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A Promising Cane. In the report upon the leaf-hopper, presented to the Trustees of the Hawaiian Sugar Planters' Association last year, by Mr. C. F. Eckart, Director of the Experiment Station, reference was made to the "Altamatti" cane and that it seemed to be more resistent to leaf-hopper attacks than the other known varieties.

Since that time, Mr. Eckart has interested himself in this variety and has grown at the Station a small amount of seed cane, which has been distributed among the plantations for experimental purposes.

The Altamatti cane came to the Experiment Station originally from Niulii Plantation on Hawaii, and it was noticed by Mr. Eckart last summer that this cane was to a much less extent attacked than Rose Bamboo and other varieties. Mr. Hall, the Manager of Niulii Plantation, says that this year the leaf-hopper has attacked the Altamatti to some extent, but that he considers it a very promising cane.

A noteworthy feature regarding this variety of cane is that the rind is covered with a coating of velvety fur, which prevents the leaf-hopper from laying its eggs in the stick. When it is considered that a wound fungus, such as the Rind Disease, may readily take hold of the cane after the leaf-hoppers have punctured the rind, the advantage offered by this variety is of considerable importance.

The so-called velvety fur on Altamatti is quite different from that of other varieties. The fur completely covers the entire stick of cane while on the Lahaina variety the hairy prickles are found only on the leaf sheath. It will be noticed in regard to this Altamatti cane that the young leaves contain on their upper surface a slight scattering of hair-like projections. These plant hairs on the leaf wear off as the leaf grows older, but the fur on the rind of the cane stalk becomes more pronounced as the cane ages.

It is believed the fact that the younger leaves contain these hairs on the epidermis is advantageous of itself (leaving out of consideration the principal characteristic, viz: the fur on the rind.) These plant hairs on the leaf protect the latter in a large measure from the hoppers, and the leaves are thus allowed to carry on their functions in a more normal manner until the leaf ages sufficiently to lose its hairy surface and thus become more susceptible to the egg-laying hoppers.

The small plant of this cane at the Experiment Station has been watched very carefully and it has suffered less from the leaf-hoppers than any of the thirty-seven other varieties there growing, and the stalks are practically free from leaf-hopper punctures.

At the present time it is impossible to estimate the value of the cane as a sugar producer, but from this standpoint, the general appearance of the cane is promising.

It is noticed with this variety that the sticks vary as to the amount of fur which covers the rind, and the idea in regard to this cane is to observe a careful selection of seed at the time of planting, choosing such cuttings as have the most hairy surface; it is to be expected that by this course a cane will be obtained which will be practically immune to Rind disease and at the same time will successfully resist the leaf-hopper.

In the Hilo district, there is cane called "Woolly Bamboo," which resembles in outward appearance the Altamatti. It may be possible that they are the same canes and that some confusion as regards names may have separated them into varieties. The Woolly Bamboo is not in high favor as a sugar producer, but Mr. Eckart believes that it can be made to resist such cane troubles as rind fungus.

It may be, if the leaf-hopper, and the fungus diseases which seem to follow its attack and which really do the most damage, so over-run the cane fields as to decrease to a large extent the percentage of sugar in the canes, that the planters, in order to gain an immunity from the pests, will have to be satisfied with a less percentage of sugar in consideration of the gain of a higher percentage of immunity.

In considering the possibilities of the Altamatti cane, it must be understood that at the present time the comparative freedom from leaf-hopper attacks and the consequent fungus diseases holds good for the conditions at the Experiment Station only, and it may be that in other localities this cane will not make the same showing that it does there. Mr. Eckart has noticed it on only one plantation, and there only in small patches, surrounded by Rose Bamboo.

This fall, Mr. Eckart is going to endeavor to grow some Hawaiian seedlings and thinks that there is a good chance of crossing such a cane as Altamatti with a rich variety like Lahaina. The resulting cane would have a nature more resistent of rind diseases than Lahaina and a higher sucrose content than Altamatti.

The growing of seedling canes here is a matter of much uncertainty, and if Mr. Eckart manages to raise some to any large extent, he will be doing more than has heretofore been done by any of our planters, so far as we know. He is going at the matter very carefully and results will be awaited with interest.

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Leaf Hopper. We are in receipt from the Federal Agricultural Experiment Station of its Bulletin No. 5, entitled, "A Sugar Cane Leaf-Hopper in Hawaii," by Mr. D. L. Van Dine. The Bulletin is very well written and quite profusely illustrated. It deals with the life history of the leaf-hopper, its injury to the cane, symptoms of the attack, limitations of the natural enemies of the pest in attempting to check its ravages, the work of such natural enemies as are now present in the field, and remedies and preventive measures.

Under the head of "Preventive Measures," Mr. Van Dine says:

"In the main, dependence is placed on preventive methods, to control the pests of field crops. The planter will be able to control the leaf-hopper on the cane largely by precautionary measures. The greatest success in the control of injurious insects to field crops has been attained by methods of cultivation, taking into consideration the habits and life-history of the pest and the selection of resistant varieties. Since the cane is the sole crop and must be planted year after year on the same lands and also since certain portions of the plantations bear cane in the various stages of growth throughout the year, insuring a constant food supply to the pest, many of the precautionary measures practiced elsewhere are eliminated.

"There is noticeable in general throughout the plantations a marked difference in the power of the different varieties to resist the attack of the leaf-hopper. While the same variety would vary in different localities as regards growth and resistance, still the difference between any two varieties remained constant. For example, of the common varieties grown, Yellow Caledonia and Demerara 117 were invariably the more resistant as compared to Rose Bamboo and Lahaina, and while the former were more seriously attacked in some localities than in others, wherever the opportunity offered itself for comparison with the latter, the Yellow Caledonia and Demerara 117 made the best showing. It is for the planter to decide whether or not the advantages of one variety over another is offset by the ravages of the leaf-hopper. If the work of the leaf-hopper is greater than the gain, in the absence of the leaf-hopper, in the yield between the two varieties, then it is policy to select the more resistant cane. Here certainly is an important line of investigation from the standpoint of plant-breeding. A variety test should be made at once to enable the planters to know the relative value of the varieties they already possess and the further determination and establishment of other resistant canes. In the establishment of a resistant variety of cane it is encouraging to remember that cane is planted from cuttings and not from seeds, and therefore will not be likely to revert to a non-resistant form.

"Another point in preventive methods is the difference in the power of healthy and unhealthy plants to withstand an insect attack or any injury, for that matter. All plants are surrounded by their various enemies, but when the plants are in a vigorous condition of growth, the pests cannot easily overcome them. Let a plant for any reason, such as deterioration of the plant itself, lack of proper available plant food in the soil, unfavorable location as regards climatic conditions or any of the various unfavorable conditions of growth, become weakened, and the work of destruction by any enemy that is present becomes evident. The vigor of the plant must be maintained by cultivation, irrigation, and the use of fertilizers.

It seems probable that many of the plantations will find it not only necessary but profitable to give certain of their cane lands a rest once in several years and plant an intermediate crop, either for the product itself or for green manure. In some cases, the check to the cane through the work of the leaf-hopper, combined with other sources of loss, more than covers the profit. It is, therefore, hardly wise to continue to plant such lands longer to cane since such fields simply tax the remaining portion of the plantation to that extent in making the crop as a whole profitable.

"In conclusion, it can be said that the limitations of the natural enemies and the active measures are so many that the leaf-hopper cannot be controlled by these methods. A general effort on the part of the planters in selecting a variety resistant to the attack of the pest, a careful consideration of the various sources of loss in the cane fields, aside from the destructive work of the leaf-hopper, cultivation based on the life-history and habits of the insect, and the maintenance of the vigor of the plant by irrigation and the proper fertilizers along with thorough cultivation, will be the methods of control for this pest."

We believe we are fortunate, rather than otherwise, that the theories of the entomologists here in respect to the methods to be adapted in controlling plant diseases are at variance.

There are two methods of controlling insect pests and plant diseases; one by propagating a variety of the plant attacked which will be immune or disease resistant; the other, of fighting the pests with their natural enemies, based on the fact that every insect has its enemy which keeps it down and under control.

Both of these methods have proved successful in many instances and each have their supporters among the scientists.

We are watching with great interest the experiments carried on with the Altamatti cane, elsewhere referred to, and hope that this variety of cane will resist the attacks of the leaf-hopper and fungus diseases. At the same time we do not lose sight of the fact that the parasite of the leaf-hopper, commonly known as the Kealia parasite, has been very instrumental in saving many of our plantations from serious loss. It is too early to say anything of what may come of the visit of Koebele and Perkins to Australia in search of other enemies of the hopper, but it looks as though they are on the right track.

So far as the Hawaiian planters are concerned, they are ready to endorse and support any method of controlling the pests if immunity will be assured.

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LECTURES ON THE DISEASES OF THE SUGAR-CANE.

By L. Lewton-Brain, B. A., F.L.S.

(Bulletin of Imperial Dept. Ag. for the West Indies.)

PREFACE.

The following pages contain the substance of three lectures, recently delivered before the members of the Barbados General Agricultural Society, on some fungoid diseases of the sugar-cane, by Mr. L. Lewton-Brain, B.A., F.L.S., Mycologist on the staff of the Imperial Department of Agriculture.

The diseases referred to attack canes to a greater or less extent in all the sugar-producing colonies in the West Indies. The root disease (*Marasmius*) was especially prevalent at Barbados last year, and it was largely due to the attacks of this fungus that the sugar crop of 1903 (35,000 hhds.) was lower than any during a period of thirty-four years. It was even lower than in 1895, when the ravages of the rind fungus (*Trichosphaeria*) reduced the normal crop of 56,000 hhds. to 36,000 hhds. and led to the practical abandonment of the Bourbon cane. The principal canes now cultivated are the White Transparent and seedling canes.

A conservative estimate, after making every allowance for unfavourable seasons and other circumstances, has placed the loss due to the attacks of fungoid diseases at Barbados during 1903 at 10,000 hhds. of the value of £70,000. If we take into account the loss sustained in molasses also, the total loss in 1903 would not fall far short of £100,000. It was with the view of aiding the planter to control the diseases affecting his crops, especially in these days of low prices, that the lectures delivered by Mr. Lewton-Brain were organized. If the advice given in the lectures be closely followed, there is little doubt that the loss likely to be sustained from the attacks of cane diseases might be reduced at least one-half. It is hoped, in view of these facts, that the recommendations of the Department will receive the hearty support of all members of the planting community.

The root fungus is present again this year, but, owing to the greater vigour of the canes due to favourable seasons, the effects are not so marked as last year. It is recommended that tops for planting should be selected from healthy canes only; that where the disease shows itself in small patches in the fields, these should be isolated by a trench (about a foot deep) dug round them, so as to prevent the disease from passing through the soil and attacking healthy canes; that all cane stumps whatsoever should be dug up and destroyed either by burning or being heaped up and treated with quicklime; and that where a field has been very badly attacked by root disease it should be thrown out of cultivation in canes, treated with lime, and planted with other crops for a period of at least one year—preferably two years.

These recommendations are of so simple and practical a character that no difficulty need be experienced in carrying them out; and especially, as the probability is, that they would be the means of saving a considerable portion of the loss to the sugar industry of this island which was estimated last year by responsible officers of the Department at £100,000.

D. MORRIS,

Commissioner of Agriculture
for the West Indies.

February 19, 1904.

DISEASES OF THE SUGAR-CANE.

LECTURE I.

In to-day's lecture I do not intend to deal definitely with any disease of the sugar-cane. In the first place I wish to go briefly into the structure of a living sugar-cane plant, then to explain, also briefly, the functions of the various parts of the plant.

I think this plan advisable for two reasons:—Firstly, unless one knows something of the structure of the plant, it will be exceedingly difficult to understand in what ways the parasitic fungi, that bring about sugar-cane diseases, enter and live in the plant; also, unless one knows the functions of the various plant structures, and what part they play in the economy of the plant, I do not see how anyone can understand the way in which a fungus causes disease by attacking one or other of the organs of a plant.

Secondly, in order to understand why a fungus damages its host plant, it is necessary to know what food a fungus needs, and how it obtains it, and the best way to learn this is to study the way in which an ordinary green plant gets its food materials and works them up, and then to compare the fungus with it.

Let us then take the sugar-cane plant, see what organs it possesses, find out what their structure is, study their functions and see how they perform them.

THE EXTERNAL FEATURES OF THE SUGAR-CANE.

As you know, the sugar-cane, like all ordinary green plants, may be divided into two parts—a root part which grows down into the soil, and a shoot part that grows up into the air. The shoot part consists of a central portion, the stem, on which leaves are borne laterally. The shoot part also bears the flowers, but as these are not of importance in connexion with sugar-cane diseases we will not consider them.

ROOT OF SUGAR-CANE.

The roots of the sugar-cane differ considerably from those of, say, the cotton and other plants, belonging to the large class of Dicotyledons. In these, there is one main root going straight down into the soil, and from this a number of branch roots are given off which spread laterally, from these other branch roots, which spread in other directions, and so on. All these roots are continually increasing both in thickness and length. In the sugar-cane and other plants belonging to the class of Monocotyledons there is no main root and no branches. In place of this system we get a large number of roots quite independent of one another which all grow more or less straight down into the soil, which never grow to any great size and which never branch. These roots spring in great numbers from the base of the stem, and as older roots reach their limit of growth and die away, other roots grow out from the stem to replace them.

The only other point to notice about the roots are the root-hairs. These are very tiny, delicate, white hairs, which grow out, in large numbers together, from a point just behind the tip of the root. As the roots gets older these die away, and their place is taken by other root-hairs, formed nearer to the tip, and this process continues all the time the root is alive.

STEM OF SUGAR-CANE.

The stem is, while young, covered by the sheathing bases of the leaves. It possesses a number of joints or nodes, and between these we have the smooth internodes. The internodes become shorter, and the nodes closer together, as we get nearer the tip of the stem. From the nodes arise the leaves, and, in the corner between the leaf and the stem, arise buds. As a general rule, only those buds near or in the soil develop, but every one is capable, given the proper conditions, of growing out into a branch like the parent stem. It is from the nodes also that the roots arise, several from each node; they are at first covered by the leaf bases. Unlike the buds they arise all around the stem, and if they are examined closely may be seen to arise from the inside of the stem and to have to force their way through the outer tissues.

LEAF OF SUGAR-CANE.

The leaves of the sugar-cane are much like those of other grasses. They are composed of two parts, the leaf base and the blade. The leaf base is large and forms a sheath to the stem. The blade is linear, the veins run parallel from base to apex, and the margin of the blade is rough to the touch owing to a number of minute prickles along the edge. Another interesting point about the leaf of the sugar-cane is the fact that in dry weather the blade rolls up, forming a tube, with the upper surface of the leaf inside. As we shall see later, this is an adaptation to prevent excessive loss of water from the leaves, such as might take place when both air and soil were dry.

THE INTERNAL STRUCTURE OF THE SUGAR-CANE.

Let us now briefly examine the structure of the various parts. As you are doubtless aware, all plants are made up of small bags called cells; these cells are packed closely together, and have different shapes and structures according to the different functions they have to perform.

STRUCTURE OF ROOT.

If we cut across the root of the sugar-cane and examine the structure under a microscope, we shall see at once that the root is divided into two parts; there is an outer part where the cells are all more or less alike, thin-walled and closely packed; then there is a central cylinder where we get several different kinds of cells. The cells of the central cylinder are mostly smaller than those of the outer part, and are more closely packed together. The most important of these, for our present purpose, are larger, thick-walled cells which are arranged in groups, or rather strands, because these strands are continuous right through the length of the roots and, moreover, are also continuous with similar strands which we shall meet with in the stem and leaves. These cells are different from ordinary cells in shape, being very much longer than broad, they are, in fact, tubes—hollow pipes—formed by the fusion of several cells placed one above the other. Their walls are thickened and variously marked and they also become woody and hard. The chief point I wish you to remember is that here we have a complete system of tubes, starting in the roots, running up right through the stems and into the leaves. These tubes are called vessels.

Now let us examine the structure of a root a short distance behind the growing point, that part, you remember, on which roothairs occur. The general structure here is much the same except that the wood vessels are less developed. But from the outermost layer of cells we find, growing out, very delicate thin-walled prolongations—the root-hairs. These grow out into the soil and become very closely attached to the particles of soil, while their walls become somewhat gelatinous. So you see there is a very close connexion here between the plant and the soil.

ROOT-TIP.

We will now have a look at the structure of the actual tip of the root itself. The actual tip of the root is covered over by a cap of cells which are loosely arranged and are dead, this is the root-cap and its function is to protect the delicate tip from injury. The root-tip itself is composed of small cells which are all alike, their walls are thin and they are full of living matter, protoplasm. These cells are all actively dividing and this is the only part of the root where new cells are formed, so you see, if anything happened to this growing point, all growth of the root would be stopped and the root would remain short. As new cells are constantly being added, behind, by the growing tip, this is constantly being pushed forwards into the soil and it is for this reason that it needs the protective root cap.

The structure of the stem need not detain us long, but there are one or two points to be noticed. On cutting across the stem, we see no division between central cylinder and outer part, as we did in the root. The wood vessels again are arranged in strands, but these strands are scattered irregularly about the section. The space between the strands is filled up with ordinary, thin-walled cells. These strands, as you remember, are continuous with those of the roots. On the outside of the whole stem we get a layer of special tabular cells, the epidermis. The outer walls of these cells are much thickened, and besides are chemically changed in such a way as to be quite impervious to water. The functions of this layer of cells are first to prevent the loss of water by evaporation from the stem, which would cause the plant to dry up, and second, to shield the soft tissues inside from the attacks of insect and fungoid parasites. Under the epidermis we get several layers of cells, with very hard, thick, woody walls; these cells are mechanical tissues and they serve to strengthen the stem and so prevent its being broken by the wind or otherwise.

STRUCTURE OF LEAF.

The structure of the leaf is fairly simple. If we examine a section we see on the outside, on each surface, an epidermis like that of the stem and, like that, impervious to gases and to water. On the leaf, however, we get special openings between some of the cells, these openings are the stomata. Each stoma is enclosed by a pair of special sausage-shaped cells, known as guard cells, which differ from the ordinary cells of the epidermis in containing some green colouring matter. The stomata in the sugar-cane leaf are arranged in rows down the blade, and are mainly on the upper surface. As you will see at once, the stomata are of great importance, as they are the only means of communication between the tissues inside the plant and the outer air. The main body of the leaf is made up of thin-walled cells, packed so as to leave spaces between; these spaces are continuous throughout the leaf and open to the outer air at the stomata. The cells themselves are characterized by the possession of small bodies, specialized parts of the protoplasm, which contain a green colouring matter. In this tissue we find the strands with the wood vessels; these strands pass straight through the leaf, and at the base pass into the stem and become continuous with the strands we found there.

THE NUTRITION OF THE SUGAR-CANE.

Having thus briefly reviewed the chief organs of the sugar-cane plant and their structure, let us go on to see what part they play in the life of the plant.

In order to live and to carry on the processes of life a plant, like an animal, requires to take in certain substances as food, among which these are the most important:

Lime, Magnesia, Potash, Iron, Sulphates, Phosphates, Nitrates, Carbon, Water.

Of course the plant does not take in these as such; the potash for instance may be taken in as chloride, sulphate or nitrate of potash, and so on.

Now there are two possible sources from which the plant might obtain its food—the soil and the air. It is connected very intimately with the soil by means of its root-hairs, and with the air by means of the stomata on the leaves.

ABSORPTION OF FOOD FROM THE SOIL.

It has been found by experiments that all these substances, with the exception of carbon, are taken up from the soil, while the carbon is taken from the air.

You will remember how intimately the root-hairs are connected with the soil particles, practically becoming fused with them. Now these soil particles are covered with a very fine film of water. This water of course is not pure, it contains dissolved in it very small quantities of all the soluble bodies which it has come in contact with; amongst them are various salts, compounds of potash, nitrates, phosphates, etc.

This water then, with the various food salts dissolved in it, passes through the very delicate walls of the root-hairs, and is so taken in by the plant. From the root-hairs it is passed through the tissues of the root, until it reaches the central cylinder and the wood vessels. You remember these vessels are long tubes, and that there is a continuous system of them right through the plant. It is in these vessels that the water current travels from the roots, through the stem and into the leaves; when it reaches the leaves it is distributed—still containing the food salts in solution—to the green cells of the leaf. Some of the water is used up by the plant in the leaves, but the plant has to take in a good deal more than it actually needs; the water contains very small quantities of food salts and to get enough of these for its wants, the plant has to take in very large quantities of water.

GIVING OFF EXCESS WATER.

The excess water is got rid of by the leaves; it soaks through the thin walls of the green cells, and evaporates into the spaces between the cells; it passes from these into the outer air through the stomata. This is the process of transpiration and is, you see, merely one of evaporation. It is evident that the rate at which it takes place depends on external conditions. If the air be very dry, or if the wind be blowing, transpiration will be increased, Sometimes, especially if the soil be dry, the water evaporated from the leaves exceeds that which the roots take up from the soil; under these conditions the plant wilts, the leaves droop, and so on. Many plants have adaptations to prevent this excessive loss of water in transpiration, but I need only mention that possessed by the sugar-cane. Here the leaves roll up into a scroll, in such a way that the upper surface forms the lining of the hollow tube. In this way, the stomata, which you remember are mostly on the upper surface, are protected from the wind and the sun. And so evaporation is checked.

ABSORPTION OF FOOD FROM THE AIR.

We have now traced that part of the plant's food which it obtains from the soil up from the roothairs to the green cells of the leaf. This food consists of water with the various mineral salts in solution. We will now study the taking in of plant food from the air.

It was at one time thought that plants obtained their carbon like their other foods from the soil, and in an old book I have on agricultural chemistry the author recommends adding large quantities of blubber to the soil to increase the supply of carbon there. It was easily proved, however, by growing plans in soil free from carbon, that they could obtain all they want of this element from the air.

In the air, carbon exists in combination with oxygen as carbon dioxide. This passes, with the other gases of the air, into the leaf by the stomata and into the spaces between the cells. From these spaces it passes into the green cells of the leaf through their cell walls.

ASSIMILATION OF CARBON.

Now in the cell we have the water and food-salts brought up from the soil. Under the influence of sunlight, chemical changes go on between the carbon dioxide and the water, which result finally in the production of sugar. During this process oxygen is split off and is given out into the intercellular spaces of the leaf, and so out into the air again. The change may be represented chemically by means of formulae in this way:—

CO_2	+	H_2O	=	CH_2O	+	O_2
(carbon dioxide)		(water)		(formaldehyde)		(oxygen)
$12\ CH_2O$			=	$C_{12}H_{22}O_{11}$	+	H_2O
(formaldehyde)				(cane sugar)		(water)

Now this change only goes on under certain conditions; first of all, of course, both water and carbon dioxide must be present; secondly, the green colouring matter is necessary; thirdly, we must have sunlight. The splitting up of the carbon dioxide and its combination with water is a process that requires the expenditure of a great deal of energy, and in the presence of its green colouring matter, the plant is able to seize on the energy of the light rays from the sun and convert this into the chemical energy necessary for this process.

DISPOSAL OF SUGAR FORMED.

Part of the sugar thus formed is taken to other parts of the plant and used up as food, just as we consume the starch and sugar present in the food we eat. But a good deal more sugar is formed than is consumed in this way and the excess is stored in the stem. It travels down the leaves constantly, day and night, and when it reaches the stem is stored as sugar in the thin walled cells which fill up the spaces between the strands of wood vessels.

Part of the sugar is also combined with nitrogen and other elements and built up to proteids and finally into the living matter of the plant itself. This process also goes on in the leaf.

Now the formation of sugar in the leaf is the most important point to note in the nutrition of a green plant. All plants and animals require some carbonaceous material, such as starch or sugar, for food, but the green plant alone is able to manufacture this food from simple inorganic bodies—carbon dioxide and water—present in the soil and air.

THE STRUCTURE, NUTRITION AND REPRODUCTION OF A FUNGUS.

Now to compare with the structure and nutrition of a green plant, let us examine the structure, methods of reproduction and mode of nutrition of a fungus. For our example let us take the common grey mould that appears on damp bread and similar substances, when they are kept in a closed chamber.

STRUCTURE OF MUCOR.

The body of the fungus is very simple in structure; it may be divided into the vegetative part which provides for the nourishment of the fungus, and the reproductive part which provides for its multiplication. The vegetative part of an ordinary green plant is divided into root, stem and leaf, each with its special functions; the vegetative part of the fungus shows no such division. It is composed simply of a network of threads which branch and interweave in all directions. The threads are known as *hyphae* and the branching network that they form as the *mycelium*. Some of the hyphae grow down into the substratum and serve more or less the functions of roots, while the rest spread out on the surface of the substratum. The hyphae are all alike, and the most important point to notice about them is that they possess no green colouring matter, such as is met with in the cells of ordinary green plants.

REPRODUCTION BY SPORANGIA.

When the fungus is about to reproduce, certain hyphae, rather larger than the others, grow up straight into the air instead of creeping along the substratum. The ends of these hyhae swell up and become densely filled with protoplasm, in which we find large quantities of food grains, composed of oils and proteids. Next, a cross wall is formed, cutting off this swollen head from its stalk. Then the living matter in the head or *sporangium* divides up into a number of little pieces; these pieces round themselves off and each provides itself with a wall and becomes a *spore*. The spores escape by the bursting of the sporangium and are blown away by the wind. The point to which I would specially draw your attention is the immense number of spores that are produced. On a small piece of bread, many hundreds of sporangia will be developed and each sporangium contains very many spores.

GERMINATION OF SPORES.

Of course by far the greater number of these spores fall into places unsuitable for their development and die, but their immense numbers ensure that some at least will fall upon favourable conditions; these are, briefly, a favourable temperature, a supply of food, and a supply of moisture. When a spore does so fall, it starts to germinate; this it does simply by putting out a small hypha at one side which grows and branches and very soon gives rise to a very considerable mycelium again, which presently again begins to form sporangia.

REPRODUCTION BY CONIDIA.

There are many other ways in which other fungi reproduce themselves that I will not trouble you with, but there is one method which is of considerable importance from our point of view, that I will describe briefly. When some fungi are about to reproduce, special hyphae are formed as before and their ends become filled densely with protoplasm. The ends do not swell up as before, however, but a small piece at the end is cut off by a cross wall and becomes a spore at once; sometimes other pieces are subsequently cut off below this, and we get chains of spores. Sometimes these spore-bearing hyphae occur singly and apart from one another, but very often they are massed together in special places and we get what might be called spore beds, on which thousands of spores are produced.

NUTRITION OF A FUNGUS.

The most important point to remember in considering the nutrition of a fungus is that it possesses no green colouring matter. You remember that it is because of the possession of this green colouring matter that the sugar-cane plant is able to manufacture for itself the sugar it needs as food. The fungus needs the same food as a green plant, consequently, like an animal, it must have its sugar or starch ready made. This is the whole question of the nutrition of fungi and it is this which has caused some of them to become such deadly enemies to green plants. Fungi may obtain this organic food, starch or sugar, in two ways. Some of them are only able to take it in from dead animals or plant remains, bread, boots, jam, dead wood, etc. Others, again, are only able to extract it from living plants and animals, and these, of course, cause disease to their hosts; they are the exclusively parasitic fungi. A third group can get all the starch or sugar they need from dead organic matter, but they are also able, under certain conditions, to enter living plants and get their food from those as hosts; these are perhaps the most difficult of all to deal with, as it is very difficult to starve them out. We shall consider this question of parasitism further in my next lecture.

LECTURE II.

In my last lecture we considered the sugar-cane in health; we went briefly through the different organs of the plant and their structure, and studied the part each organ plays in the life of the plant.

DISEASE, ITS NATURE AND EFFECTS.

Today, I want to deal with the sugar-cane in disease, and the first question that arises is—What is disease? Disease may be manifested in several ways; in some cases the whole plant may shrivel up and die at once, in others the growth of the plant is stunted, in many cases disease is manfested by a wilting of the foliage. Other diseases are more local in their effects and we get wounds, cankers, galls, etc., while others are shown by the dying off of definite organs, especially leaves. I think we may call any plant diseased when any one or more of its organs is not performing its proper functions or not performing them to their fullest extent. Thus the root may be prevented from anchoring the plant in the soil or from absorbing water and food salts; the stem may be prevented from supporting the leaves in the air or from conveying the water from the roots to the leaves; while leaves may be unable to carry out their important functions of the manufacture of sugar, breathing and transpiration; again the flowers may be unable properly to form seeds and fruit.

CAUSES OF DISEASE.

A diseased condition may be brought about in a plant in two ways, or rather by two kinds of causes—internal and external. As external causes of disease I may mention the absence or scarcity of food salts in the soil, the absence of a sufficient quantity of water, or the presence of poisonous substances in the soil, which may be taken in to the plant, all of which prevents the roots from performing their proper functions. Then we may have an improper condition of the soil, which prevents the roots from obtaining the air needed for breathing and so hinders their development. Again the air may contain poisonous substances, which are taken into and hurt the leaves, or it may contain fine, solid particles which block up the stomata.

To-day we are not concerned, directly, with plant diseases that are caused by unfavourable external conditions, but we have to consider those that are brought about by parasitic fungi which live in and upon the sugar-cane plant.

SAPROPHYTIC AND PARASITIC FUNGI.

You will remember that in my last lecture I pointed out that all plants and animals require some carbonaceous food, usually starch or sugar. The green plant is able to manufacture this from simple inorganic bodies—carbon dioxide and water—present in soil and air. The animal and fungus, however, possessing no green colouring matter, require their starch and sugar ready made and so are dependent upon green plants for their food.

Some fungi are only able to make use of dead animal or plant remains; these are the so-called saprophytic fungi. Others again are able to get their food only from living plants and cannot exist on dead matter; these fungi are the obligate parasites. A third and the largest group are able to live on dead organic matter of various kinds, but they are also able to enter the tissues of living plants and make use of the organic food manufactured by the green plants for their own use; we may call these fungi facultative parasites. You will see at once that they are a difficult group to deal with. An obligate parasite may be starved out by avoiding the cultivation of its own special host plant. These facultative parasites require much more thorough and careful treatment. In order to starve them out, not only must we avoid cultivating the host on infected land, but we must also destroy all dead plants and parts of plants which may serve as resting places or nurseries for the fungus. Unfortunately, most of the fungi that attack and cause disease in the sugar-cane belong to this group.

RIND DISEASE.

The most important of these diseases is the rind disease of the stem, a disease which is historically of great importance in Barbados, as it was the susceptibility of the Bourbon cane to this disease that forced planters in this island to replace this cane by other, more resistant, varieties.

SYMPTOMS OF RIND DISEASE.

The first point that requires attention from a practical point of view is the recognition of the disease. Anyone can tell when a plant is looking unhealthy, but more definite information is required before it can be told whether a plant is suffering from an impoverished or bad mechanical condition of the soil, poor cultivation, etc., or whether it is attacked by one or other of the fungi causing disease.

Usually the first sign of the disease that is noticed is the gradual drying up of the outer leaves of the top. The leaves turn yellow, first at their margins; the yellow colour gradually extends until the whole leaf is dead and dry. The outer leaves dry up first, but the withering spreads in succession to the younger leaves, until finally the whole top is dry.

If we split a cane in which the drying up of the leaves is just beginning, we shall find one or two internodes of the stem giving distinct evidence of the disease, in that they show a reddish colour. Here and there in the discoloured area we get darker patches, in the centre of each of which is a definite white area.

Later on, the stem shows distinct evidence of the presence of the disease from the outside. Some of the internodes will be seen to have discoloured areas; these areas are reddish-brown in colour and somewhat sunken, owing to the shrivelling of the tissues underneath. If we cut into the stem at these places, we find the tissues underneath red and brown with whitish spots.

At a later period, during crop time, we find numbers of these 'rotten canes' in estate yards. By this time the whole cane is discoloured and brown, the internodes are shrunken, and the cane shows a large number of tiny, black, hair-like structures. These structures are formed under the rind and burst through this to get to the outer air.

When we take one of these hairs and examine it under a microscope, we find that it is simply a mass of the spores of the fungus causing rind disease; each hair contains thousands of these spores which are loosely cemented together by a kind of mucilaginous substance. It is by means of these spores that the fungus spreads, and we will take up the study of the fungus (*Trichosphaeria sacchari*) at this point.

GERMINATION OF SPORES OF RIND FUNGUS.

If we sow some of these spores in a drop of water and keep them under observation for a few days, we shall see them begin to germinate. Each spore puts out a small tube (hypha) at one end, which grows a little and branches, at the expense of the food stored away in the spore. In water, this food is soon used up and the hypha dies.

If, however, we sow the spores in some food material, for instance in some sugar-cane extract and gelatine, or on a slab of cane that has been steamed, development proceeds further. The hypha put out from the spore, grows considerably in length and branches all over the substratum, giving rise to a very considerable mycelium, which eventually again produces spores. The fact that the fungus can be made to grow and reproduce on steamed slabs of cane or on cane extract is of some importance; it proves that the fungus can grow and reproduce on pieces of dead cane which may be lying about on the estate, and so is able to maintain itself even though there are no living canes to be attacked.

ARTIFICIAL INFECTION OF THE SUGAR-CANE.

The next question is, how the fungus enters the sugar-cane plant. You remember in my last lecture I pointed out that the stem of the cane possesses a special layer on the outside, the epidermis, the outer walls of which are thick, tough and impervious. Some fungi can make their way in through the epidermis; they secret certain ferments which dissolve this tough outer wall, and so make their way clear to the inside of the plant, even when the epidermis is uninjured. The rind fungus is not one of these. If we sow some spores in a drop of water on the outside of a cane stem, provided that the epidermis is uninjured, no infection results.

If now we take some spores on a needle and stick the needle into the stem, through the epidermis, we get a very different result. The spores germinate and the hyphae now have only to deal with the inner tissues of the plant which they are able to break down. In a short time the infected spot becomes discoloured and shows all the signs of rind disease.

Another experiment will show the same thing. We can make a small wound in the cane by stripping off one of the leaves. Now if we sow some of the fungus spores on this wound, taking care, of course, that no other fungus spores or bacteria are introduced at the same time, the cane is again infected and shows the rind disease.

These experiments show two things clearly. In the first place, they show us that the spores found on rotten canes, when introduced into the cane plant, bring about the rind disease. Secondly, they show us that so long as its epidermis is intact the cane plant is immune to the attack of the fungus.

INFECTION UNDER NATURAL CONDITIONS.

Probably under natural conditions the fungus gains entrance to the interior of the sugar-cane most often by the tunnels of the moth-borer or of the weevil borer. The spores are produced in immense numbers on rotten canes, as you will have realized; they are blown about by the wind or become attached to the bodies of ants and other insects which frequent the rotten canes. Of course, the vast majority of them never come into suitable conditions and therefore die, but some of them are sure to be brought to a wound in some way or other, and one spore is capable of causing rind disease in a cane plant. But the tunnels of these insects are not necessary for the entrance of spores. Any small wound, caused by the breaking off of a leaf by wind, or by any other means, is a possible centre for infection, and with the thousands of spores produced the chances of one reaching the wound are fairly high.

GROWTH OF FUNGUS IN SUGAR-CANE.

Now let us see how the fungus lives when once it has started growth inside the tissues exposed by a wound. The hyphae put out from the spore first of all enter the thin-walled cells which, you remember, pack in between the strands of wood vessels. The tip of the hypha probably secretes some ferment which dissolves the thin wall of the cell, and the hypha then grows on into the cell cavity. In this way the hyphae go on, branching and growing, passing from one cell to another, until every cell around the point of infection is filled with the hyphae of the rind fungus.

DAMAGE CAUSED BY THE FUNGUS.

You remember that it is in these cells that the plant stores the excess sugar manufactured in the leaves as a reserve, the sugar for which we cultivate the sugar-cane, and the sugar the fungus requires as food. Of the three of us the fungus now has the advantage, and it consumes or destroys all the sugar contained in the attacked cells; the cells are meanwhile killed, they dry up and become discoloured, thus giving rise to the discoloured shrunken areas which are characteristic of the rind disease.

But this is not the only damage done by this parasite. Not only can it dissolve and break through the thin walls of the packing cells, but it can also dissolve the hard, woody walls of the vessels that carry the water current. A hole is bored through the wall of a vessel, and the hypha then passes in and grows and divides in the cavities of the vessel. In this way the fungus is able to intercept, and take for its own use, the water and food salts which are being taken from the roots to the leaves. So far as the plant is concerned. this is a more serious damage than the other. The sugar in the thin-walled cells is a reserve, and so long as the fungus confined its attention to this, the plant would still be able to manufacture all it required for its actual growth and life. But now the supplies of water, etc., are cut off from the leaves, and the plant can no longer manufacture its sugar and proteids. The leaves then begin to die from starvation, the outer ones first, and first their margins, then the death of the tissues gradually goes further until, finally, the whole top of the plant is killed off. The process reminds one of the starving out of a besieged city, where the besiegers have been able to cut off the water and a great part of the food supply, so that it is only a question of time when the besieged people will die off, first those who have the greatest difficulty in getting food, but finally, everybody.

REPRODUCTION OF THE RIND FUNGUS.

Now the fungus proceeds to reproduce itself. Close under the rind of the dying plant, the hyphae begin to branch and interweave vigorously; they draw supplies from the hyphae back in the stem. The cushion of hyphae thus formed becomes a spore bed in the manner I mentioned at the close of my last lecture; the hyphae nearest the surface grow out parallel to one another, and begin to cut off spores; thousands on thousands of these spores are produced, until finally, the pressure on the rind becomes so great that it is burst and the mass of black spores, bound together by musilage, is pushed out like a curly, black hair. The spores are now ripe and are ready to be carried by the wind or insects to fresh host plants.

REMEDIAL MEASURES.

Finally, we have to consider our means of fighting this pest, and it is evident that these methods may be divided into two classes: first, those that aim at the destruction of the fungus, and second, those that aim at the encouragement of the host plant. Now the most important thing about these measures is that they must be systematic and regular. It is not a bit of good fighting the fungus energetically for a time and then letting it slide, for with the immense numbers of spores produced, a very little colony of the fungus is capable of infecting a very large area. Again, they must be general. It is not fair to a planter who spends considerable time and care in destroying the fungus, if his neighbour takes no care or trouble but lets the fungus breed on his estate ready to infect the first planter's carefully cleaned land.

DESTRUCTION OF DISEASED MATERIAL.

The first way of fighting the fungus is to destroy all rotten canes. These are the breeding places of the fungus where it produces its spores, and the more promptly they are destroyed, the less chance the fungus has of spreading to healthy canes. Too often, rotten canes are stacked by themselves in the estate yard and the fungus is left to breed; I cannot conceive of any more efficient method of helping the spread of the fungus than this. Sometimes workmen are allowed to carry off the canes for fuel, and sometimes they are used in making pen manure; these practices should never be allowed. All rotten canes should be carefully collected and burnt as promptly as possible; if the canes are worth it, they may be crushed and the megass burnt. If this is carried out thoroughly and regularly, the chances the fungus has of forming spores will be very much reduced.

PREVENTION OF WOUNDS.

Then every effort should be made to prevent the formation of the wounds by which the fungus enters the cane. It is impossible to prevent wounds altogether, but the most dangerous wounds in this respect—those caused by boring insects—can be dealt with to a very large extent, if the recommendations made at various times by the Imperial Department of Agriculture are carefully carried out.

ROTATION OF CROPS.

Again, we have the chance of trying to starve out the fungus by a rotation of crops. Where this is systematically carried out, as in England, fungoid diseases give very little trouble. But we must remember that it is of little good cleaning a piece of land from the fungus, unless at the same time, we try, by all the means in our power, to prevent it from becoming infected again.

SELECTION OF CUTTINGS.

Now for our methods of helping on the host plant. The first of these is to avoid making cuttings from diseased canes. If this be done, the plant is infected as soon as it begins to grow and is doomed; not only this, but it forms a base on which the fungus can maintain itself, produce spores and infect other plants.

IMPROVED CULTIVATION.

Then we should try by careful and thorough cultivation to get healthy canes. A weak plant, like a man with a feeble constitution, is always more liable to be attacked by, and succumb to, a disease than a healthy plant or man. So by all means in your power help the plant to make a healthy, vigorous growth, so that it will be able to help itself in the struggle with the fungus.

SELECTION OF RESISTANT VARIETIES.

Finally, we have the selection of varieties of canes that will resist the attacks of the fungus. A great deal has been done in this way and is still being done to get improved resistance in varieties of cane. Of course, we cannot expect to get a variety that will be immune to disease, nor a variety that will maintain its resistance in the face of improper methods of cultivation. So by all means plant the most resistant canes you can find, but at the sametime cultivate them, so that they maintain their resistance, and use every other means in your power to prevent the spread of the fungus.

PINE-APPLE DISEASE.

The other disease of which I wish to speak to-day is the so-called pine-apple disease of cane cutting.

SYMPTOMS OF PINE-APPLE DISEASE.

The effects of this disease are to prevent the germination of the cuttings or to stop the growth of the young shoots soon after they come above ground.

The failure of these cuttings to germinate is usually put down to drought, and it is quite true that the disease is far more abundant in a dry, than in a wet, planting season. This is another example of the fact that the health of the host plant is of the utmost importance in considering the spread of its parasites. In a wet planting season, as we had last year, the cuttings make healthy and vigorous growth and so are able to throw off the disease, but if the season be unfavourable, the plants grow slowly and feebly and so readily fall victims.

On splitting open a diseased cutting a distinct odour of pine-apples is noticed, and the cutting is seen filled with a black, mouldy mass composed of the hyphae and spores of the fungus (*Thielaviopsis ethaceticus*).

INSPECTION OF CUTTINGS.

If we take some sound cuttings, dip them in water, which contains some of these spores, and then plant these cuttings, we find that they all have been infected with the disease. Infection takes place at the ends of the cuttings or at bruises and wounds, anywhere, in fact, where the cutting is not protected by its epidermis.

INFECTION OF CUTTINGS.

The next question is how to protect the cuttings from the attacks of the fungus. Numerous experiments have been carried out to test the effect of various substances in this way. Some experiments were carried out by Mr. Howard in Barbados to test the effect of immersing the cuttings in water, lime wash, dilute carbolic acid and Bordeaux mixture, also the effect of tarring the cut ends either with or without previous treatment with Bordeaux mixture.

The results of the experiments were published in full in the West Indian Bulletin (Vol. III, p. 73), but briefly put, they showed that by far the best way to treat cuttings was to immerse them, as soon as prepared, in Bordeaux mixture for six to twelve hours, then allow them to dry and tar the cut ends. Bordeaux mixture alone also gave very good results. The cost of the double treatment he worked out at $12 per 100 acres.

EXPERIMENTS IN BARBADOS.

It is still a question whether this treatment will pay when carried out on an estate scale. To test this, Mr. Bovell carried out some experiments during the last planting season in December, 1902. The results have already been given in the Agricultural News (Vol. II, p. 99), and are inconclusive. The experiments were carried on in ten series to show the results of treating cuttings with tar, and of covering them with ¼ inch of soil.

RESULTS.

Owing to the very favourable weather which prevailed at the time, from 72 to 81 per cent. of all the cuttings germinated. This shows that in a favourable season it does not pay to tar the ends. It still remains to be seen whether it will do so in a dry season and, then, taking wet and dry seasons together, whether the treatment is worth adopting as a general thing.

EXPERIMENTS IN ANTIGUA.

During the planting season of 1902-3, some experiments, based on Mr. Howard's recommendations, were carried out by the Hon. Francis Watts, at Cassada Garden estate, in Antigua. The results were published recently in the Report on Sugar-cane Experiments in the Leeward Islands, from which the following summary is taken:—

In each experiment 100 plants or cuttings were planted. There were four series, one series remained untreated, in one the plants were treated with Bordeaux mixture for two hours; in the third the ends were tarred, and in the fourth the plants were first treated with Bordeaux mixture and the ends tarred.

In each series 100 plants were planted nearly vertically at such a depth that the ends were covered with soil; another 100 were planted nearly vertically but the ends were left uncovered; a third 100 were planted flat. This gives twelve experiments, and each of the twelve was carried out in one case with tops and in the other case with cuttings.

RESULTS.

Mr. Watts sums up the results briefly as follows:—

"*Bordeaux mixture:* This is the most efficient of the agents experimented with, its influence being most strongly marked when 'cuttings' are used for plants. Without it, i. e., of the untreated cuttings, less than 20 per cent. survived, while 75 per cent. of treated cuttings grew. With tops thus treated 96 per cent. grew, while only 61 per cent. of untreated ones survived.

"*Tarring the ends:* This was of no benefit in connexion with tops, and of but very slight benefit with cuttings.

"*Bordeaux mixture and tarring the ends:* This treatment did not produce any better, or even such good, results as those obtained from the use of Bordeaux mixture only.

"From which we conclude that Bordeaux mixture when used alone, is an efficacious agent in preserving cane tops and cuttings until they germinate; that the treatment is particularly useful where cuttings are used, and a high mortality may be feared; and that this treatment will probably be useful when drought may be feared, or when canes are planted in areas liable to fungoid attack."

It does not appear that a comparison was made between cuttings treated in the ordinary estate way—with water, lime wash or dilute carbolic acid and those treated with Bordeaux mixture. So we still want conclusive experiments, carried out on the estate scale, to show the effect of Bordeaux mixture.

USE OF SOUND CUTTINGS.

There is another preventive method which should be generally adopted, and that is to avoid planting cuttings which show any wounds, especially those caused by the moth or weevil borer. These cuttings will probably be infected before they are planted and give the fungus a good start. So that, as in the case of the rind disease, only perfectly healthy and sound cuttings should be planted.

OTHER SUGAR-CANE DISEASES.

These are a few other fungi causing cane diseases, some of which attack the leaf, others the leaf-sheath, and damage the plant by destroying a certain amount of leaf-tissue in which sugar formation is going on; but they do comparatively little damage and are economically of small importance.

The root disease, which at the present time is the most important of all the fungoid diseases of sugar-cane in the West Indies, I shall consider in my next lecture.

(To be continued.)

SUGAR IN THE WEST INDIES.

By Dr. C. A. Kern.

The recent passage of the Cuban Reciprocity treaty has called the attention of the American sugar world to the resources and history not only of the Island of Cuba, but also to that of the other West Indian Islands, especially Haiti and Santo Domingo.

The increase of the sugar product, and also the lessening of the cost of its production, as reported by the United States Consul General in Havana, F. Steinhart, is remarkable, and it shows what might be accomplished in this line on the other islands.

First I shall give a short recapitulation of the present status, facilities and future possibilities of Cuba in regard to sugar. A caballeria—the usual land unit in Cuba—is equal to 33 16-100 acres. The cost of cultivation, planting, etc., is $1,201 per caballeria; this produces at a fair average 614 tons of cane; virgin soil yields as high as 1,000 tons of cane, but the aforementioned quantity is the average taken from statistical figures. The average yield in sugar is from 195 to 235 pounds per ton, according to the more or less improved machinery employed. The percentage derived by the use of modern machinery is from 10½ to 11 per cent of sugar, while that derived by old machinery amounts to from 8½ to 9 per cent.

However, the best result of increased output of sugar per acre is not entirely dependent on the grade of machinery used in the manufacture of sugar, but on the rational cultivation of cane, as shown by the astonishing results obtained in Java. In Java the average percentage of yield per acre with the use of old machinery is 14 to 16 per cent. In Cuba about 12 per cent. of the plantations work with modern machinery and 88 per cent with old machinery.

The possibilities of enlarging the output of sugar in Cuba are enormous. Of all the available land for cultivation of cane, only one-quarter is cultivated, viz., 12,784 caballerias of the suitable 51,344 caballerias. With proper cultivation and with improved modern machinery Cuba alone is in the position to produce annually about 5,000,000 to 6,000,000 tons of sugar, or about half of the present production of the world.

Cuba has not always been the foremost sugar-producing island in the West Indies, and the following little historical sketch will show the changes in these countries. It is an historical fact that Columbus, on his second voyage to America, brought the first sugar cane to the West Indies from the Canary Islands and Africa, and that the first place (1403) it was planted was in Santo Domingo (Hispaniola). In one of his reports to the King of Spain he tells of the splendid results from the sugar cane cultivated in Hispaniola. The historian Ovieda claims in his *Historia natural de las Indias* that he saw the first sugar cane planted in America; also, that the first roller mill was introduced from the Canary Islands by Gonsalo de Veloso. The latter built the first sugar mill (driven by water) on the River Nigua.

In 1515 the first sugar from the New Country was brought to Spain, and the new industry developed so rapidly that in 1518 there were eighteen sugar mills in operation. The religious order of the Hieronymites were especially active in advancing money and importing slaves to advance the industry. In fact, in 1525, thirty of the large sugar houses were so active that all the forests within a radius of twelve miles around Santo Domingo were consumed as burning material. In 1556 forty sugar mills and thirty thousand negroe slaves were working sugar cane in Santo Domingo. In fact, the importation of the negroes was mostly due to the introduction and cultivation of sugar cane, and this was also responsible for the important ethnographic change of part of our continent, and especially the Africanization of an important part of our continent.

In 1625 the Island of St. Christoph was simultaneously occupied by England and France, and they began the cultivation of sugar cane and the manufacture of sugar, the former about 1643 and the latter 1644. From this island the English invaded the Barbadoes (1627) and introduced the cane (1641), and five years later exported sugar. The French conquered Guadalupe and Martinique about 1635. The sugars manufactured on these islands were inferior in quality to that imported from Brazil, and could not compete with the latter, until the Dutch sugar planters, who had been driven out of Brazil by the Portuguese, came to the West Indies and brought with them the then most improved methods and machinery for sugar production. In 1676 the Barbadoes alone exported 60,000 tons of sugar. From the Barbadoes (1664) the sugar cane was introduced into Jamaica, which had shortly before been conquered from Spain by the English. At the time of this conquest Jamaica had only three small sugar mills, but in 1670 the number had increased to seventy-five. The sugar industry of the English islands was not of such a high standard as of the French islands, where this art was perfected by the Dutch who had been expelled from Brazil, and who produced a better and cheaper sugar in larger quantity, so that the English could not compete. Here we find the first traces of the coming struggle for independence by the United States of America against England. The English planters had complained to their home government of the deplorable condition of the sugar industry, and a commission (committee) was sent to the New World to investigate and report. This report stated as causes that the methods of cultivating sugar cane and manufacturing sugar were not up to date, but that the greatest drawback for the English sugar trade was the trading and buying of sugar, syrup and rum by the North American Colonies, direct from the French Islands, which was against the law. The North American colonists complained that the English planters in Jamaica, Barbadoes, etc., produced only an inferior quality and too small a quantity for their consumption, and that the prices were exorbitant. In view of these facts England by an act of Parliament (1739) levied prohibitive custom duties on all sugar, molasses and rum imported into the British colonies. The consequential result of this act was a very elaborate system for smuggling sugar into North America and a developing dissatisfaction with England.

The most highly cultivated island in the eighteenth century was Santo Domingo, which was occupied by the French, having been conquered by them from the Spaniards about 1660. At this latter date the sugar industry of these islands was very nearly extinct, but the French colonists and those Dutch who had been driven out of Brazil revived it in a very short time, so that as early as 1724 there was a production of over 10,000 cwt. of sugar from about 200 mills; in 1726 the export amounted to 198,000 cwt.; in 1770, to 800,000 cwt., and in 1773 1,200,000 cwt., raw sugar, 30,000 barrels syrup and 1,500 barrels of rum, valued at over 100,000,000 francs. But all this highly developed industry was destroyed by the great revolution of the negro slaves in 1791, when 1,130 sugar plantations and mills were devastated in sixty days, and since then Santo Domingo has ceased to rank high in the sugar trade.

Santo Domingo is about one-half as large as Cuba, with a population approximating 40 per cent of that of its larger neighbor. Potentially it is in proportion to its area quite as rich as Cuba. In fertility of soil and in excellence of climate it is Cuba's rival. Its commerce is largely a matter of guesswork, and would compare with Cuba's about as follows:

	Cuba.	Santo Domingo.
Imports	$60,000,000	$3,000,000
Exports	70,000,000	6,000,000

This great difference in the economic conditions of the two countries is due primarily, if not entirely, to Santo Domingo's persistent reign of political disorder. With inducement for life and property, Santo Domingo would become, acre for acre, as fruitful as Cuba. With assurance of peace under an honestly administered government, there is no reason to doubt that Domingoan sugar production would speedily be increased to 2,000,000 or 3,000,000 tons per annum. Through the negro revolution in 1791 the sugar industry was transferred to Cuba and Louisiana.

In 1790 Cuba produced 141,629 cwt. of sugar, and the product during a century gradually increased to 1,300,000 tons. All the other West Indian islands together produce 3,000,000 to 4,000,000 tons.

It is safe to say that by proper cultivation and selection of cane, as in Java, and by utilizing the available acreage on all the islands, the West Indies are able to supply the present demand and consumption of the world, which is estimated at 10,000,000 to 11,000,000 tons of sugar.—(Fed. Reporter.)

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GERMAN BEET-SUGAR INDUSTRY.

(From United States Consul Warner, Leipzig, Germany.)

INTRODUCTION.

At the time it was decided to make a report upon the German beet-sugar industry the writer was ignorant of the fact that it had been so ably handled by many, either in an official or a private capacity, both in this country and in the United States. Especial attention is called to the exhaustive way in which the German sugar industry has been treated by the United States Bureau of Statistics, beginning on page 2587 of the Monthly Summary of Commerce and Finance of the United States, January, 1902, and the reprint extracts thereof which appeared in the same publication for November, 1902. It is hoped that by bringing some of the figures appearing therein down a year later and handling the subject in a somewhat different way—*i. e.*, by dealing more with the agricultural and economical features thereof—it will have accomplished what was intended, namely, to furnish information that will be of interest to the American beet-sugar industry, which, although yet in its infancy, is destined to become a great commercial factor.

HISTORICAL.

It was in 1747 that the German chemist Marggraf (1709-1782) discovered the existence of sugar in beets and recommended that they be cultivated in order to produce sugar; but almost fifty years elapsed before practical results were obtained therefrom.

In 1796 Dr. Franz Karl Achard, a pupil of Marggraf, having succeeded in extracting sugar from beets in commercial quantities at a cost so as to enable it to compete with cane sugar, the then ruler of the world's markets erected the first beet-sugar factory at his farm, Kunern, near Steinau, Lower Silesia. The politicial events of the succeeding years tended to further the production of sugar beets, as did the improved technical methods. The continental blockade (November 21, 1806) prohibiting the importation of English goods into European countries caused the cane sugar imports to decrease and at the same time gave an impetus to the beet-sugar industry. After the downfall of the Napoleonic regime (1815) it was not for the mother country of sugar beets to continue in the lead; indeed, the devastation and depression of the country and the resumption of the cane-sugar imports retarded the growth thereof in Germany. Instead, this new industry began to flourish in France, owing to public subventions and the great wealth of the country. As early as 1828 there were already 108 beet-sugar factories established there. In Germany, on the other hand, the production of sugar beets did not begin to increase until the 1830's, from which date to the present time it has steadily grown, until now Germany's beet-sugar industry is the largest in the world. A clear conception of this growth may perhaps best be obtained from an examination of the following figures:

TABLE I.—*Growth of the beet-sugar industry in Germany.**

Year	Factories in operation.	Beets worked up.	Raw sugar produced.	Average quantity of beets worked up per factory.	Beets required to produce a ton of raw sugar.	Sugar in beets.
	Number.	*Metrictons.*	*Metrictons.*	*Metrictons.*	*Metrictons.*	*Per cent.*
1836-37	122	25,346	1,408	207.7	172.9	5.55
1840-41	145	241,486	14,205	1,665.4	170	5.88
1850-51	184	736,215	53,349	3,001.1	138	7.25
1860-61	247	1,467,702	126,526	5,942.1	116	8.62
1870-71	304	3,050,745	186,418	10,068.1	116	8.62
1880-81	333	6,322,203	573,030	18,690.3	110.6	9.04
1890-91	406	10,623,319	1,284,485	26,195.8	79.5	12.54
1900-1901	395	13,253,909	1,874,715	33,552	67.2	14.86
1901-2	395	16,012,867	2,182,361	†40,538.9	73.4	13.63
1902-3 (13) months	393	11,270,978	1,645,444	28,679.3	685	14.6

The causes of the increase in the beet-sugar industry of Germany, as well as of the European countries, may be attributed to three things, namely:

1. Beets thrive in different kinds of soils, in diverse climates, and over a large area (of course, some varieties of beets being better suited to certain climates and soils than others).
2. The assistance rendered by agricultural chemistry undertaken by public experiment stations, societies, and private individuals.
3. The liberal subventions given the industry by some governments.

With these things to foster the beet-sugar industry of this country, its increase has been very marked, though somewhat irregular. The extraordinary encouragements offered beet growers led in 1884 and 1885 to an overproduction, which brought with it all the usual evils, viz, a reduction of prices, a stagnation of business, and a decreased production, which lasted several years. During this period of depression, however, other countries were continuing to increase their respective productions, and it was not until 1892-93 that the German industry began to show new signs of growth, though by no means in the same proportion as formerly. For the purpose of comparison the figures given below show the production of beet sugar in Germany, France, Russia, and Austria, the four most important beet-sugar countries:

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*Compiled from Handworterbuch der Staatswissenschaften, Vol. VII, p. 999, and other authorities.

† Estimated.

‡This year is made to end with August (the year previous hereto ending on July 31) to conform to a provision of the Brussels convention; hence the thirteen months.

TABLE II.—*Production of raw beet sugar.**

Year.	Germany. Met. tons.	France. Met. tons.	Russia. Met. tons.	Austria. Met. tons
1852-53..	84,000	50,000	25,000	30,000
1859-60..	145,000	111,000	30,000	84,000
1869-70..	217,000	289,000	132,000	151,000
1880-81..	573,000	317,000	276,000	533,000
1890-91..	1,331,000	694,000	544,000	778,000
1900-1901..	1,979,000	1,155,000	893,500	1,080,675
1901-2..	2,302,000	1,170,000	1,104,700	1,288,055
1902-3..	1,748,556	837,178	1,215,000	1,057,202

There are other countries that are rapidly becoming large beet-sugar producers, some of which are Italy, Sweden, Japan, Spain, and the United States. Belgium and the Netherlands, while they produce more than enough for the home markets, can not materially increase their productions, owing to the small available area they possess. Spain, with her cane sugar, already possesses more than enough to supply the local demand, and Italy is already almost independent of foreign markets.

Before concluding the historical summary, a word further should be said about the cane-sugar industry. The table immediately following shows a comparison between the production of the world's beet and cane sugar. The same, however, is not correct, because the statistics regarding India, China, and Japan are not available. However, it indicates that the beet-sugar industry is today far ahead of the cane. Perhaps now that the political, economical, and social conditions of the tropical countries are being so much bettered, there will develop a new era in the life of sugar cane.

TABLE III.—*World's sugar production.**

Year.	Production of— Beet sugar. Metric tons.	Cane sugar. Metric tons.	Total production Metric tons.
1852-53..	202,000	1,260,000	1,462,000
1859-60	451,000	1,540,000	1,991,000
1869-70	846,000	1,740,000	2,586,000
1880-81..	1,820,000	2,027,000	3,847,000
1890-01..	3,666,000	2,860,000	6,526,000
1900-1901..	6,040,000	3,435,000	9,475,000
1901-2..	6,905,000	3,796,000	10,701,000
1902-3..	5,613,000	4,118,000	9,731,000

*Compiled from Le sucre de betterave en France (Paris, 1900) and other authorities.

*Compiled from Handworterbuch der Staatswissenschaften, 2d ed., Vol. VII, and other authorities.

PRODUCTION OF SUGAR BEETS.

It is true that German agriculture has experienced many changes since the formation of the Empire in 1871, not only in the kinds of crops, but in the quantities thereof as well. The system of intensive farming has been so developed that today there is hardly an acre of land, however poor, that is not used for some purpose or other. In the year 1878 the area devoted to the cultivation of cereals was about 32,927,-471 acres, and in 1900—the year the last statistics were compiled—35,930,680 acres, showing an increase in area of 3,003,-209 acres. In 1878, 8,779,463 acres were planted with vegetables, of which 6,715,168 acres were potatoes and 434,401 acres were devoted to the cultivation of sugar beets and sugar-beet seeds. In 1900, 11,349,874 acres were planted with vegetables, of which 8,010,606 acres were potatoes and 1,138,-971 acres sugar beets. The increase in the total vegetable area and in that of potatoes and sugar beets has been 29.3 per cent., 17. 5per cent., and 162.2 per cent., respectively. In a word, it may be said that the enormous increase in the production of potatoes and sugar beets is to be accounted for by recalling that such articles, because of their auxiliary industries, are especially adapted to the most intensive form of farming.

From the last two official crop statistics, for the years 1893 and 1900, we are able to note the exact changes that have taken place in the way the land has been cultivated, as is to be seen from the following table:

TABLE IV.—*Division of area.**

	Area cultivated.		Total area.	
	1893.	1900.	1893.	1900.
	Acres.	Acres.	Per cent.	Per cent.
Agriculture	86,891,715	86,621,926	60.1	64.8
Arable and garden products........	64,846,979	64,881,820	48.55	48.56
Cereals....	35,357,620	35,869,097	26.4	26.85
Vegetables..........	10,471,257	11,349,874	7.84	8.5

The cultivation of beets is, of course, included under vegetables in the above.

The following table shows the total area in vegetables, in sugar beets, and beets of all kinds for the years 1903 and 1900, respectively:

*Compiled from Vierteljahreshefte zur Statistik des Deutschen Reichs and other authorities.

TABLE V.—*Area in vegetables and sugar beets.*

Year.	Vegetables. Acres.	Sugar beets. Acres.	Total beets. Acres.
1903	10,471,257	976,823	2,097,106
1900	11,349,874	1,138,942	2,420,910

In the year 1893, 1.56 per cent. of the arable and garden land under cultivation in Germany was devoted to the raising of sugar beets and sugar-beet seeds. In 1900, it had increased to 1.81 per cent.

The efforts which the farmers have made to cultivate sugar beets have not remained unrewarded. Their profits have been increased, not only because of the beet production and its by-products, which are so valuable for cattle raising, but by reason of the greater fertility and productivity of the soil consequent on beet growing.

The process of extracting sugar from beets would seem to be an industry which may be most profitably operated on a large scale, as regards the number of persons employed. This may perhaps be seen from the following table:

TABLE VI.—*Number of employees and factories in 1895.*

Factory	Number of factories.	Number of employees.
1 to 20 persons	10	78
21 to 100 persons	43	2,913
101 to 500 persons	384	78,983
501 to 1,000 persons	18	11,843
More than 1,000 persons	1	1,345
Total	456	95,162

Now, before taking up the practical part of this subject, a few more statistics must be inserted herein. This is done without comment, it being hoped that the next two tables have been compiled so as to show at a glance, important features connected with the manufacture of beet sugar.

*Compiled from Vierteljahreshefte zur Statistik des Deutschen Reichs and other authorities.

*Compiled from Statistik des Deutschen Reichs, 1895, vol. 113, and other authorities.

TABLE VII.—*Regarding raw-sugar factories.*

Description.	1896-97.	1901-2.	1902-3.
Number of factories..	399	395	393
Steam engines:			
Number..	5,446	5,789	5,811
Horsepower	105,788	134,567	138,020
Number of periods of labor of 12 hours..	68,757	65,342	4,859.1
Beets worked up, metric tons	13,721,601	16,012,867	11,270,978
Area of beets, acres..	1,089,881	1,182,970	1,056,727
Average of beets per hectare (2,471 acres), metric tons.	32.3	33.4	26.4
Production of raw sugar, metric tons.	1,738,885	2,182,361	1,645,444
Average production of raw sugar per 1 double centner (220 pounds) of beets, kilograms..	12.66	13.63	14.6
Quantity of beets necessary for the production of 1 kilogram (2.2046 pounds) of raw sugar, kilograms.....	7.9	7.34	6.85

CULTIVATION OF SUGAR BEETS.*

The agrarian crisis, which occurred in Germany as well as in other European countries, in the year 1879 was caused by the importation of large quantities of American cereals to these markets.† This resulted in many of the larger farmers limiting the area devoted to the production of grain and en-

*Compiled from Vierteljahreshefte zur Statistik des Deutschen Reichs, 1902, Part IV, and 1897, Part IV, and other authorities.

* Works which have been used in connection with this paper are: W. Katzenstein's Die Deutsche Zuckerindustrie und Zuckerbesteuerung; Von Lippman's Die Entwicklung der Deutschen Zuckerindustrie von 1850 bis 1900; Stutzer's Zucker und Alkohol; Knauer's Rubenbau; Kiehl's Ertagreicher Zuckerrubenbau; Von Schonberg's Handbuch der Politischen Oekonomie; Handworterbuch der Staatswissenschaften, 2d ed. In addition thereto the writer, by visiting large farms in the Province of Saxony, where beets and beet seeds are cultivated, was able to learn from the farmers themselves how sugar beets are grown. For the kind assistance rendered by Oekonomierat Hornig the writer is deeply grateful.

† In the North American Review, August, 1903, p. 247, Signor Luzzatti speaks, perhaps in ill-chosen words, of "an absolute agrarian revolution" having been produced.

larging that of vegetables, especially sugar beets and pota toes.

Farming in Germany is very different from anything known in the United States. There are many causes therefor, the most important of which are the sound educational and financial features. However, these will not be taken up in this paper, but will be held for a more appropriate occasion.

CLIMATE.

Sugar beets are successfully planted in all parts of Germany. Of course in some sections better results are achieved than in others. The Province of Saxony, which formerly belonged to the Kingdom of Saxony, is where perhaps the largest and best crops are grown.

Sugar beets need a certain amount of water, as well as plenty of sunshine and light. Experience has demonstrated that the temperature of the growing season is an important factor in the percentage of sugar contained in beets. All things being equal, the longer the days the greater will be the sugar percentage and the purity coefficient, due to the action of the sun's rays.

SOIL.

It is believed by some experts that a maximum beet yield produces a smaller percentage of sugar than a normal one. Beets are known to thrive in many kinds of soils; perhaps the best of them is a mild, loamy, sandy one, with plenty of depth and humus. The beet is a deep-rooting plant, which takes a large part of the moisture it requires at a depth of from 20 to 30 centimeters (8 to 11.8 inches). Beet fields must be well drained, not only on the surface but to a depth of 50 centimeters (19.68 inches). While the plants require a certain amount of moisture, if they have too much the crop of leaves will be increased at the expense of the roots and the sugar percentage. One might almost say that plateau lands, as well as the slightly sloping "limestone farm lands," are best adapted for sugar-beet raising.

MANURING.

Of all root vegetable plants the sugar beet is one of the most susceptible to the nourishment which it receives from the soil. Farmers, therefore, in order to obtain the best results, manure their lands very thoroughly.

Manuring should be done in the autumn, shortly after the harvesting is over. The manure should be spread over the land and then plowed under, in which condition the fields should remain until the following spring. It has been found that good average land will be kept best up to the standard by spreading thereon 250 cwts. of manure to the morgen.* Cattle and sheep manure may both be used. Some kinds of manure are of course better for certain kinds of soil than others.

PLOWING.

New land, or such as has been cultivated but one or two years at the most, is not the best for raising sugar beets. If only such land, however, is available, the soil will be greatly benefited and the power of producing considerably augmented by planting alfalfa, field pease, or something of the kind, and when the plants are in bloom plowing under. Intensive farming requires that soil be plowed deeper than under the old system, it having been demonstrated that better results are obtained thereby. Where formerly soil was turned to a depth of 6 to 8 inches with a two-horse plow, it is now being turned 14 to 16 inches by means of steam, electric, or six-horse plows. Oxen are also used. It is the opinion of an expert, who is one of the largest sugar-beet-seed growers in the world, that the additional power required to plow 16 inches deep instead of 12 inches in good, healthy soil does not make enough difference in the beet yield to warrant its being done; that for all practical purposes no soil except that of new, slack, or stale land need be turned more than 12 inches deep. Slack soil is plowed from 14 to 16 inches deep; new or stale soil should perhaps be plowed even deeper.† A field should be plowed as soon as possible after the crops thereon have been harvested. A good, open soil 12 inches deep would appear to give the best results. The plowed fields should not be harrowed until spring. Soils need plenty of air, which the coarse furrows enable them to obtain.

FERTILIZING.

It is not enough simply to manure the land. Good results are obtained by applying a mixture consisting of the following:

	Per cent.
Dissolved phosphates	36
Ammonia	20
Saltpeter, Chilean	16
Other mineral substances	28

*The morgen used by the consul is doubtless the German morgen, or land measure, of 0.63 acre.

†Oekonomierat Horning, owner of the Volkstedt beet-seed farm, is my authority.

This mixture is spread upon the fields 2 centners (220 pounds) to the morgen either by hand or machinery.

PLANTING.

Most of the planting is done in the months of April and May. The time for planting is, perhaps, when the temperature of the soil averages about 54° F., when the soil is warm enough to insure the seeds germinating within six or eight days. The seeds are drilled in rows about 16 inches apart. Care has to be taken to see that seeds are not covered up too deep. From one-half to three-fourths of an inch is about right. It is much better to have seeds covered too thinly than that they be buried too deep.

LABOR.

In Germany machinery as well as hand workers are employed in raising sugar beets. As can well be imagined a very large number of laborers is required. In addition to the reasons already given why this country has attained such prominence in the beet-sugar industry another reason is that such cheap farm labor is to be obtained. For the most part the people who till the soil of the German beet fields are two-thirds females and one-third males. They are brought from Posen, Germany, Russian Poland, and from the Province of Galicia, Austria, usually by employment agents. Their railway fares going and coming, amounting to about 8 marks ($1.90) each way, are paid by their employers, by whom they are fed and lodged.

By working twelve to sixteen hours a day they are perhaps able to earn 50 cents—usually less, however. The mental and moral condition of these people has often been the subject of official reports, investigations, etc., and, while all admit that their lot is a sorry one, nothing has been done to improve it.

CULTIVATION.

As soon as the seeds are in the ground, the fields are usually gone over with a roller. By this means the moisture, so essential to germination, is preserved, thus keeping the surface soil from drying for a longer period of time. Shortly after the plants become visible, the work of hoeing and thinning out is begun. The former loosens the earth about the plants, covers up the roots thereof, and works out the weeds, thus enabling the plants to have more air; the latter, by leaving a distance of about 7 inches between the plants, gives each one more soil from which to obtain nourishment. The better weeded the rows are kept and the more frequently they are worked, including hilling—perhaps it should be called rowing—the better will be the yield as regards both quality and quantity.

HARVESTING.

About the 1st of October the beet leaves begin to turn yellow and droop, which is a sign that they are ready for gathering. At the very first indication that the beets are ripe the harvesting is not commenced, but a week or two later. By making too early a start with the harvesting, there is danger that the beets will not have attained their maximum percentage of sugar.

Now, before continuing with the harvesting of sugar beets, that point in the production thereof has been reached where a word should be said in explanation of the way that beets are grown.

For seed purposes.—The raising of sugar beets and sugar-beet seeds are two very distinct and separate occupations. Germany has taken the lead even more as regards the latter than the former. Indeed, three-fourths of the world's annual production of sugar-beet seeds (1,200,000 sacks) are grown in Germany, the Province of Saxony alone contributing 800,000 sacks. In this country the two occupations are practically separated. The professional seed growers produce a smaller quantity of sugar beets, and the professional sugar-beet growers often make no effort to raise beet seeds. Generally speaking, it may be said that the two best species of sugar-beet seeds are the Vilmorin, or French, and the Kleinwanzlebener, or German, both of which are very extensively grown. Both species are divided into any number of varieties. Indeed, every professional seed grower has his own particular brand of seeds, some of which have more or less distinctive features. There is perhaps really very little difference between the first-class seeds of these two species. As said before, the plants are allowed to ripen, which takes from one hundred and fifty to one hundred and sixty days; then the harvest begins. Each plant is pulled up one by one and placed in silos, which are usually on a side of the field—at any rate invariably in the immediate vicinity thereof. The beets remain packed in the silos until the following spring, when the time for planting comes round; then they are taken out, and each one is subjected to a chemical analysis and only those which show a high percentage of sugar and purity are set out in rows 24 to 30 inches apart. The beets that are rejected are fed to cattle.

The plants go to seed the second year. They are harvested about the 1st of October, after the stalks have become thoroughly dry and before the rainy season sets in. The stalks are afterwards thrashed by machines in the same manner as are cereals, care being taken to keep the seeds as dry as possible. Afterwards the seeds are subjected to a screening process, which consists in passing them over a number of sieves, the chaff, stalk splints, etc., being thus separated, and afterwards the large, healthy seeds from the smaller ones, which are fed to cattle. The stalks are either used as straw bedding or else are consigned immediately to the manure pit. At the end of two years, however, the seeds are not used as first-class sugar-beet growers. The same process of two years' duration must be thrice repeated before the seeds reach the high standard required. Indeed it is said that the first quality of seeds is only obtained after five campaigns, which means only at the expiration of nine and a half years from the time the experimental seeds were first drilled.*

For factory use.—To return now to the harvesting time. The beets are here also pulled up, one by one, by hand. The machine pullers, although known, are little used. A number of laborers, who work together, are assigned a section of a field. After pullling up and laying in piles about as many beets as they can top in a day, the topping begins.

TOPPING.

This is done with one stroke of a sharp knife, which has perhaps an 8-inch blade and is a cross between a corncutter and a butcher's knife. The leaves, as well as about one-fourth to three-eights of an inch of the top of the beet, are cut off. As soon as possible after beets have been topped they are loaded into wagons and started on the way to a factory. Where it is not convenient to deliver beets at once to a factory they should be placed in silos, so that there will be little possibility of their suffering from frost.

HAULING.

The hauling is done in large two-horse wagons, holding perhaps from 1 to 2½ metric tons each, the wheels of which are 3 to 4 inches broad. The advantage of having such broad-wheeled wagons, which are very plainly though substantially built, is that they are easier to draw, especially where the ground is soft, as over plowed fields, soggy roads, etc. Beets must be raised as near to the factory to which they are to be delivered as possible. The longer the haul the smaller the profits for the grower.

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*Seeds may not be kept for a number of years before planting. To obtain the best results from their use they should be put in the ground the spring following the time they were harvested.

RAISERS.

The most successful sugar-beet as well as sugar-beet-seed raisers are the plantation owners. This is doubtless because this class of farmers is the only one able to get the full benefit of the by-products of the beets. The intensive system of farming requires that large quantities of manure as well as fertilizers be spread over the soil. The farmers are not able to buy sufficient quantities; therefore they must have a large supply of live stock constantly on hand to make such. The stock are not only fed with the beet leaves and tops, but with the small seed, beet pulp, and molasses as well. The factories give the farmers the pulp obtained from the beets which each one delivered, and the molasses they buy at a small price. Again, as sugar beets are worked almost entirely by hand, the big farmers are usually the ones who are in the best circumstances to pay for such labor. Another point: The three-crop system is the most common form of intensive farming. By this is meant planting different kinds of crops in rotation. For instance, on good healthy ground a crop of potatoes will be sown the first year; this will be followed the next year by sugar beets; and the third year some kind of cereal will be grown thereon. Only those who have large tracts of farm land are able to plant their fields in the rotating order here mentioned.

The most successful of the large farm owners in this country usually take charge of the entire farming themselves. The occupation is considered a highly respectable one; perhaps it is regarded more highly in Germany than in any country in the Western Hemisphere. This class of farmers is especially well qualified for the work. They are theoretically, as well as practically, educated in all branches of agriculture.

BANKING FACILITIES.

Although the farmers of this country are complaining about the little financial assistance accorded them they have certainly been provided for, not only by the State but by private individuals as well, far better than those of all other countries. Further, their educational qualifications make them competent to use to advantage the, in some respects, none too modern though liberal banking facilities offered them.

LOCATION OF FACTORIES.

Sugar-beet factories are located as near to where beets are grown as possible. Certainly an additional reason for the growth of the German beet-sugar industry to those previously given is to be found in the co-operative factories. In the campaign of 1901-2 40.8 per cent. of the beets consumed were grown by factories themselves or by shareholders in co-operative factories. In Germany sugar factories are not the direct results of the money of capitalists seeking investment. They have sprung up because of the necessity which the farmers of a certain community may have manifested for them.

TAXES.

Before concluding, a few words should be said about the taxation to which the beet-sugar industry has been subjected. The history thereof shows that it has been of the greatest benefit to the industry, enabling it to build up an enormous export trade. There have been, as a matter of fact, three forms in which these taxes have been levied. The first, and that which continued for the longest period (1841 to 1884), was the taxation of sugar beets. While this tax was at first but 10 pfennings (2.38 cents) per double centner (220 pounds) before the law under which it was levied was finally repealed, it had increased to 1.80 marks (43 cents) per double centner, it having been increased whenever it was found that a larger quantity of sugar could be obtained from a double centner of beets. When sugar was exported the taxes were refunded, the Government assuming a certain number of pounds of sugar to have been produced per double centner of beets consumed. This assumed quantity was necessarily a general average for all establishments.

The larger factories, owing to the higher percentage of sugar contained in the beets and to improved machinery, had a decided advantage over the smaller ones, as regards the export trade. The former, by exporting, received bounties larger than the actual taxes paid by them. Such trade was, therefore, more profitable for them than selling in the home markets. The financial success of this system was not that which was expected of it, as will be seen from the figures of the last year the same was in force, namely, 1887-88:* Total taxes collected, 118,388,000 marks ($28,196,344); total export rebates, 105,568,000 marks ($25,125,184); net proceeds, 12,920,-000 marks ($2,951,160).

The result of Germany's increased export of beet sugar caused the sugar prices in foreign countries to fall. It caused France Austria, and other beet-sugar countries to guard their beet-sugar industries by means of similar bounties, direct or indirect, in order to hold their respective export trades. In 1888 the constant falling of prices occasioned by overproduction caused the governments of the countries exporting beet sugar to make an effort to abolish all bounties, drawbacks, premiums, etc. A conference was held at London in

1888 for this purpose, the results of which were fruitless, however.

The second system of taxation, or that introduced in 1888, was of short duration, lasting but four years. This provided for a tax of 80 pfennigs (19 cents) per double centner (220 pounds) of beets and, in addition thereto, one of 12 marks ($2.85)' per double centner upon manufactured sugar. Further, the drawbacks were correspondingly reduced. The results of this system, during the last year (1891-92) it was in force, may be seen from the following figures: Total taxes collected, 143,515,000 marks ($34,156,570); total export rebates and bounties, 74,611,000 marks ($17,757,180); net proceeds, 68,904,000 marks ($16,399,152).

This system was not found to be satisfactory for much the same reason as the first one—the inadequate revenue collected therefrom as well as the partiality shown the sugar industry by fostering the export at the expense of home consumption.

The third system—provided for under the law of 1891—abolished the tax upon beets and increased that upon sugar to 18 marks ($4.28) per double centner. The export bounties were considerably reduced, averaging perhaps 1.60 marks (38 cents) per double centner (220 pounds) for the three kinds of sugar. A further reduction was also made in 1895 to about 1.35 marks (32 cents) per double centner.

In 1896 a law was passed more than doubling the export premiums and increasing the tax upon sugar to 20 marks ($4.76) per double centner. In addition thereto two important features were also introduced, namely, the so-called Betriebssteuer, which taxed larger factories heavier in proportion than the smaller ones, the taxes being levied upon the amount of sugar produced, and the Contingentierung, limiting the annual production of beet sugar. These measures were adopted in order to protect small factories against the competition of the larger ones, as well as to prevent the possibility of an overproduction. The financial result of this system for the year 1901-2 may be seen from the following figures:* Total taxes collected, 144,332,000 marks, ($34.351,016); total export bounties, 40,739,000 marks ($9,695,882); net proceeds, 103,593,300 marks ($24,655,205).

For the thirteen months beginning August 1, 1902, and ending August 31, 1903, the financial results were as follows: Taxes collected, 154,939,000 marks ($36,875,482); total export bounties, 37,346,000 marks ($8,888,348); net proceeds, 117,593,000 marks ($27,987,000). The year is made to end with August 31 to conform to a provision of the Brussels sugar convention.

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*Statistisches Jahrbuch fur das Deutsche Reich, 1903, p. 229.

The general character of the beet-sugar industry does not appear to have undergone any considerable change since the introduction of this third system of taxation. Compared with England and the United States, consumption of sugar per capita is very small in Germany, as well as in other European countries. Indeed, some assert that it would be well for the people were they to take more of the nourishment sugar affords. Perhaps one of the results of the Brussels convention, abolishing export bounties in the countries of the contracting parties, which went into effect on the 1st of September, 1903, will be to lower the price of sugar and thus increase the home consumption.*

BRAINARD H. WARNER, JR.,
Leipzig, Germany, December 2, 1903. Consul.

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INSECTS BENEFICIAL TO MAN.

By John Isaac.

We hear so much of the cost and destructiveness of insects that it is somewhat difficult to conceive that there can be any good in the insect world, a world that, to the farmer, seems to be wholly devoted to his injury. We know all about the destructive work of the Hessian fly in our wheat fields, the damage which the chinch bug does to our growing grain. We know about the codling moth in our apple orchards and how costly it is and the immense damage it does us. We know all about scale insects and their enormous cost to us. We are well acquainted with the army worm, the cut worm, the tent caterpillar and numerous others, which thrust their unwelcome and disagreeable presence upon us year after year to our cost and detriment, and whose existence among us has compelled our farmers to take up the study of economic entomology in their own defence.

We have it on good authority, that at least ten per cent. of all the farm products of the United States is annually devoured by insects, and if this computation errs, I think it errs in being too conservative. This means that over $300,000,000

*The excise tax on sugar was reduced to 14 marks per double centner on September 1, 1903.

annually is taken out of the pockets of our farmers to support these undesirable and unwelcome members of our commonwealth. Could we get rid of these pests of the orchard and farm and save to the farmer what they consume, he could support the army and navy of the United States out of his savings and still have a handsome balance left, or he could maintain all the educational institutions of the country out of his pocket and then have half of the amount saved to put in the bank for a rainy day. It has become a continuous contest between the farmer and the bugs as to which shall harvest the crops, and while in any event they deprive us of much, it is only by constant effort and at a great cost in time, labor and money that we succeed in keeping them from taking all. In order to defend himself, therefore, the successful farmer has had to educate himself and has become a pretty expert economic entomologist. But it is generally the case that our ills are more deeply felt and more keenly appreciated by us than our blessings, and while we groan loudly under the former, we allow the latter to pass unnoticed. No one thoroughly appreciates good health, or realizes that he possesses it, but when he loses it he knows it. Its possession he takes as a matter of course, and it is not worthy of consideration. So it is with all the phases of life and so it is in the insect world. Our injurious insects are ever before our eyes, they cause us to lose our sleep and to turn prematurely gray in our efforts to get the better of them and, in the consideration of this class alone, we at last get to believe that all insects are an unnecessary and pestiferous part of the creation.

* * *

Now, as there is no unmixed good, so there is no such thing as an unmixed evil, and it is to draw your attention to the deep blessings we enjoy from the insect world, and the debt of gratitude which we owe to its members, that I have chosen my subject today, and I think it will surprise you when I assert that we could better afford to lose by them five times as much as they now take than to be deprived of them altogether. In fact, were it not for members of the insect world, I question very much whether there would be anything left for us on earth. It is to the insect world that we owe all our many floral beauties; it is to them that we owe our choice fruits, and to them we owe the vast numbers and varieties of vegetable forms with which our earth is decked. These little and seemingly insignificant members of the animal kingdom, have been the agents through which a beneficent nature has operated to vary and spread her works. We honor our own Luther Burbank for the wonderful work which he has achieved in his lifetime in giving us new varieties, yet he has only done, in a limited way, and in a short time, what the insects have been doing over the whole world and for all time. I need not call your attention to the honey bee in this regard, and its beneficent work in carrying pollen from flower to flower but the bee is not the only insect which does this work and others perform it where the bee would utterly fail; the butterflies and the moths, for instance, with their long tongues, reaching to depths where the short tongued bees could not penetrate. It is in the work of fertilization of plants, very many of which could not exist were it not for them, and most of which would deteriorate and finally succumb, that we owe our greatest debt to the insect world. But aside from this great work, there are very many insects which are directly beneficial to us from a commercial standpoint, that is as actual and immediate producers of wealth. Coming back to the bee again, we all know how immensely valuable is its annual product of honey and wax, so valuable, indeed, that were the supply shut off for a time we would suffer severely, not alone in our food supply, but in many of our arts and sciences. The silk worm is another insect to which we owe a debt of gratitude, for it not only adds greatly to the graces of our ladies, but is a source of enormous wealth in its output of silk, its manufacture and transportation, and should it stop its labors for a year, it would entail enormous losses the world over. The materia medica is indebted to the insect world for one of its most valuable vesicatories in the Cantharis vesicatoria. Nor is the family of scale bugs, which injure us so much, wholly without its redeeming members. Some of the most valued dyes used by the ancients, and not altogether fallen into disuse yet, although they have been largely displaced by analine colors, were derived from members of the scale family. The scarlet grains of Poland, which were used for ages for producing a beautiful scarlet, were scale bugs. This insect was forced from its prominent position by the discovery of the new world and the introduction of cochineal, another scale bug, which had been used by the ancient Mexicans from time immemorial for the same purpose that the scarlet grains had been used on the other side of the world. Another scale bug to which the arts are very largely indebted is the Carteria lacca. This supplies us with the different forms of lac, as shellac, seed lac, stick lac, etc., which form the principal ingredient in all our varnishes and polishes. It is, therefore, to a scale bug that we owe a great part of the beauty of our homes, for without it we would miss the high polish of our pianos, the gloss from our furniture, and all the many forms of laquered and Japanned ware which enter into our every day use. Another scale bug produces the beautiful white wax of China, while another supplies us with the manna which is so common a food for our children and invalids; still another, known as the ground pearl, is used as a personal adornment and, in the Bahama islands, is worked up into jewelry with excellent effect. Nor is the use of the products of the scale insects mere curious experiment, but the value of these products amount to many millions of dollars annually. The United States alone every year pays nearly $2,000,000 for the imports of the lac insect. There are also many indirect ways in which insects aid us, but to these I shall not allude, but come at once to another class of beneficial insects, those which assist us by keeping in check others which prey upon our substance, and these are more numerous than some of us imagine. You have all heard the old rhyme to the effect that:

"These fleas have lesser fleas,
And these have less that bite 'em,
And these fleas have lesser fleas,
And so, ad infinitum."

And there is a world of truth in the doggerel. Nature deals largely in checks. She no sooner completes a work, than she sets about producing means for its destruction, and so soon as a species grows in strength until it becomes threatening, another species arises to attack it and keep it down. Were it not for this wise law of nature, this preying of one species upon another, the world would soon be overcrowded, and the most prolific would force all others off the earth, and our planet would become a desert. From the working out of this law we get the survival of the fittest, but the fittest to survive in the struggle for life, is not always the fittest for man's requirements, so it behooves us to study this great law of nature and turn it into channels for our own advantage by surrounding our friends with protective measures and, so much as possible, expose our enemies to their attacks. Another natural law is that those species most subject to destructive force are most prolific. Were this not the case, they would soon be forced off the earth. Animals of large size, great strength or swift of foot, produce few young and at long intervals, whereas those most subjected to danger, which have the slightest tenure upon life, produce enormously. The aphis, for instance, is one of the tenderest of insects; it is subject to very many predaceous insects, which devour the offspring by millions, it is utterly incapable of defending itself in any way; every wind that blows, every storm, every change in temperature, sweeps them off in swarms, and it is only by its enormous fecundity that it is enabled to exist, and how enormous this fecundity is, a computation made by Sir John Lubbock, a most careful investigator, will show. He has estimated that were it not for the numerous checks to which this insect is subjected, the offspring of a single aphis in one season would exceed in ponderable matter over 500,000,000 able bodied men. There are numerous checks at work on all our insect foes, and unfortunately on our insect friends, too, and they are kept within reasonable limits by this means. In their younger days, while in their crawling state, scale insects are exposed to so many dangers from predaceous insects, unfavorable meteorological conditions, etc., that they die by millions and it is doubtful if much over one *in a thousand escapes to continue the species, but you* will all agree with me that that one is enough. In their latter stages, they are still subject to attack by parasitic insects, fungus disease and various destructive forces, and by these means they are kept in check and prevented from wholly devouring all that we produce.

Now, having touched upon beneficial insects in a general way, I will come to the main branch of my subject, insects which benefit us by keeping down those other insects which are detrimental to us. These may be divided into two general and very large groups, the predaceous and the parasitic.

Predaceous insects are such as work on the outside of their victims, which move freely from place to place and pick up their prey wherever they happen to find it. In this class some members of nearly all the natural orders are found, and they are not confined to any particular order. Perhaps the most widely known and most serviceable of this class is found in the Coleoptera, or beetles, and of these the Coccinellidae, or lady birds, are at once the most popular and the most effective family. To them we owe the fact that aphids and scale insects are not more numerous and destructive than they are, for, in every stage of their existence they devour these pests in enormous numbers. Perhaps the ladybirds are the more generally in favor the world over than any other member of the insect world, and the children everywhere look upon them as friends and pets, hence we have the popular names of ladybirds and lady-cows in England, and God's cows and the Virgin's animals in France. We have a very large number of different species belonging to this family, very diverse in size and markings, some so small that it requires a good eye to detect them, while one, the giant of its family, the Synonycha grandis, is nearly half an inch in diameter. We may safely assert that the whole ladybird family is beneficial and should be protected.

(Continued to August Number.)