It seems worthy of further trial, especially in the more northern states.

CHAPTER XXI.

THE POTATO.

History.—The potato (*Solanum tuberosum*) is one of the few food plants of great value to the world which was native to America. It has been found growing wild both in South and North America, from Chile to New Mexico. It had been cultivated in a rude way by the natives of parts of South America before the discovery of the continent by the Spaniards. It is not certainly known that it had been so cultivated in what is now the United States. It is thought it was introduced into some of the early settlements by the Spaniards, who also took it to Europe, probably about 1550. It was grown in a very small way in several countries in the west of Europe, but attracted little attention until near the end of the sixteenth century. Sir Walter Raleigh took some of the tubers to England in 1586 and brought them to the attention of Queen Elizabeth.

The culture of the crop was a long time in becoming general. It was first grown largely in Ireland. It is scarcely more than one hundred years since its culture became general in the west of Europe. Even in America it was long in attracting the attention it deserved. It is now largely grown in many parts of the civilized world. Although best adapted to a temperate climate, it is grown in tropical regions and also very far north. Next to the cereals it is the most important food plant for man.

While there are many varieties and great differences

between them, it is not believed there have been any radical changes in the potato since its cultivation became common.

The name potato is probably derived from *batata*, the name by which the sweet potato was formerly known. It is often called "Irish potato," probably because of its general cultivation by the Irish people.

Production.—The average acreage on which potatoes are grown in the United States is not far from 2,250,000. In some years it has exceeded 2,500,000. The crop has not reached 200 million bushels more than two or three times. The crop of 1891 is the largest ever grown, the best estimates placing it at about 225 million bushels. The average yield per acre, for 1891, is placed at ninety-four bushels. The average for a series of ten years was only seventy-six bushels. It has never reached 100 bushels for the whole country, although the average in some states has frequently been above this figure. Yields at the rate of 1,000 bushels per acre have been recorded, and reports of crops of from 400 to 600 bushels per acre are not infrequent. A yield of 150 to 200 bushels per acre is to be considered good. New York, Pennsylvania, Ohio, Illinois, Iowa and Kansas are the chief potato states, but not always in the order given. In 1888 these states produced a little more than half the crop of the whole country. New York is easily first in acreage and yield. In 1888 it produced more than one-seventh of the total crop.

While the average price per bushel for a series of years has been only fifty cents, the value per acre of the potato crop is greater by far than that of any of the cereals, and is only exceeded, among the chief

crops of the country, by tobacco. The cultivation of potatoes does not increase so rapidly in the United States as does that of other leading crops. In ten recent years the increase of acreage was about 25 per cent.

Germany is the greatest potato-growing nation of the world. Russia, France and Austria each produce much larger crops than do the United States. Great Britain and Ireland, with a less acreage, also have a larger annual product than does this country. The crop of 1891 is believed to have been larger in Europe and America than that of any former year.

Uses.—The potato is chiefly used for human food, but a large part of the crop is also used as food for cattle and hogs. The refuse potatoes in many countries are fed to farm animals either cooked or uncooked, and sometimes the whole crop is so used if the price is especially low.

Great quantities of starch are made from potatoes in this and other countries. Sometimes sugar or syrup is made from the starch. Considerable quantities of intoxicating liquor are distilled from potatoes in some countries.

Potatoes are healthful, palatable and fairly nutritious as food for man. They have a large percentage of water. The chief defect for food is in the small percentage of albuminoids. The potato is not well adapted to be the exclusive diet of man. In parts of Ireland it has been so used at times.

Varieties.—The number of varieties of the potato is very great and is rapidly increasing. As in other somewhat similar cases there is confusion in regard to names. Varieties, which are much alike, are some-

times called by the same name, while one variety, or potatoes practically alike, may be known by several names. The difference between varieties is often marked. The habit of growth of the plant; the size, shape, color, flavor and texture of the potatoes; the number produced, and the time of maturing, all differ.

New varieties are obtained by planting the seed produced abundantly by some varieties and sparingly, or not at all, by others. Seed from the same ball may produce varieties much unlike, or they may considerably resemble the parent variety. For the last quarter or third of a century much attention has been paid to the production of new varieties by cross-fertilization of the flowers. In this way desirable qualities of two varieties are frequently combined. Many thousands of varieties have thus been produced by single experiments.

One of the first to give especial attention to the production of new varieties in the United States was Rev. C. E. Goodrich, of Utica, N. Y., who began the work nearly fifty years ago, and produced and tested nearly 15,000 seedlings. He obtained several varieties of potatoes from Chile and other South American countries. Few of the varieties produced by him were especially valuable, but from some of them, seedlings were produced which became very popular. In later years large sums of money have been paid for new varieties.

It is noticeable that no variety of the potato has long retained popularity in this country. Probably no variety grown fifty years ago is now cultivated. The Early Rose retained wide popularity for about twenty-five years, and is still largely grown. The

Beauty of Hebron and Early Ohio are other examples of varieties which have been popular favorites over much of the country for a considerable number of years. In many cases varieties have been introduced, highly praised, widely disseminated, largely grown, and then dropped out of favor within a half-dozen years. Few varieties brought from Europe have done well in this country. Some American varieties have become popular in Great Britain.

In the opinion of many it is impossible to long cultivate any variety without some deterioration in quality, hardiness or productiveness. Other successful growers believe that the general deterioration is the result of lack of care in selection or poor cultivation.

Among the qualities desired in a variety are, vigor of growth and abundant leaf surface of the plant; the production of tubers of uniform size and shape, either round or oval, and free from protuberances, with comparatively few "eyes," and these shallow. Potatoes with a bright, light color are most attractive, but some of the best varieties have a dark and unattractive skin. In quality dryness and mealiness, when cooked, are important points. Some of the most popular varieties have no decided flavor. Early maturity and productiveness are most desirable qualities, rarely united in any remarkable degree in one variety. Generally varieties producing tubers of very great size are not of first-class quality. Single tubers, weighing two or three pounds each, have been produced, but those weighing not more than one-half pound each are usually preferred.

Culture.—The potato does best in a cool and moist climate. The average yield per acre is greater

in the northern than in the southern states; and greater in Canada or Great Britain than in the United States. It can be grown in the far north, but the yield is small and the quality poor.

The crop will do fairly well on a large variety of soils, but best on the light, warm and well drained, naturally fertile or well manured. Large crops of potatoes of excellent quality are grown on some sandy soils with little natural fertility, by the liberal use of manure. The dark colored prairie soils, so well adapted to the production of corn, is not the best for potatoes. Planting on land which has been in grass or clover is a favorite practice with many farmers. Well rotted stable manure is the cheapest fertilizer in many parts of the country. The so-called complete artificial manures are largely used in the older potato-growing regions. While a potato crop requires much potash, the application of manures containing much potash often gives less satisfactory results than when superphosphates are used.

Securing a good condition of the soil is as important as for almost any other crop. Fall plowing is preferred by many. Disk harrowing and the use of the roller, or some other clod-crushing implement, is advisable.

Early planting generally gives the best results. The date will vary with the region of country, but they may safely be planted as soon as the soil can be put in good condition and danger of severe freezing is past. The crop is best adapted to a moist, cool climate; drouth injures it much, especially while the plants are young.

With few farm crops are there greater differences

in practice, so far as thickness of planting and quantity of seed is concerned. The habit of growth of different varieties is to be considered. Usually the largest yields are secured from rather thick planting. In field culture the rows may be from two and one-half to three feet apart, with the potatoes dropped from one foot to eighteen inches apart in the row. Sometimes they are planted in hills so as to permit cultivation each way.

The weight of evidence from a very large number of experiments is in favor of the use of medium sized tubers, cut into pieces with two or three eyes each, leaving as much as possible of the potato on each piece. Large yields of excellent potatoes have been secured by planting small pieces with single eyes, or from planting very small potatoes. Planting large potatoes uncut frequently secures a large yield, but often the average size of the potatoes is reduced. The large quantity of seed required is a sufficient objection to this practice. Many successful potato growers use small potatoes and claim that no loss is sustained in either quantity or quality of the produce, even if the practice is continued for years.

Hand dropping is the most common practice, although there are machines which do the work well if the potatoes or pieces used are of fairly uniform size. Moderately deep planting is recommended, especially on dry, sandy soils. Planting in trenches in which manures are spread, and only partially filling the trench at first, has given good results in many cases. Level culture is better than "hilling up" for most soils. Hand hoeing may be made very effective but is costly. In good soils there is little need of deep cultivation;

deep and close cultivation after the tubers have begun to grow often does harm. Keeping the soil free from weeds and the surface loose are the points desired. The implements used and the frequency of cultivation differ greatly in different regions.

Harvesting.—Potatoes may often be left in the ground until there is danger of frost, but it is safer to harvest them as soon as they have thoroughly ripened. There are several machines for harvesting the crop, which answer the purpose fairly well. Some simple and low-priced ones are somewhat like a sub-soil plow, with rods running back from the shovel, between which the earth passes while the potatoes are carried to the surface. Other machines are larger and more complicated.

In all cases the potatoes must be picked from the ground and sorted by hand labor. The sorting is best done in the field. The potatoes may at once be placed in barrels or boxes, in which they are kept until sold, or they may be stored in bins or pits in the ground. A dry, cool place, with as little change of temperature as may be, is essential to their best preservation.

SWEET POTATOES.

The sweet potato (*Convolvulus batatas*) L., is of uncertain origin. Dr. Candolle gives the preference to America, but admits the strength of the arguments in favor of an Asiatic origin. It was taken from America to the south of Europe by the Portuguese or Spaniards. It is now largely grown in the warm climate regions both in the new and old world. In parts of the southern states it is more common than the white potato. It can be successfully grown in the more

northern states, but is not an important crop north of the fortieth parallel.

It does best in sandy or loam soil, but good crops may be grown on well drained clay soil. When the soil is quite loose there is a probability that the roots will grow long and slender. To check this, shallow plowing, leaving a compact sub-soil, is often advised.

The crop is grown from sprouts or sets, produced abundantly by the roots when they are placed in hot-beds. These are set in ridges or hills; when grown as a field crop in the central states the ridges are preferred. These may be made by throwing two furrows together with a common plow, after the soil has been put in good condition. It is helpful, but not essential, to finish the ridge-making with the hoe. Narrow, sharp-topped ridges are preferred. They may be three to four feet apart. The plants are put twelve to eighteen inches apart in the ridges. In dry weather it is helpful to "puddle" the roots before planting, but this is not essential if the ground is fairly moist. A mason's trowel is an excellent tool for use in making the holes for the plants, which are put in before the trowel is withdrawn. The soil should be well firmed about the plants.

Often little cultivation is needed. A large, single-shoveled plow may be run between the ridges or hills; the weeds being removed from between the plants with the hand hoe.

If the plants show much tendency to send out roots at different places they should be lifted or moved occasionally. Often the surface is completely covered by the vines and leaves. On the other hand, a fair

crop of the potatoes is sometimes produced when the tops have made but small growth.

The crop should be harvested before frost. If frost unexpectedly comes the vines should at once be cut close to the ground.

The sweet potato requires more careful handling than the common potato. It should be well dried before being stored, and must be kept warmer than is desirable for the common potato.

Under favorable conditions the yield is enormously large; the average yield is greater than that of the common potato.

CHAPTER XXII.

ROOT CROPS.

The cultivation of root crops for use in feeding farm animals has long been advocated by intelligent farmers, practiced by a considerable number with satisfactory results, but has never become common over any considerable area in the United States. In Great Britain and in parts of the European continent root crops are very largely grown; often one-fourth or more of the cultivated area of farms of large size will be in roots. In parts of Canada their cultivation is more common than in the United States.

Large crops of either of several kinds of roots can be grown; they are palatable and healthful food for all classes of farm animals. While all are watery the total yield of dry matter is large. The long winter feeding season over much of the country makes some succulent food very desirable. These and other points in favor of extensive field culture of roots have been urged for many years, but without effecting general practice.

The climate of the United States is not the best for root crops of any kind. They do best in cool and moist climates. Their most successful culture requires a good deal of hand labor, which is relatively high-priced in this country. The ease, certainty and cheapness with which food for live stock can be secured by the growth of Indian corn is a chief reason for the lack of popularity of root crops for stock feeding. The growth of the practice of preserving corn in silos,

thus securing it in a succulent state for winter use, removes a chief objection to it and makes it more nearly supply the place of roots. On many American farms corn takes the place in the rotation of crops occupied by roots in Great Britain.

The severity of American winters in the Northern States prevents the practice of out-door feeding roots and makes their preservation more difficult. The large percentage of water in the roots almost makes them less desirable as food in very cold weather. More than 100 pounds of turnips are sometimes given daily to a fattening ox in Great Britain.

BEETS.

The beet (*Beta vulgaris*, L.) has long been grown for human food. For more than two hundred years it has been grown in England as food for farm animals. There are very many varieties, differing much in form, size and percentage of sugar contained in the juice. In general the larger growing varieties are coarser textured, have a larger percentage of water, and much less sugar than the small varieties grown for human food or the manufacture of sugar.

Some of the larger varieties of what are called sugar beets are extensively grown for stock feeding and sometimes reach a great size, but the mangel-wurzel, sometimes written mangold-wurzel, is more commonly preferred. This is believed by many to be simply a modification by culture of the common beet.

There are a number of varieties of the sugar beet for stock and very many of the mangel-wurzel. The most striking difference, aside from color, is in shape. Some are long, others oval. Those of the latter shape are generally of better quality, but the long varieties

frequently give the larger crops. Single roots weighing sixty pounds and crops of nearly one hundred tons to the acre have been produced under favorable circumstances. In this country crops of twenty-five to thirty tons per acre are not uncommon, without especially favorable circumstances.

Culture.—All varieties of beets do best in rich, loamy or sandy soils. They do not thrive on wet or very compact soils. Liberal manuring with well rotted stable manure is a safe practice unless on very fertile soils. Fairly deep plowing is desirable, except on naturally loose soils. Getting the surface finely divided and moderately compact is desirable.

Planting should be done fairly early, before rather than after corn planting. A fair degree of moisture is needed to insure germination. Dry weather while the plants are young greatly retards growth.

The seeds may be put in rows from fifteen to thirty inches apart. When the ease of cultivation is of more consequence than the area of land used, the wider planting is advisable. Five or six pounds of seed per acre are required. They may be sown with a seed-drill or dropped by hand—a slow and tiresome process. They should be covered from one to two inches deep, unless the soil is quite moist. If the soil is dry, compacting the soil about the seed by the use of a roller is desirable. In some cases the seed is soaked in water for twelve to twenty-four hours before planting.

Hand hoeing is often necessary while the plants are small; afterward the culture may be chiefly by horse cultivators. The plants should be thinned to single plants from eight to twelve or more inches

apart, according to the size of the variety grown. This thinning may be done in part with a hoe, but hand picking is necessary to some extent. Sometimes thinning is delayed until the roots have grown to a diameter of a half-inch or more, when they can be pulled and fed to cattle or pigs.

Harvesting.—Beets may be left in the ground until there is reason to expect the approach of frost. The tops may be cut with a hoe, but it is safer to have them twisted off by hand, as cutting the top of the beet increases the probability of its rotting. Some varieties grow with a large part of the root above the surface and can easily be pulled. With others it is better to loosen the roots by plowing a furrow close to them, throwing the earth from the row. The roots may be laid on the ground or at once carried to the place in which they are to be stored. The leaves have some value as food for stock. They may be fed green or preserved in silos.

Beets are easily injured by frost. They may be stored in cellars or in out-door pits. Except for regions in which the weather is very cold in winter, pits are preferred to cellars by many. They are best made long and narrow, with divisions of earth at frequent intervals, so comparatively small quantities only are exposed to the air at any one time. When extreme cold weather is to be expected, cellars or houses especially constructed for the purpose are essential. The roots should be dry when stored and it is well to have ventilation for the cellar, except in extremely cold weather.

TURNIPS.

Turnips (*Brassica*), one of many varieties and sev-

eral species. Those most commonly grown as food for stock are some of the many varieties of the common turnip, *Brassica rapa*, L., and the larger, coarser ruta-bagas or Swedish turnips, *Brassica Campestris*, L. The turnip is of European origin. Some species have long been cultivated in Europe and parts of Asia. The field cultivation of turnips as food for stock was introduced into England from the continent about 1650, and made great changes and improvements in British agriculture.

A moist, cool climate is best for turnips and the crop is especially subject to attack by insects. The uncertainty of securing a good stand of the plants; the small percentage of solid matter and consequent low feeding value, compared with bulk and weight, and the impracticability, in most parts of the United States in which the summer climate is suitable, of having the crop eaten, where it grows, by sheep, a common practice in England, have all tended to prevent popularity of the crop among American farmers generally.

Culture.—The largest and best crops are grown where the seeds are sown in drills far enough apart to permit cultivation. But in many parts of the country, especially where the land is comparatively low-priced, broadcast sowing is more commonly practiced.

The seed may be sown in July or August, sometimes in the early part of September. Ruta-baga seed should be sown earlier; in June or early in July. The soil should be finely pulverized. For the flat or globe-shaped varieties deep culture is not necessary. The seed should be very slightly covered. It is desirable to sow while the soil is moist. Dry weather at

the season at which the seed should be sown is often the cause of a poor stand of the plants.

The crop is sometimes sown among the standing corn, soon after the last cultivation, especially when it is expected to cut and remove the corn comparatively early in the autumn. It may follow wheat or other small grains, or a crop of early harvested potatoes. When the soil is naturally loose the surface should be compacted with the roller before or after seeding.

The harvesting and storing of the crop is much the same as with beet crops. Turnips are less injured by freezing than are beets.

Cattle and sheep usually eat turnips readily. Horses and hogs care less for them. Feeding large quantities of turnips to dairy cows sometimes gives an unpleasant odor to the milk.

CARROTS.

The carrot (*Daucus carota*) is much liked by many as food for horses, and is relished by most farm animals. It is especially liable to injury by dry weather and its early growth is slow and feeble. Careful hand labor in weeding the young plants is usually necessary. This is a chief obstacle to its growth by farmers generally. It gives large yields, 500 to 700 bushels per acre often being harvested. It is less easily injured by frost than are beets. It does not require so rich land as the beet. The methods of culture and storing the crop are much the same as those found best for beets. There are many varieties. The long orange and the white Belgian are popular varieties.

PARSNIPS.

The parsnip (*Pastinaca edulis*) has a pleasant flavor, is well liked by stock, is especially recommended for dairy cattle. Unlike most other roots it is improved rather than injured by freezing, and may be left in the ground until spring.

Its culture is the same as for the carrot. The seed should be sown early in the spring. If the ground is dry, soaking the seed before sowing is advisable.

JERUSALEM ARTICHOKE.

The Jerusalem artichoke (*Helianthus tuberosus*, L.) is a coarse, strong growing species of sunflower, producing tubers which resemble potatoes in size and shape. The plant is almost certainly of American origin. It was cultivated both in America and Europe at least two hundred years ago. The word Jerusalem in the name is said to be a corruption of the Italian name for sunflower. It is supposed to have been called the artichoke from some likeness of flavor of the tubers to that of the true artichoke.

Extravagant claims as to the value of this crop as food for stock, especially hogs, have often been made. The tubers are offered for sale by most seedsmen. The plant is entirely hardy, easily cultivated and gives enormous yields of tubers, well liked by hogs.

Once established the crop continues to occupy the ground year after year. But probably not one farmer in ten thousand in the United States has cultivated the crop, and many who have tried it have abandoned it. It is not probable this tuber will ever be commonly grown, but there is so little cost in caring for it that it may be well to grow it on a small scale.

The tubers may be planted in the same way as potatoes, as early in the spring as is convenient. The rows should be three to four feet apart. The crop can be cultivated in the same way as corn until the stalks have made a fair growth. The food value of the tubers is low, and often it is not profitable to dig the crop and store the tubers. The stalks may be cut with a mowing machine and the tubers plowed to the surface and eaten by pigs turned in the field. Hogs will dig them from the ground. They are not injured by frost. Usually enough of the tubers are left in the ground to continue an abundant growth the next season. The surface may be leveled in the spring, and, after the crop has fairly started to grow, by the use of the plow or cultivator the plants may be killed, except in rows. Farmers have often complained of the difficulty in getting rid of the crop, while it has given little trouble to many others when the land was planted with some other cultivated crop.

There are several varieties, differing in size, color and shape of the tubers, but little attention has been paid to selection or improvement of the tubers.

CHAPTER XXIII.

SUGAR PLANTS.

The use of sugar as an article of diet is almost entirely modern. As an ordinary food its use was nowhere common for one hundred years after the discovery of America. It came into use in the sixteenth century in connection with the use of tea and coffee. The annual output of sugar in the world during the five years, 1885 to 1890, is estimated at rather more than five million tons.

The plants from which sugar is made, maple trees excepted, have been cultivated from very remote times. The plants which produce sugar (sucrose) are beets, sugar cane, sorghum, the date palm and sugar and other maples. A large number of the fruits contain sugar but it is not extracted for commercial use.

More sugar is made from date and similar palms than from sorghum. Fifty years ago almost all the sugar was made from sugar cane. There is now more sugar made from sugar beets than from sugar cane.

Sugar is produced in the United States from cane, sorghum, beets and the sap of maple trees. It is principally made from cane. A good article of syrup has been made from watermelons.

The United States produce about one-twentieth of the world's supply of sugar. Louisiana is the principal sugar-producing state.

An act of Congress taking effect July 1, 1891, provides that for fourteen years a bounty shall be paid to persons producing more than 500 pounds of sugar

annually from beets, sorghum, sugar cane or maple sap. Two cents a pound is paid on sugar containing not less than ninety per cent. of pure sugar and one and three-quarters cents on that containing not less than 80 nor more than 90 per cent. of pure sugar. Under this law there are 4,770 licensed sugar producers, of which 4,025 produce sugar from maple sap, 731 from sugar cane, 8 from beets and 6 from sorghum.

SUGAR CANE.

The cultivation of sugar cane (*Saccharum officinarium*) is very ancient. It was known to the Chinese and to the people of India in very remote times. It was cultivated in the countries bordering the Mediterranean in the Middle Ages and sugar was made from it. The manufacture of sugar did not become commercially important, however, until the sixteenth century, at which time the plant was introduced into the West Indies.

It is estimated that the annual production of sugar from cane during the five years, 1885 to 1890, was about two and one-third million tons. The United States produces one-quarter of a million tons.

A ton of sugar cane may produce from 150 to 300 pounds of sugar. The average in Louisiana is probably somewhat over 125 pounds, with one-half to two-thirds as many pounds of syrup. There has been great improvement in the methods of sugar-making in the past decade, and consequently in the number of pounds of sugar obtained from a ton of cane. A variation of from ten to forty tons of cane per acre is not extraordinary. An acre of cane may, therefore, produce from 1,000 to 8,000 pounds of sugar.

Structure.—The sugar cane belongs to the grass family. It resembles Indian corn somewhat in its general appearance and growth. It may grow six to fourteen feet high according to soil, climate and variety. The stalks of some varieties attain a diameter of three inches and weigh twenty-five pounds. Louisiana cane as it goes to the mill is from three to eight feet long and may weigh from one and one-half to eight pounds.

In some varieties the joints are but two or three inches in length. In others they are eight or nine inches in length. In the axil of each leaf or at each joint there is a bud. The upper joint, called the "arrow," may be four to five feet long and may be terminated in a panicle of flowers 18 to 20 inches high, which frequently produce seeds. In cultivation the canes usually do not flower. Recently it has been found that the seed from cane will germinate and many hundred new varieties have been produced by this means.

According to Stubbs, average Louisiana plant cane will contain about 77 per cent of water, 12.5 per cent sucrose, .7 per cent glucose, 8.5 per cent fibre and 1.3 per cent of other solids. Sugar cane may contain 18 to 20 per cent of sugar. Unripe cane may contain considerably less sucrose and more glucose. The latter is not only a loss in itself but it prevents an unknown quantity of cane sugar from crystallizing. The quantity of sugar available also varies with the method of extraction. Seventy per cent may be considered a good average.

Like Indian corn sugar cane is very much modified by the conditions under which it is grown. There are,

therefore, many varieties. Probably the most striking variety characteristic is the color of the cane, which may be green, red, purple or yellow, or combinations of these.

Climate.—Sugar cane is a “Child of the Sun.” It is cultivated in the tropics of both hemispheres. Southern Louisiana is about the northern limit of its successful culture. It seems to reach its best development on islands and sea coasts; hence in a moisture-laden atmosphere. Cold is detrimental.

Soil.—Sugar cane may be raised on any fertile soil with proper drainage and tillage. A soil suitable to the growth of Indian corn in a sugar cane climate will grow cane successfully. An excess of humus produces a large yield at the expense of sugar content. Fresh soils are not quite so good as those which have been cultivated somewhat.

Systematic manuring is not generally practiced. The waste products—leaves and bagasse, are more or less completely returned to the soil. Where fuel is scarce the bagasse is burned and only the ashes are returned.

Sugar comes from the air and not from the soil. If only the sugar was removed the soil would not decrease in fertility. Molasses contains some soil elements, principally potash.

Experiments show that green manuring with cow peas and other leguminous crops is beneficial. A rotation including these crops may be more profitable if they can be economically used.

Nitrogen and phosphoric acid are more valuable than potash for the production of sugar cane. An excess of nitrogen decreases the sugar content.

Culture.—Sugar cane is reproduced by cuttings. The upper part of the cane contains much less sugar than the lower part and is considered, if anything, superior for planting.

Methods vary. The seed-bed is prepared about as for Indian corn. The land is laid out with a plow into furrows from five to seven feet apart and six to ten inches deep. Sometimes holes are dug by hand. Into these furrows canes are laid end to end, slightly over-lapping. Two or more may be laid side by side. When two canes are laid side by side it takes four tons of cane to plant an acre. The canes are cut into convenient lengths for handling before planting. It is not essential to the growth of the cane.

In Louisiana it is considered good practice to plant thin enough to allow the plants to stool or tiller freely. An acre may produce from 15,000 to 45,000 canes.

After the cuttings are planted, they are covered with a couple of inches of loose earth. As the plants grow the earth is gradually filled in about them until the ditch is full and the soil is hilled or banked up about the plants. This is supposed to help the canes to maintain an erect position.

The planting may be done in the fall, winter or spring.

A field once set in cane may remain many years, each succeeding crop giving a decreasing yield of sugar. The rapidity of the decrease depends largely upon the locality. The length of time it is desirable to maintain a field without replanting will depend upon the rapidity of the decrease and the cost of planting. In Louisiana it is considered good practice to replant about one-third of the land annually.

Cane is ground during November and December. The remaining leaves are removed and the tops, with a couple of the upper joints, are discarded. This is usually done in the field. Where there is danger from frost the canes are often thrown in a windrow, so that the tops cover the lower parts of the canes just in front of them.

The manufacture of sugar may be simple and with comparatively inexpensive machinery, but for the best results, both in quantity and quality, an extensive plant, large capital and much skill and technical knowledge is required and cannot be described here in detail. In brief the steps are about as follows:

The juice is extracted by some form of pressure, which ruptures the cells and allows the juice to escape, or by diffusion, in which the juice flows out of the cells on the same principle that it flows from one cell to another. The juice is then purified by heat, chemicals and filtration. The surplus water is next evaporated and the thickened syrup set away in a proper temperature, when the sugar crystallizes. The molasses may then be allowed to drain away through openings in the bottom of the receptacle, such as a hogshead, or the molasses may be extracted by placing the massicute in a rapidly revolving cylinder, whose sides are a sieve which allows the molasses to escape, but retains the crystals of sugar.

The result is a soft sugar of a varying color from brown to white and varying in purity, according to the skill in manufacture and the completeness with which the molasses is extracted. These processes are usually performed on the plantation; the subsequent refining, frequently at some distant refinery.

Nearly all the sugar now made in Louisiana is refined during the process of manufacture on the plantation.

SORGHUM.

Sorghum (*Sorghum Saccharatum*) is the only agriculturally important plant which has been introduced into the United States since the American Revolution. It was introduced about 1845 from China and was widely distributed during the decade prior to the war between the states.

Since that time it has been somewhat extensively grown in a secondary way for the production of molasses. It has been grown in China many thousands of years for its seed, which is used for food both for man and beast. It is claimed that it has never been used there either for syrup or sugar. Broom corn, Kaffir corn, Millo maize, Doura, etc., are non-saccharine varieties of sorghum.

In 1879, 28 million gallons of sorghum molasses were produced in the United States. This was nearly twice as much as cane molasses and nearly twenty times as much as of maple syrup. The production of sorghum molasses has probably sensibly declined since that time.

Prior to that time but little sugar was produced from sorghum and but little systematic effort was made to produce it. During the past decade the subject of producing sugar from sorghum has been thoroughly studied and several plants have been established in different states for its manufacture. A considerable quantity of good sugar has been produced but the commercial status of the industry is still unsettled.

Assuming a favorable climate some of the difficulties have been:

1. A rather small yield of cane. The yield of cane has varied under normal conditions from about five to ten tons of clean cane per acre.

2. A low average percentage of sugar in the cane. The percentage of sugar is much more variable than in sugar cane or beets. The other solids are higher, thus making the per cent of available sugar still less. The total per cent of sugar in the juice of sorghum manufactured commercially has probably been considerably under ten per cent.

3. The rapid deterioration of the sugar in the sorghum from unknown causes usually considered climatic or from improper handling. Sugar cane may lie some weeks before it is used; beets may be stored for months; sorghum must be used at once.

4. Imperfect methods of extracting the juice.

5. Improper treatment of the extracted juice.

All these difficulties must be overcome before the manufacture of sorghum sugar can be a success. In the nature of the case the first three items are the most serious. The United States Department of Agriculture is still faithfully studying the subject.

Varieties.—Other things equal early maturing varieties are best. Later maturing varieties may be planted to produce a succession of cane. Early Amber and the Oranges under different prefixes have probably been grown as extensively as any other varieties. The former is probably the best early maturing variety grown. Link's hybrid is another well known late variety. The variety to plant will depend

very much upon the latitude, and requires special study in each case.

Improvement of sorghum by planting the seed of canes showing a high content of cane sugar is being attempted by the United States Department of Agriculture with hopeful prospects. The process is easy. There are two obvious difficulties, viz: (1) The variability of the sugar content apart from variety, and (2) the fact that the seed has been produced by cross-fertilization with pollen of an unknown plant. Here as elsewhere, the more highly bred the plants are, the less injury from the second source.

Climate.—Sorghum will grow anywhere where Indian corn will grow, but is better adapted to the warmer and dryer parts of the United States. The area for the production of sugar is restricted. Where the season is short the plant does not ripen sugar but will produce molasses. Sufficient time must elapse after the cane is ripe to allow it to be worked. The climate of Kansas and the Indian Territory is believed to be particularly favorable to the growth of sorghum as a sugar plant.

It stands drouth rather better than Indian corn. For this reason it is used in some localities for fodder in place of Indian corn. Experience teaches that the fodder is inferior to the latter.

Culture.—The soil and culture adapted to sorghum is similar to that of Indian corn. It grows slowly during the early part of its growth. Hence the necessity of a well prepared seed-bed.

Planting should be delayed until the soil and atmosphere is fairly warm, say ten days later than corn. It is usually planted in drills with the drill rows the

same distance apart as corn. The aim is to have the plants about twice as thick as for corn. It is usual to plant over twice as much seed, because it does not germinate so freely and evenly. If too thick it may be thinned when the crop is hoed.

As the plants start so slowly it is usually necessary to hoe the crop once or twice during the fore part of its growth, to keep it from being smothered by weeds.

After it gets started it grows rapidly. The cane should be cut when the seeds are in the hardening dough. For molasses it is usually topped and stripped of leaves by hand. At sugar factories the cane is cut up into pieces an inch or so long with the leaves on and the leaves afterward are removed with a fanning mill.

The seed has some value as a stock food. To be most economically used the seed should be siloed.

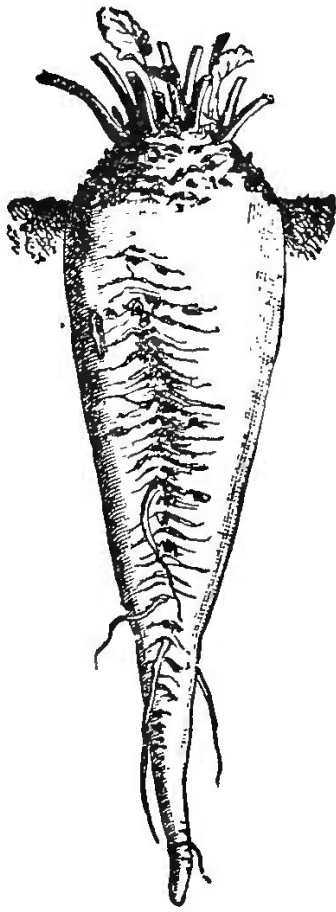
SUGAR BEET.

Sugar was first extracted from the beet in a German laboratory in 1747. It was not, however, until 1795 that sugar was manufactured from them. It was not until thirty years later in France and forty years later in Germany that the manufacture of sugar from beets became an established industry. It is estimated that during the five years 1885 to 1890—fifty years later—there were three million tons of sugar manufactured in Europe. Germany produces considerably more than any other country.

About sixteen tons of beets, containing fifteen per cent of sugar, was the average for Saxony in 1888. About 35,000 beets were grown per acre. Possibly 250 pounds of sugar per ton or 4,000 pounds per

acre could be recovered in manufacturing. This probably represents beet culture under its most highly improved condition.

The production of sugar from beets was first attempted in America in 1830. Since 1863 more or less continuous attempts have been made in various sections of the country. One factory in California has



VILMORIN'S
IMPROVED BEET.

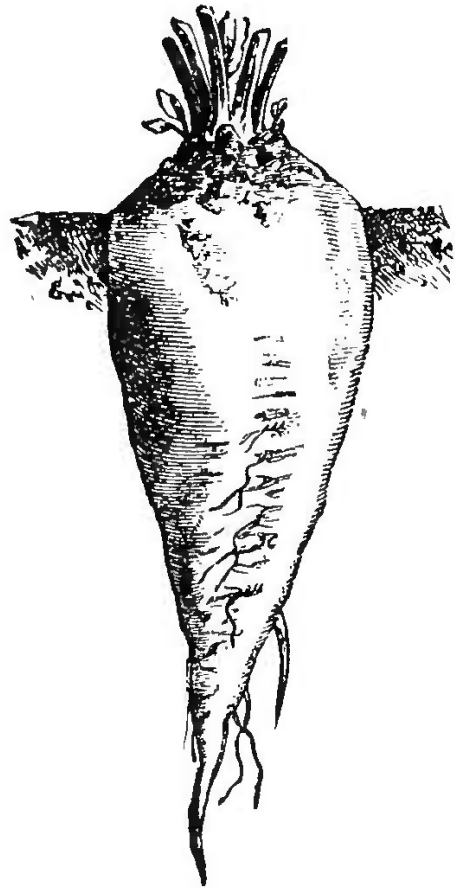
been running more or less successfully during the past few years and several others have recently been established. Attempts are now being made to introduce the culture and manufacture into Nebraska, Kansas and other states. The economical production of the beets is the main difficulty to be overcome. It is hoped that the manufacture of sugar from sorghum and beets may be profitably combined, although the best climatic conditions for each are not the same.

Varieties.—There were four varieties of the common beet (*Beta vulgaris*) known at the time the manufacture of sugar began, viz.: The small and large red, the yellow and the white. It was the white variety which was selected for the manufacture of sugar.

At the time the manufacture of sugar began the juice of the beet contained only six per cent of cane sugar. By subjecting beets to chemical and physical tests and only growing those for seed which had

a high percentage of sugar, varieties have been produced, such as Vilmorin's Improved, which produce regularly 15 to 18 per cent of sugar. This process has been aided by judicious cultivation and fertilization. The selection of "Mothers" of a known quality for the production of seed is systematically carried on. Cost of the seed is an important item in beet culture.

The essentials of a good variety are large yields, high sugar content, purity of the juice and keeping quality of the beets. The beet should have an even texture, smooth outline and symmetrical shape. The typical sugar beet should weigh rather more than a pound, contain 14 per cent of sugar, and 80 per cent of the total solids in the juice should be cane sugar. There is a tendency for the total yield of the beet to decrease with the increase in the per cent of sugar. Extremes in either direction should be avoided.



WHITE SILESIAN BEET.

The type of the sugar beet is to be seen in the White Silesian, which is the one from which all other varieties have been derived. It is the variety largely used in Europe. Vilmorin's Improved and Klein Wanzlebener are the two which have been most widely grown in this country.

It is not at all improbable that the beet sugar in-

dustry in America will not reach its fullest development until varieties have been produced by selection and cultivation which are adapted to the conditions of soil and climate of the country.

Climate.—The proper climatic conditions are very essential to the successful culture of the sugar beet. These are so complex as not to be capable of prediction with certainty in advance of trial. It has been found in general that an average temperature of 70 degrees Fahrenheit during the months of June, July and August, and a minimum rain-fall of two inches per month during these months, is desirable. This limits the area of profitable production east of the one-hundredth meridian to an irregular strip whose central portion lies mostly between the 42d and 44th parallels of latitude. According to this standard much of the Pacific States would be suited to the production of sugar beets.

These are not the only desirable conditions. Excess of rain in the autumn months is harmful. Early approach of severe cold weather is undesirable. In general, the comparatively dry and warm weather of July and August ripens the beets before they have obtained sufficient size, and upon the recurrence of growing weather in the latter part of August and in September the beets are apt to begin to grow again, in doing which the stored-up sugar is used.

Soil.—The area limited by climate is still further limited by the necessity of a proper soil. Depth of soil is essential to either large yield or high sugar content. The surface soil should be ten to twelve inches deep and the subsoil should be porous and either naturally or artificially well drained. The soil

should be friable, contain an abundance of lime and lie in such a way as to get the full exposure of the sun. Soils that have been in crops several years give better results than new soils.

For method of planting, culture and harvesting see chapter on Root Crops.

CHAPTER XXIV

FIBRE CROPS.

COTTON.

History.—The general cultivation of cotton is not very ancient as compared with that of wheat. In a limited way it was cultivated in southeastern India in early times. The clothing of the ancient Egyptians was made from wool and flax. Alexander the Great is supposed to have brought the culture and use of cotton to the notice of Europeans. It was found in cultivation and use from Mexico and the West Indies to Brazil and Peru when America was discovered.

The cultivation of cotton in the United States was very limited before the Revolutionary War. It is said that in 1784 eight bales of American cotton were confiscated in Liverpool on the plea that cotton did not grow in America.

Production.—The culture of cotton became one of the World's industries upon the invention of the cotton gin by Eli Whitney in 1792. In 1791 the yield of cotton in the United States was two million pounds; in 1801, forty-eight million pounds, while for the decade just closed the average annual yield has been three billion pounds.

The leading cotton producing states in the order of their importance are Texas, Mississippi, Georgia and Alabama. The cultivation per land surface is greatest in Mississippi. It is almost exclusively produced in ten states—the eight South Atlantic and Gulf States with Tennessee and Arkansas.

The acreage in cotton in the United States is now only exceeded by corn, wheat, hay and oats. It exceeds in value the oat crop. The following table gives the essential features of the crop of cotton of 1888:

Area, acres.....	19,000,000.
Yield, bales.....	7,000,000.
Value, dollars.....	292,000,000.
Yield per acre, pounds.....	180.
Price per pound, cents.....	8½.
Value per acre, dollars.....	15.30.

A bale of cotton containing 400 to 500 pounds is considered a good yield per acre. Over 2,500 pounds of cotton have been reported from a single acre.

The United States produces about half the cotton grown in the world. About two-thirds of it is exported in the raw state. Practically all the cotton of commerce is manufactured in Europe and the United States. The latter manufactures about one-fourth of it. The rest is about equally divided between the United Kingdom and the Continent.

Use.—The cotton plant is in many respects the most important upon the globe. It furnishes the clothing of the larger portion of the inhabitants of the world. It is subject to more extended and varied uses under the widest conditions of climate and civilization than is any other fibre. It is the most important article of trade.

The seed yields about fifteen per cent of its weight in oil, which is used as a lubricant in paints, for burning in mines and for making soap. The refined oil is used as a food directly or in butterine and lard and in place of olive oil. Although a perfectly desirable

and healthful article of food its use is unfortunately somewhat surreptitious.

The kernel after the oil is extracted is about 35 per cent of the seed and is the cotton seed meal or cake used in stock feeding. The cotton seed meal is also used as a fertilizer. It is the source of nitrogen in some commercial fertilizers. The hulls are used for fuel, fertilizer or food for stock. For cattle feeding they are worth about as much as rather poor hay.

Climate.—The culture of cotton is not only increasing both in the world and in the United States but the extent of its possible production is almost unlimited. It can be cultivated in all inhabited sections of the world lying between parallels of 36 degrees of latitude north and south. Therein lies the largest land surface of the globe.

It is now mostly cultivated between parallels 20 degrees and 35 degrees north latitude. In the United States it is principally cultivated between parallels 30 degrees and 35 degrees. Cotton requires hot, clear skies. Rainfall during picking season is very injurious. It, therefore, is more largely grown inland. North of the 35th parallel the seasons are too short for economical production. The plant requires four to five months to bring it to maturity, and then there should be two to three months without killing frost for picking.

Soil.—The area of production in the United States is somewhat restricted in practice by the nature of the soil. The soils mostly used are the river bottom soils, the black or cane-brake lands, the red lands, and the black rolling prairie lands of Texas. Mellow, friable soils which are easily worked by light machinery are

preferred. They should contain a good supply of vegetable matter and be well drained.

The lint contains but a trifling quantity of fertilizing material. For each pound of lint there are about two pounds of seed. The seed is about from one-eighth to one-fifth part of the plant and is rich in the precious elements. The seed is not injured either as a fertilizer or as a stock food by the extraction of the oil. If all the plant except the lint and oil is returned to the soil the loss of fertility by the sale of the products is trifling. The soil loses fertility by the oxidation of the vegetable matter in the soil during the hot summer months, and the washing away of the material thus made soluble during the winter months. The comparative bareness of the soil facilitates both these processes.

Varieties.—Cotton belongs to a family of plants, *Malvaceae*, which is entirely different from the cereals and grasses. Okra and hollyhock belong to the same family. There are several species of cotton, all of which are perennial. The cultivated species are treated as annuals.

The principally cultivated species is the common upland or short staple cotton, *Gossypium herbaceum*. It is a shrubby plant having alternate stalked and lobed leaves and a long deep tap-root. The flower is white or cream-colored on the first day, turns red on the second and falls on the third, leaving a small boll enveloped in the calyx. The boll is three to five celled and when ripe is the size and shape of a fowl's egg. When ripe it bursts open through the middle of the cells, liberating numerous dark colored seeds covered with cotton.

When planted in April it flowers in June. The bolls begin to open in August and continue until killed by frost in November. The cotton is picked by hand from time to time as a sufficient number of bolls become open to make it pay to go over the field. The most and best cotton is picked in September and October.

The Sea Island or long staple cotton, *Gossypium Barbadense*, is produced to a limited extent along the coast of South Carolina and Florida. It is characterized by a fine, soft, silky staple nearly two inches long. It commands a higher price than the upland cotton but does not usually yield as much per acre. This is more largely produced in the West Indies.

There are a great many varieties of these species and in some instances considerable care is taken to produce good varieties and to plant with seed of improved varieties, but in the majority of cases very little attention is paid to the kind or quality of the seed. The quantity of seed planted is enormous. From a bushel to three bushels, per acre, containing from 100,000 to 150,000 seeds per bushel, is a very general practice. The excess of seed is a valuable fertilizer.

Culture.—Land which has been in other crops is sometimes fall plowed, cotton land seldom. The depth of plowing varies greatly, but is often only two to four inches deep. Cotton is almost universally planted in ridges. Frequently the land is not previously plowed. Furrows are opened into which may be placed any rubbish or fertilizer as desired. Over these furrows the land is thrown into ridges by back furrowing. The distance apart of the ridges varies in extreme cases from two to seven feet. The richer

the soil and consequently the larger the growth of the plant, the further apart the ridges. Four to five feet is usual. Sometimes the space between the ridges is not plowed, after-cultivation being depended upon. Thorough preparation of the seed-bed, however, is desirable.

When the planting is done by hand a furrow is opened on the top of the ridge with a small plow, into which the seed is scattered in profusion. The seed is covered about an inch deep with a light harrow or a plank attached to the bottom of a small plow. Cotton planters are now used successfully which with less seed plant uniformly in straight rows—important conditions in the after-cultivation.

The time of planting varies with the latitude, the season and the soil, from the first of March to the middle of May. Much of it is planted in the first half of April. The richer the soil the later the planting may be postponed.

The germination is very variable. In general, about two weeks after the seed is planted the plants will be several inches high and have three or four leaves. It is then cultivated by plowing the land from the cotton, after which the cotton plants are chopped out with a hoe, leaving several plants in a place at distances varying with the nature of the soil and consequent growth of the plant. The distance may vary from ten to forty-eight inches, twelve to twenty-four inches being the most common distance. The plants are subsequently thinned to one or two in a place.

In the thinning the weeds or grass in the row are removed as completely as may be. At the next culti-

vation the soil is thrown to the row. Cultivation continues until the plants shade the ground, which is usually in the latter part of July. The early cultivation may be deep but the later cultivation should be as shallow as possible for thorough weed killing.

Practically all the cotton of the world is raised by colored labor.

FLAX.

The history of flax is contemporaneous with that of wheat. The clothing of the ancient Egyptians and Hebrews was largely made of flax, and its culture has been handed down with our civilization. Its culture was introduced into Europe in very remote times. Flax fibre is comparatively much less important than before the general introduction of cotton. The principal sources of supply are Russia, Germany, the Netherlands and Ireland.

The crop of 1891, which was probably the largest ever produced in the United States, was raised on a little less than two million acres, with an average yield of about eight bushels per acre. The acreage was about the same as that of barley, rye or potatoes. The crop is almost all raised west of the Mississippi River, it having traveled westward with the pioneer farmer. Minnesota and South Dakota are at present the leading states.

Flax is grown both for its fibre and for its seed, sometimes for the one, sometimes for the other, and sometimes for both. The seed yields twenty to twenty-eight per cent of oil of the best quality for use in painting. The residue, linseed meal, is used in cattle feeding, considerable quantities of it being exported.

The fibre is obtained from the bark of the plant

and consists of the long straight lint called flax and the short tangled fibre which separates in dressing from the long lint, called tow. Coarse tow is made by simply removing the remaining part of the stem, and baling the tangled mass. It is used in upholstering, in making twine, bagging, paper, etc.

Flax is almost entirely raised in the United States as a seed crop. In localities favorably situated coarse tow is produced. When not used in making tow the straw is allowed to rot, is burned, or stacked and eaten by stock. It is sometimes said to produce injurious results, although large quantities are eaten by stock without injury to them.

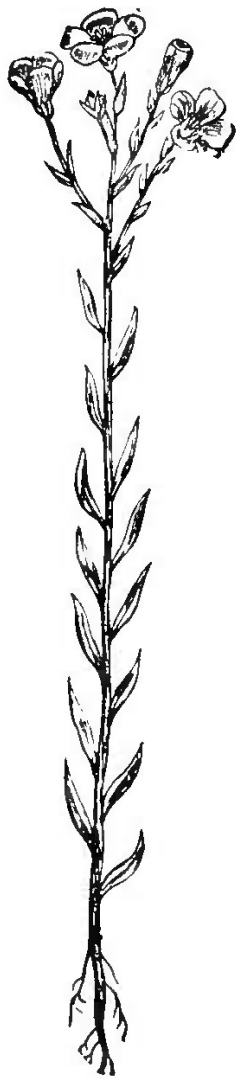
Flax may be grown in any climate where wheat is grown, but for the best production of fibre requires a continuously moist but not excessively wet climate.

In the United States it is a new land crop, especially in spring wheat regions, where corn is relatively less productive. This production has been sufficient to supply the somewhat limited demand for seed and tow. Sandy loams are rather better than clay loams, although any soil adapted to cereal crops will grow flax.

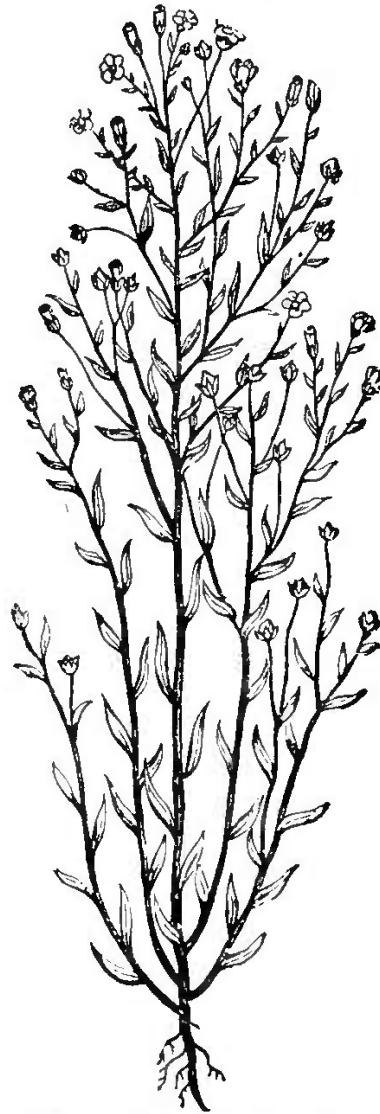
It has long been known that flax could not be grown continuously on the same land in some localities. This has recently been shown by Luggier to be due to some active principle in the plant which upon being absorbed into the soil is injurious to a succeeding crop of flax. At least five years should elapse before flax is again sown on the same land.

Flax (*Linum usitatissimum*) is a herbaceous plant, generally two or three feet high, with alternate, stemless, entire leaves. The blue flowers are produced in

clusters at the end of the branches. Each seed produces a single stem. Unlike the cereals the plant is much modified by the thickness of seeding. When the plants grow alone or thinly the stems produce many branches and consequently many seeds. When sown sufficiently thick no branches are produced ex-



THICK SEEDING.



FLAX PLANT GROWING ALONE.

cept at the top and but few seeds, but the fibre is of superior quality. When fibre is the chief object three to four bushels of seed are sown per acre, when seed only is desired two to three pecks. It is claimed that a satisfactory quantity of seed and fair quality of tow may be obtained by sowing six pecks per acre.

There are three varieties of flax: perennial, winter and summer flax. Of summer flax there are two types. In one the seed bolls burst open and scatter the seed, in the other they do not. Only the latter is cultivated to any considerable extent. Of course there are varieties of this type.

The culture of flax for seed is not essentially different from that of spring wheat. As the seeds are much smaller rather more care is needed in preparing the seed-bed and in distributing and covering the seed. It may all be done with ordinary machinery, however.

It is a pleasant crop to harvest with the self-binder. It is not readily damaged while standing in the shock. It may be thrashed with the ordinary thrashing machine.

When cultivated for its fibre, weeds growing in the crop reduce the value of fibre by their presence. It is essential that previous cultivation of the land be such as to free the land as much as may be from weed seeds. Where fine fibre is raised the crop is frequently weeded by hand. Sometimes sheep are employed, as they will eat the weeds and not the flax.

The harvesting, which is usually done by pulling the plants; the retting, or rotting, which is done in a running stream or stagnant pool, and the scutching to remove the shives or the parts of the plant not fibre, will depend upon the demands of the market for which the crop is grown and need not be described here.

HEMP.

Hemp (*Cannabis sativa*) a plant closely related to the hop and ramie, is a native of Western and Central

Asia, and has been cultivated from remote times in China.

It is now extensively cultivated in many countries for one or more of three purposes: (1) the fibre of its stems; (2) the resin exuded on leaves and stems; (3) and for its oily seeds. In some places it is grown chiefly for the resinous exudation, from which various intoxicating preparations are made. Five times the population of the United States get drunk on these preparations.

Hemp was one of the first plants introduced by the American colonists. It is now considerably grown in the United States for its fibre, from which cordage and coarse cloth are made. Hemp binding twine is becoming a regular article of trade. It has been chiefly raised in the blue grass regions of Kentucky, but it is now being raised in several northern states in connection with cordage and other factories, notably in New York and Illinois.

It thrives best in a temperate climate and on any soil adapted to Indian corn. Where the waste products are returned to the land it is not considered an exhaustive crop. In some places it is raised continuously for many years on the same land.

Hemp is a rough erect annual, eight to ten feet high, with male and female flowers on separate plants. The fibre is from the inner bark. The yield of fibre may be from 500 to 1,500 pounds, and of seed per acre ten to thirty bushels.

It is usually sown broadcast at the rate of four to six pecks per acre between oat sowing and corn planting. It fully subdues all weeds.

The harvesting depends somewhat on the rankness

of the growth. It is cut with a mower or self-rake reaper when not too large, or it is cut by hand, as in the case of Indian corn. It is allowed to lie on the ground until retted or rotted by dews and rains, when it is shocked as Indian corn or tied in bundles and stacked.

In some cases the hemp is broken in the field, thus leaving the waste products on the soil; in other cases it is carried to a central place where more rapid machinery is used.

RAMIE.

Ramie (*Boehmeria nivea*) is a perennial shrub with herbaceous shoots belonging to the same family as hemp, which it somewhat resembles in general growth and appearance.

It has been grown in Eastern Asia from very remote times in a limited way. The fibre is there extracted by hand by a slow and tedious process, and is used for cordage and other coarse manufactures as well as for making textiles of great beauty. It is capable of a great variety of uses.

It is an inter-tropical plant, and grows readily in the Gulf states in any soil which has a good supply of moisture, coupled with thorough drainage. It is claimed that three crops per season may be obtained.

The plant is propagated by seeds, cuttings or division of roots. If by seeds, the plants must be started in hot-beds. Cuttings of the ripened wood, including three buds, are set like willow cuttings, with the middle bud at the surface of the ground. The propagation by the division of roots of the fully matured plants is recommended for this country. The plants should be placed about as thickly as hills of Indian corn.

It is not, however, an established industry in this country, and cannot become one until some machine is brought into use which will economically extract the fibre from its tough, gummy stalk.

JUTE.

Jute has been cultivated in somewhat recent times in Southern Asia and tropical Africa. The most of the jute of commerce comes from Bengal.

There are two species. *Chorchorus capsularis* is nine to ten feet high, and has short, globular pods, while *Chorchorus olitorius* is smaller and has elongated cylindrical pods. The fibre of both is practically the same. The leaves of the small species is largely used as a vegetable.

Jute likes a moist, warm climate, and a rather sandy soil. It may be grown in the cotton belt. It is raised from seed, which may be sown about the same time as cotton. It may be drilled like wheat, using fifteen to twenty pounds of seed per acre.

Like ramie, it will not become an established industry in this country until the fibre can be economically extracted from the stalk.

SISAL.

Several species of the *genus agave*, to which the century plant belongs, have been cultivated by the natives of Central America for thousands of years, the most highly prized being *Agave rigida var. Sisalana*. Yucatan is the principal source of our commercial supply of sisal fibre. The fibre is obtained from the large thick leaves by crushing with crude machinery.

The sisal or century plant grows on barren rocky land which is useless for other agricultural purposes.

Attempts were made to introduce its culture into Florida over fifty years ago. The escaped plants are now growing wild in lower Florida. Further attempts are being made to establish the sisal industry in that state. Reports indicate that the climate and soil are suitable to its growth. The question of its economical production is unsettled.

CHAPTER XXV.

MISCELLANEOUS CROPS.

BUCKWHEAT.

Buckwheat is a native of Northeastern Asia. Its cultivation is of comparatively recent origin. Although not belonging to the grass family, but to that of the smart-weeds and the docks, it is generally classified as a cereal.

It is the least important of the six important cereals grown in the United States. It has less than half the acreage of barley and rye. Its gross value per acre has been equal to that of oats. New York and Pennsylvania raise about two-thirds of the crop. In proportion to population it is much less important than fifty years ago. Formerly it was used as a cheaper substitute for wheat, now it is used as a luxury.

The flour of buckwheat contains considerably less albuminoids, about the same per cent of oil and rather more starch than wheat flour; hence it contains less muscle-forming and more-fat forming nutrients than wheat flour. Brewer suggests that inasmuch as plants of the buckwheat family are used for their medicinal properties, perhaps the cultivated species has some such property which affects its physiological value as a food. A constant use of buckwheat is supposed to produce a feverish condition of the system which manifests itself in eruptions of the skin.

Buckwheat is often fed to fowls to stimulate their

egg-laying propensities. It is an important honey plant. The straw is practically valueless.

Buckwheat is produced in the moister, cooler and more elevated portions of the United States. The center of production lies further north than any of our other cereals. It is easily affected by drought and when sown late is apt to be caught by a frost.

It will grow on comparatively poor land. Appar-

ently soil has less effect on yield than does the climate, although a light, well drained

soil is best. In-

asmuch as it is

sown in June or July it is often

sown as a catch crop when some

earlier crop fails.

From two to five

pecks are sown

broadcast per

acre.



JAPANESE BUCKWHEAT.

There are three

cultivated species recognized, but the principal one and the one cultivated in this country is *Fagopyrum esculentum*. The varieties are not numerous.

After the plant begins to flower, which is when it is rather small, flowering continues, if allowed, until stopped by frost. The crop is usually harvested when the first flowers ripen seed.

It is not an especially easy crop to handle. Where the land will permit, a self-rake reaper is probably the most desirable implement, otherwise a cradle may

be used. It may be set up in shocks something after the manner of corn-fodder and thrashed as soon as dry.

TOBACCO.

Tobacco (*Nicotiana Tabacum*) is an American plant, native of Ecuador and neighboring countries. Its cultivation is very ancient. The use of tobacco for smoking, chewing and snuff-taking was diffused over the greater part of the American continent at the time of its discovery.

The crop of the United States has a greater commercial value than that of rye or barley, although the acreage is but one-fourth to one-third as great. The average annual production during the past decade has been about one-sixth that of cotton. The average yield per acre has been about 725 pounds, worth eight and one-half cents per pound. This makes by far the largest value per acre (\$61.50) of any of our important crops, potatoes standing next.

Kentucky raises about one-half this crop. The states bordering on Kentucky raise about two-thirds of the rest. Tobacco of high quality is raised in Connecticut and Massachusetts.

Judging by the distribution, the climate affects the tobacco much less than does the soil. Tobacco needs a fertile soil, a rather sandy loam being best. It is considered a particularly exhaustive crop. In some localities all the manure of the farm goes to the tobacco "patch," much to the injury of the rest of the farm, the same land remaining in tobacco for many years. Tobacco followed by wheat, with which clover is sown, and this allowed to remain a couple of years is generally conceded to be a good rotation. In Kentucky

exhausted tobacco lands are sometimes seeded to blue grass, and allowed to remain several years.

Nitrogen and potash fertilizers have a marked effect upon the yield and quality of the tobacco in some localities.

Tobacco is an acrid narcotic, annual herb, with large, clammy, entire leaves, belonging to the same family as the potato, tomato, egg plant, ground cherry, henbane, and Jamestown weed.

The quality, and consequently the price of tobacco, varies greatly with the soil and climate, and still more greatly with the method of handling and curing. Any variety is soon modified when grown under new conditions. There are, therefore, many varieties and sub-varieties. Tobacco is also classified according to the way it is cured, the use to which it is put, and the market which it supplies. Most varieties produce several grades. The classification of tobacco is, therefore, intricate. The Havana or seed leaf, and the burley, each with the many different prefixes, are probably the principal variety types.

The culture of tobacco is similar to that of cabbage. The small seeds are sown in hot or sheltered beds in March. Care is required to have the bed as free of weed seeds as may be, because the plants are easily injured if disturbed by weeding.

The plants are transplanted when about the size of cabbage, into hills about three by four feet, varying with variety, soil and method of cultivation. The plants require not only intensive soil culture, but also careful culture. Any disturbance of the plant is harmful. On this account some recommend exclusive hand culture, and thicker planting.

The great expense of tobacco is in the care of the plant. It is attacked by the large tobacco worm, which must be constantly searched for during the season. When the plant begins to blossom, it must be topped, taking off the flowers and such leaves as experience shows will not ripen in a given locality. Ten to sixteen may ripen. After topping, suckers appear in the axil of the leaves and must be removed. Some remove the lower leaves while growing, as they are of inferior quality.

In about two weeks after blossoms appear, the leaves begin to turn yellow and get brittle. It is then ready to harvest. The whole plant is severed at the ground, and hung up (top downward) by various devices in an airy shed to dry. In some instances it is kiln-dried. The sheds are kept open in dry, and closed in moist, weather.

During the warm moist weather in the winter, the tobacco is stripped, sorted, and packed for market. Every operation in connection with the culture, curing and handling of the crop requires technical knowledge and good judgment.

BROOM CORN.

Broom corn is an American innovation, which is probably about old enough to celebrate its first centennial. It is a more or less saccharine variety of sorghum, which is cultivated for its seed panicles. With these the well-known American brooms are made. The varieties used for broom are not materially different in appearance from the more distinctively saccharine varieties.

The entire crop of the United States in 1886 was about 20,000 tons, nine-tenths of which was raised in

Illinois, Kansas and Nebraska. A ton of brush from four acres is a fair return; twice this quantity may be obtained.

The area of possible production is as wide as that of sorghum for molasses, but as the demand is limited it should not be attempted on any extended scale, except on rich corn land, and probably not much north of the fortieth parallel. Inasmuch as broom corn is harvested soon after the flowers have set, the crop is not an exhaustive one. It has been raised fifteen to twenty-five years continuously on the same land without apparent diminution of fertility. Insect enemies and fungus diseases, however, increase.

The seed is too immature to be an important item of the industry, although it has some food value. The stalks furnish abundant fodder of fair quality. They are, probably, more frequently plowed under than burned.

The planting and culture of broom corn is similar to that of sorghum. Thickness of planting modifies the quality of the broom. The thicker the planting the finer the brush. The proper thickness will depend upon the character of the soil, the variety and the quality of the brush desired. This can best be learned for a given locality by experience. In general there may be three to five stalks every fifteen to eighteen inches, in rows three and one-half to four feet apart.

Brush of a light color is desired and is obtained by cutting as soon as may be after the flowers have set. The early cut brush is also said to be heavier and more durable. The milk stage is as late as it may safely be allowed to stand.

When the broom is ready to harvest two rows are

bent across each other at about right angles, so that the top part of the stalk is horizontal at about the height of a common table. The brush or seed panicle is then removed with about eight inches of the stalk. The brush is collected from the table where it is laid by the cutters and taken to the stripper, which removes the seed. The clean brush is then placed to dry in airy sheds arranged for the purpose. At some stage of the process, as found most convenient, the brush is sorted. When dry it is baled and is ready for market.

The price is very unstable. Variations of from sixty dollars to one hundred and twenty-five dollars per ton have not been unusual in recent years and formerly they were much greater. The production of broom-corn is best engaged in only by those who make it a specialty after having studied the business carefully in all its details.

HOP.

The hop (*Humulus lupulus*) came into general cultivation in Europe in the Middle Ages. The production is in general about equal in weight to that of broom-corn, on a somewhat less acreage. Perhaps a thousand pounds is a fair yield and two thousand a large yield per acre. The variation in price is very marked. Some years it is a very profitable crop, in others it does not pay the cost of production. The quality of the hop deteriorates rapidly upon keeping.

The plant is perennial and hence a yard once set may last many years. There are male and female flowers, borne on separate plants. The female flowers are borne at the base of scales which are arranged in clusters. It is these ripened clusters that are

known in commerce as hops. The male plants are planted among the female plants, say one male to 100 females, so that the female flowers will ripen seeds.

Hops are planted on any good corn land. Sheltered places with good exposure to sun are preferred.



BRANCH OF STAMINATE HOP-VINE.

Reduced in size, and showing at the lower left-hand side a single flower of the natural size.

Sets or roots may be obtained from an old plantation. Usually four, each with two or three buds, are placed in a hill. The hills may be seven to ten feet apart each way.

The first year the land is usually planted with any cultivated crop and the few hops not picked. The second year two poles 15 to 20 feet high are usually placed in each hill, about 15 inches apart. Two vines are trained to each pole and rests are usually re-



BRANCH OF A PISTILLATE HOP-VINE.
(Shown in reduced size.)

moved. In some cases a modified trellis is used. The land is kept cultivated to remove weeds. Each year the hills are opened and the plants pruned, leaving enough buds for the vines.

Hops ripen in August and September and are picked when the seeds get hard. The vines are usu-

ally cut near the base and the poles laid on a support at a convenient height for picking. The hops are picked in large boxes and carried to kilns in sacks, where they are emptied in a large carpeted room or oven heated to about 180 degrees Fahrenheit, in which the hops dry in about 8 to 10 hours. When cool they are baled and marketed as soon as may be.

FIELD PEAS.

Field peas (*Pisum arvense*) are a somewhat important field crop both in Canada and in Europe, but have never become so in this country. In Canada 35 to 40 bushels per acre are reported in individual instances.

The plant belongs to the clover family, and hence has a similar renovating value for the land. The seeds, which are fed ground, have about twice as large a percentage of albuminoids as does Indian corn, and are therefore a desirable supplementary food for milch cows and growing stock. The manure from stock fed with peas would be more valuable than that of stock fed with cereal grains. The straw or haulms is of little value.

Sandy loams are better than clay loams. On rich soils the plants are apt to lodge. Peas should be sown at the rate of three bushels per acre, as early in the spring as the soil will permit. Use an ordinary wheat drill, one which will not break the seeds in planting.

Black-eyed, marrowfat, golden vine and multiplier are good varieties.

In Canada they are sometimes cut with a pea harvester attachment to an ordinary reaper. A common practice there, also, is to use a sulky rake, one end only being used, in order that the horse may not be

compelled to walk upon the peas. Harvest when about two thirds the pods are yellow, and when dry stack under cover, or thresh immediately. They may be threshed with the ordinary thresher, although it chops the straw up rather fine.

CHAPTER XXVI.

WEEDS.

Soil culture is an active warfare against weeds. This warfare occupies a great portion of the time of every tiller of the soil. A million of weeds may grow on an acre of land during a single season.

Definition.—In ordinary usage any homely plant is called a weed. The ox-eye daisy is universally conceded to be a comely flower; the tomato a homely plant. Emerson once said in his quaint way that a weed was a plant, the virtue of which had not yet been discovered. The roots of burdocks have medicinal properties. Parsnips, mustard and hemp are examples of cultivated plants which are pernicious weeds under some circumstances.

Perhaps the statement that a weed is a plant out of place is the most satisfactory definition of the term as we ordinarily use it. The plant is not out of place in nature, but out of place so far as man is concerned; in the way, as it were.

How Injurious.—Weeds are injurious in several ways.

1. They consume plant food. Every piece of land has a limited quantity of available plant food. If part is consumed by the growth of weeds, the amount of food is thereby restricted for the cultivated crop.

It has been found that a ton of air dry pig-weed, *Amarantus retrofexus*, would contain as much phosphoric acid, twice as much nitrogen, and nearly five times as much potash as a ton of ordinary manure. A

ton of pig-weed contains as much phosphoric acid as fifteen bushels of wheat, as much nitrogen as twenty bushels, and as much potash as seventy-five bushels.

2. Weeds shade the ground. Plants require a certain degree of warmth of the soil to grow satisfactorily. By shading the ground, weeds may prevent it from obtaining the necessary warmth.

3. Weeds occupy space. Plants require a certain amount of room, both for roots and tops. If occupied by weeds it cannot be occupied by useful plants. The Canada thistle is probably more harmful in occupying space than in any other way.

4. Weeds take water from the soil. All growing plants transpire large quantities of water. The quantity will vary with the humidity of the air. Lawes found in England that 150 to 270 pounds of water were transpired for each pound of increase of dry substance in different cultivated crops. Hellriegel found in Germany that about 300 pounds of water was transpired for each pound of increase of dry matter. Plants cannot reach their full development without an abundance of water throughout their entire growth. Weeds rob the soil of its water, and thereby restrict their growth. An area covered by vegetation evaporates much more water than bare soil, or even a similar area of water.

Sturtevant says that the vineyardists on the uplands of New Jersey find weeds injurious; those on the lowlands do not. On the wetter land the transpiration by the weeds cause that dryness of soil that is beneficial to the grape.

5. Weeds are troublesome and injurious to stock. The cockle burr is more troublesome to stock than it is

injurious to cultivated plants. Wild barley (*Hordeum murinum*) causes much loss to stock owners in the west by its pestiferous awned seeds.

Weeds restrict the circulation of the air as well as taking plant food from it. The amount of carbonic acid which comes in contact with the cultivated crops in a given time is thereby restricted. Too little, however, is known of air chemistry and physics as related to plant growth to make it possible to hazard an opinion upon the effect of this on the growth of the crop.

The amount of fertility which a crop of weeds takes from the soil may be supplied to the land and still the weeds will be injurious. Some crops are not injured by shading the ground, such as potatoes, which are raised in some localities by mulching with straw. It would seem that the space which the weeds occupy in a corn-field would not be injurious to corn, yet weeds must be removed in order to get a full crop. Until there is further evidence it must be concluded, therefore, that the most important injury that weeds do is in exhausting the water from the soil.

Kinds which are Injurious.—No one can tell with absolute certainty whether a weed will become troublesome in a given locality. Not more than one in twenty of our bad weeds is a native plant. Most of the foreign plants which have become troublesome here are of little importance in their native places. Plants indigenous to this country and not usually troublesome here have become great pests when introduced elsewhere. Evening primrose and water-cress are examples.

The pernicious character of weeds varies in different

sections of our own country. It is affected by both soil and climate. The Canada thistle and the ox-eyed-daisy are not especially troublesome in Ohio, Indiana and Illinois (because they usually do not produce seed) but to keep an eastern farm free of them requires eternal vigilance.

Prolificacy.—The difficulty of eradicating weeds is due to at least four causes; viz.: their prolificacy, the vitality of the seed, their means of dissemination and the adaptability of the plant.

The ordinary burdock burr will contain fifty seeds. Each seed may grow into a plant, producing thirty-five to forty thousand seeds. A common thistle-head may contain three hundred seeds. Each seed may produce a plant with fifty thousand seeds. The common tumble-weed (*Amarantus albus*) growing in some fence corner of a twenty acre field may have seed enough to supply one seed to every square foot of land in the field.

Below are given a few common weeds, with the number of seeds produced on a single plant of not unusual size.

	Number of seeds on a plant,
NATIVE—Annual—	
Ragweed.....	4,000
FOREIGN—Annual—	
Purslane.....	400,000 to 2,000,000
Jamestown weed.....	100,000
Pigweeds.....	150,000 to 800,000
Fox-tails.....	15,000 to 45,000
Velvet leaf.....	8,000
Chess.....	4,000
Cockle.....	3,000
FOREIGN—Biennial—	
Common thistle.....	10,000 to 65,000
Burdock.....	38,000 to 50,000

	Number of seeds on a plant.
FOREIGN—Perennial—	
Canada thistle.. .. .	0 to 10,000
Ox-eye daisy.....	800 to 95,000
Sour dock.....	36,000 to 90,000

Vitality.—Under the proper conditions seeds may maintain their vitality for years. Jamestown weeds have been known to grow in a piece of land for ten years from a single seeding. A single plant containing 100,000 seeds may, therefore, be the source of considerable annoyance, not to say expense.

Beal buried twenty common varieties of weeds seeds twenty inches deep in pint bottles of sand. At the end of five years eight varieties failed to grow. Of the twelve remaining varieties thirty-one out of fifty grew. Of purslane nineteen, of pig-weed twenty-one, fox-tail thirty-four and of sour dock forty-five out of fifty seeds grew at the end of five years.

When, however, seeds are exposed to the usual conditions of heat, moisture and air, many either grow or rot. Our worst annuals are those which are prolific and have the power of resisting these influences for a long time.

The reserve force of seeds is illustrated by the cockle-burr. Each burr has two seeds. Ordinarily only one of these grow. But if the plant is destroyed the second seed grows.

Disseminonita.—Most of our worst weeds being of foreign origin it follows that their presence depends on some means of dissemination. These are many and often curious and may be divided into two general classes: natural and artificial.

Distribution by wind is one of the most familiar natural means. Many seeds of the sun-flower family,

such as the thistle, float in the air by means of their pappus. The tumble-weed is a familiar example of a whole plant being moved by the wind. Seeds drift with the snow.

Water is a common source of distribution. Farmers whose lands are over-flowed by spring freshets find it impossible to keep their land free of weeds grown by their neighbors farther up the stream. Co-operative effort is here necessary. In 1882 the high waters brought the horse-weed (*Erigeron canadense*) to farms in the southern part of Ohio, where it was unknown before.

There are many devices of the fruit of plants by which they stick to animals and are thus carried from place to place. Cockle-burrs, burdock burrs and spanish-needles are familiar examples.

Seeds are carried in the mud, clinging to the feet of birds and other animals. Many seeds are distributed by being swallowed but not digested. Birds may carry seeds long distances in this way. Doubtless farm animals which are transported from place to place may do the same. It may pay the careful farmer to look to this matter.

Some plants have the power within themselves by which seeds are disseminated to a slight extent. The seed-pods of the wood sorrel (*Oxalis stricta*) explode, scattering the seeds. Plantain in moist weather exudes a gelatinous substance which carries the seeds to the ground and causes them to stick to passing objects.

The seeds of the bunch grass (*Stipa*) have a sharp point, and a long spiral awn which twists and untwists with the moisture of the air, thus causing the

seeds to bury themselves in the soil. They often cause flock-owners much trouble by burying themselves in the flesh of their sheep.

By artificial means of dissemination are meant those in which man is concerned.

Weeds have been introduced by being grown for ornamental purposes, such as butter and eggs (*Linaria vulgaris*), and velvet leaf (*Abutilon avicennae*). Others have escaped from cultivation, such as parsnip and mustard. From being plants in place they have become plants out of place.

Common carriers are a source of weed distribution. Weeds and other seeds have followed the pioneer step by step along the lines of common travel. The progress of many plants have been traced along these thoroughfares. Useful plants have also been distributed. Thus Kentucky blue grass is known to have been introduced into one locality of Northern Illinois by the night camping of the pioneer. When first introduced it was thought to be a harmful weed which would ruin the country.

Weed seeds are brought from the Eastern hemisphere by the ballast which ships bring in their western trips. The packing of marble shipped from Vermont has been known to bring Canada thistle seeds to Illinois. In honoring the dead the trials of the living have been increased. The army weed (*Amarantus spinosus*) is so called in Ohio because it was introduced into that state during the civil war.

Impure seed is a common source of weed distribution, and one that may in a great measure be avoided. Clover and grass seeds are a frequent source of trouble. Canada thistle, ox-eye daisy, and bearded plantain are

apt to be introduced in this way. Every farmer should avoid as much as possible getting grass and clover or even other seeds from a distance, or from unknown sources. Your neighbors' seeds may contain weed seeds, but they are not so apt to contain those that are not already on your farm.

The importance of a few seeds is not realized unless their prolificacy is fully understood. The number is usually under-estimated. Lazenby found in a sample of seed wheat, nine thousand seeds of chess per bushel. If a bushel of wheat contains one pound of chess, it would contain as many seeds of chess as of wheat.

Adaptability.—The adaptability of plants in their struggle for existence often prevents their extermination. A fox-tail plant (*Setaria*) has been known to ripen seed at two inches in height (one to two feet is a common height) by being surrounded by other plants.

A chess plant, standing alone, may easily produce four thousand seeds. When sown like small grain, it will hardly produce one hundred fold. When subdued by the generally stronger growing wheat probably much less will be produced.

When prairie lands were broken up, far away from any other cultivated area, the striking horse weed (*Erigeron canadense*) often sprang up in profusion. This weed had not been seen there previously. The only explanation that can be given is that the plants were growing there, but were so kept in check by the other vegetation as to be passed unnoticed, just as would be the fox-tail above mentioned.

Many weeds seed when they are very small. Pur-

slane begins to produce seed almost as soon as it has any top, so that it is often well nigh impossible to prevent seeds being formed.

Eradication.—Weeds may be eradicated, but with our present system of farming, complete extermination is not practicable, certainly not essential to successful agriculture. Along the Mediterranean coast farmers are known to have fought the same weeds for three centuries without one species having been eradicated.

To eradicate certain kinds of weeds, often the most pernicious kinds, and to keep all kinds in subjection, is both possible and feasible. The more intensive the farming, the more completely this may be done.

With annuals, the prevention of the plants from seeding, the destruction of the seed in the soil, and the prevention of the introduction of seeds from outside sources, is all that is necessary. The reason for the difficulties will be understood from what has gone before.

Clean culture is the chief essential to success. It kills the weeds which are growing on the land, and hastens the destruction of the seeds in the land by causing them either to grow or rot. One great difficulty is that all the land is not, and can not be brought, into cultivation. Waste places, hedges and fence rows produce weeds abundantly. A tumble weed grows along a fence row. A crop of oats, perhaps, is harvested and the land plowed. On a windy day, the tumble weed loosens anchor, and freighted with 100,000 seeds, goes rolling across the land, literally sowing destruction in its path. A thistle in a hedge, or a burdock in the corner of a cornfield visited by cattle, are

sources of danger. Hedges, on account of concealing the growing weeds, are a constant menace to clean culture. As far as possible all waste places should be brought into cultivation, and the number of fences should be reduced as far as compatible with good husbandry.

Early plowing of stubble ground after harvest would prevent many weeds seeding. In place of this, burning off the stubble would destroy both weeds and seeds. While there would be some loss of organic matter, including nitrogen, this practice has much to commend it. It not only destroys weed seeds, but also insect enemies and fungus diseases. Weedy roadsides are a source of much injury to the clean cultivator, as well as most unsightly, and should be kept mown by co-operative effort, when in most cases useful grasses will soon displace the pernicious and unsightly weeds.

Inasmuch as we can not hope to eradicate entirely our most prolific and thoroughly introduced weeds with our present methods of farming, we should try to arrange so as to give our crops the first and best chance, and the weeds the poorest. Rolling oat ground for example, in a dry time may firm it about the weed seeds near the surface, enough to cause them to grow without having any appreciable effect on the oats. If the land had not been rolled, the weeds might not have grown.

It is often advisable to delay the planting of a crop until the land is warm enough to cause it to grow rapidly, so that it will out-strip the weeds in their race for place.

If land infested with morning glories is planted with corn, the land should not be cultivated until both

corn and weeds have a good start. Before any other cultivation is given the morning glories should be removed with a hoe. With ordinary cultivation thereafter the morning glories will not cause further trouble that season.

Biennial plants require to be watched for two years in order to kill them. In practice it is best to cut them down when they begin to flower, cutting well into the ground. The root then dies.

With perennials the plants must not only be kept from going to seed, but the plants themselves must be destroyed.

No common flowering plant can live without leaves. Constant cutting of the tops so that no part appears above the ground will kill it. Some perennials, such as morning glories, may be killed on restricted areas by pasturing with sheep.

Land may be left fallow or put in some hoed crop, and in either case given thorough cultivation. Heavily manuring the land and growing some grain crop, followed closely by another, and perhaps still another, and afterward giving thorough cultivation, will often kill perennials completely. Rye and millet are good crops to use. In short, any method that prevents the plant from producing tops will kill it. With care and judgment it may be done without great expense.

Successful farming in all its branches is an exacting business. It requires constant and careful watchfulness. Weed destruction is not the least exacting of its many phases.



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