PHILIPPINE BUREAU OF AGRICULTURE.

DEPARTAMENTO DE AGRICULTURA DE FILIPINAS.

FARMERS' BULLETIN No. 1.

BOLETIN DEL AGRICULTOR NO. 1.

A PRIMER ON THE CULTIVATION OF SUGAR CANE

ELEMENTOS SOBRE EL CULTIVO DE LA CAÑA DULCE EN FILIPINAS

BY

POR

WILLIAM S. LYON,

EXPERT IN TROPICAL AGRICULTURE.

Perito en Agricultura Tropical.

PREPARED UNDER THE DIRECTION OF THE CHIEF OF THE BUREAU.

PREPARADA BAJO LA DIRECCION DEL JEFE DEL DEPARTAMENTO.

MANILA:
BUREAU OF PUBLIC PRINTING.
1902.

CONTENTS.

LETTER OF TRANSMITTAL.

SIR: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, the manuscript of a paper on "The cultivation of sugar cane."

The importance of the sugar industry to these Islands can hardly be overstated. At the present time it furnishes all the sugar required for domestic consumption and a surplus for export, which, in 1900 amounted to 143,719,971 pounds valued at $2,397,144, and, with the exception of hemp, this industry gives employment to more of our rural population than any other branch of agriculture. Diminished cane areas, diminished crops, and diminished profits entail suffering in the rural districts that extends far beyond the landed proprietor or owner of a sugar estate. Abandoned cane fields and idle mills throughout the Archipelago indicate a depression of such magnitude as to render it incumbent upon this Bureau to do everything in its power to remedy these conditions.

The causes producing the present depression in the sugar industry, other than those resulting from the prevailing financial conditions and excessive rates of interest on mortgage loans, are to be found both upon the farm and in the mill. The present practices plainly indicate a lack of knowledge of certain fundamental principles in cane cultivation, and the purpose of this paper is to place before the cane grower in compact form the elementary information essential to the success which lies within his reach.

Respectfully,

WILLIAM S. LYON,
Expert in Tropical Agriculture.

Prof. F. LAMSON-SCRIBNER,
Chief, Insular Bureau of Agriculture.

A PRIMER ON THE CULTIVATION OF SUGAR CANE.

INTRODUCTION.

Upon most modern estates the manufacture of sugar is carried on in connection with the growing of the cane, but this is not always the case, and cane growing alone may be profitably followed by those who have no milling plant, but who must deliver their crop to the nearest crushing mill.[1] The conditions for profitable returns are exceptionally favorable upon these Islands; the climate can not be surpassed, the cane soils are unequalled, there is abundant water supply, the facilities for transportation by water are unusually good, while the difficulties of land transportation will be quickly overcome by the successful planter. It must be the aim of the cane grower to produce upon a given area the maximum of both tonnage and quality in order to secure the greatest profit. This can only result from a judicious selection of land, both as to location and soil, a careful selection of the most productive varieties of cane, and the highest class of tillage and management of the growing crop.

LOCATION OF FARM.

The essential feature for the consideration of the grower who does not design to crush the cane himself lies in the accessibility of his farm to a mill. The measure of this accessibility will be determined entirely by the cost of transportation, which will depend on the condition of existing roads; the cost of construction of new ones, or of tramways; or the availability of waterways for more distant carriage. This last in these Islands is so valuable a means of transportation that it can be utilized for the extension of cane growing into regions that otherwise could not be made available.

Most modern sugar mills are now equipped with unloading facilities, and by the aid of special labor-saving contrivances effect the discharge of cars, carts, and boat loads of cane with remarkable ease and celerity. These are all contributory factors to "accessibility" and are, therefore, mentioned in this connection.

The next feature that commands attention in the selection of a sugar cane farm is the suitability of the soil for the designated purpose. It has been contended that sugar cane can be made profit-paying upon *any*

[1] This is the general practice in New South Wales, where the numerous holdings are, as a rule, small in area. The cane is purchased from the planters, principally by the Colonial Sugar Refining Company, whose various crushing mills and refineries are fitted with machinery of the most modern character.

land, when the rainfall is sufficient and the other climatic conditions are favorable.

It is also conceded by the many authorities responsible for this contention that there are many requisites necessary to bring unsuitable lands to a state of productivity; and that, except in regions where the needed supplies are cheap and plentiful, it is inexpedient to attempt their reclamation to sugar growing. In the Philippines, lands exceptionally well fitted for the growing of sugar cane are so abundant that there seems to be no valid reason for the selection of those that can only be reclaimed to this use by tedious and costly processes.

In determining the suitability of the soil, we have, as a matter of first consideration, its physical or mechanical condition.

SOIL CONDITIONS.

With a possible exception of tobacco, there is no staple agricultural crop where the physical condition of the soil plays so important a part as it does in the growing of sugar cane. It is a plant that, by virtue of its great size and rapid growth, not only draws heavily upon the fertility of the soil, but its shallow root system and restricted area for each plant demands that the mechanical condition of the soil be such as to facilitate in every way the full exercise of the root's functions. In all regions and in all sugar-producing countries, a strong, deep, argilaceous, or slightly calcareous soil has always been found best fitted to meet these requirements.

In the sandy, sedimentary, alluvial soils along the sea coast, or in rich mountain valleys, heavily charged with the humus in which the cane rejoices, phenomenal crops are often taken, but for long-continued cropping and with a minimum of restoratives the soils first mentioned are those which have longest stood the crucial test of time.

Such lands as these abound in the Archipelago and often extend for miles along the lower and easily cultivated foothills, and these today offer more inviting fields of operation than many of the apparently more alluring valley lands along the coast.

The land chosen must not be less than one foot in depth, but that will be sufficient, provided the substratum on which it rests is permeable to water. The perfect permeability of the subsoil is a sine qua non for the perfecting of the cane, for stagnant water at the roots is a more dangerous menace to success than long-continued drought. It is this peculiarity that clearly differentiates valley lands suited to cane growing from those adapted to rice, an aquatic grass, whose roots thrive in the same soil as the cane, but which must be underlaid by an impervious subsoil that will retain water throughout the growing season.

Nevertheless, the planter need not be discouraged who finds his shallow top soil underlaid by a formidable bed of clay. In most cases it will be found full of stones, bits of tufa or volcanic scoria, and, unless it lies per-

fectly level with the water table close to the surface, is at times susceptible to the free and rapid percolation of water.

It is suggested to the prospective cane planter who is unfamiliar with the physical character of the subsoil, that he dike a small experimental plot of land, making his dikes as nearly waterproof as possible, and then observe the behavior of the land subsequent to one or two torrential rains, noting the tardiness or rapidity with which the water disappears. If, after a two-inch rainfall upon soil previously wetted through, the water remains standing for more than two or three hours, a complete and comprehensive system of drainage is essential before putting such lands into cane.

SOIL FERTILITY.

Fertile soils can nearly always be assured in what are known as "virgin soils," and such are at present in almost unlimited quantities in these Islands. It may seem paradoxical to say that on a narrow sea zone, densely peopled by a race who have been engaged in agriculture for generations, virgin lands are more abundant than in what we call a new country within temperate latitudes. Strictly speaking, such is not the fact, but within the tropics, land that has once been cultivated and then allowed to lapse, so quickly reverts to its primitive condition that in a very few years it effects what would require a generation to accomplish in a northern climate, and to all practical intents becomes once more virgin land. Such lands are more valuable in some respects than the undisturbed soil of the primeval forests. Their reclamation to cultivation is more cheaply effected, while the rapidity with which the processes of growth and decay progress in the tropics, are assurance of a liberal supply of the humus, the one fertilizing agent of all others most vital to the highest perfection of the sugar cane.

In some tropical forest regions the remains of decaying vegetation are so great that they are sometimes present to an almost injurious excess.

On such soils, as also occasionally upon truly virgin sedimentary river bottoms, the cane develops to a size and with a luxuriance that is phenomenal; yet in this abnormally excited growth it frequently becomes gorged with unassimilated alkaline salts, prejudicial to sugar making, difficult to eliminate and depreciative of the market value of the cane.

But the quasi virgin land that has only the accumulated vegetable detritus of a few years, offers a happy medium for the growth of a strong, vigorous cane, rich in the precious saccharine matter that crystalizes freely, and that always commands the highest price in the sugar mills of the world. Under the question of soil fertility, it is pertinent to inquire if some practical suggestion can not be made whereby the equilibrium of the humus in the soil, in relation to its mineral elements may be constantly maintained.

A piece of land by the irrefutable logic of good money returns may

have demonstrated its superiority for growing cane; it may teem with the elements of soil fertility, yet in a few years the humus is depleted, and the cane and its value rapidly begin to deteriorate. There can be no middle course—the exhausted humus supply *must* in some way be restored.

Humus, as we know, serves a two-fold purpose—one, purely mechanical in its effects, rendering stiff soils pervious to the aeration and moisture without which perfect root action can not be maintained; the other, the added fertility which it supplies. It is rich in available nitrogen, without which, and notwithstanding a surfeit of other fertilizing agents in the soil, there can be no successful issue to a cane crop.

The two materials known to common agricultural uses that most nearly approximate humus in their action are stable or barn manures and cotton seed meal. Both these substances are not only rich in nitrogen, but both, while undergoing decomposition in the soil, exert mechanical influence analogous to that of humus.

In countries where cotton is grown and farm stock housed or corralled, one or both of these invaluable agents are easily obtained, and no difficulty is experienced in growing a succession of cane crops and in preserving continuously normal soil conditions. In these Islands we are practically excluded from the consideration of either, for cotton is not produced in commercial quantities, and, outside of a few large cities, the stall feeding of farm animals is unknown, and consequently the use of barnyard manures is out of the question. In this extremity there is no alternative for the cane grower but to lay down his cane fields every third year to, say, cowpeas, vetches or some leguminous crop that will compensate for the more direct fertilizers that he is unable to procure. As a result, one-third of his sugar fields will be annually unproductive of sugar; nevertheless, there is little doubt that eventually the farmer will be enriched by the operation. These renovating crops can first of all be partly cut and cured for forage, and will afford assured maintenance for the stock that is an indispensable condition to the profitable working of the farm. Stock so fed, if not immune, will at least be far less susceptible to epidemic diseases than those allowed to roam at large over pastures where the herds have previously been decimated by disease.

In addition, the yard feeding of his cattle will necessarily result in the accumulation of manures that, if properly protected from leaching by rains, will place at his command one of the best means for maintaining continued productivity. In the end, after the saving of the forage, there still remains the stubble, which, when plowed under, acts as humus, while the deep-rooting legumes have not only subsoiled his land, but have stored up while he slept an abundant supply of the nitrogen in the cheapest available way.

A practice in some places in the Islands is for planters to "rest" their

cane lands every alternate year. Such rests, it may be remarked, are quite as "tiring" to the land as its continuous production of cane. The rest does not last long enough to restore the growth that would in time renew it, nor is it even fallow plowed, which would at least greatly improve its mechanical condition. The "rest" is simply idleness, productive of ill rather than benefit.

PREPARATION OF THE SOIL.

If the land is what we now understand to be virgin soil the brush and timber will be cut closely to the ground,[1] any wood required for fuel removed, and the remaining tops and branches, when dry enough, gathered in small heaps and burned. Large fires are to be avoided, as the smoldering embers are apt to ignite and burn out much of the precious humus in the soil. It is on this account maintained that *all* trash should be removed and burned outside the plantation limits. Nevertheless, if the fires are kept small in size, the loss from this source will be inconsiderable, and hardly great enough to compensate for the extra cost of handling, or for the potassic salts lost by the removal of the brush from the ground; but, most important of all, the scattering and burning of the brush not only kills and facilitates the subsequent removal of the stumps, but helps to dstroy the larvæ of pernicious insects that abound in most forest lands.

The grubbing of the stumps can not be profitably undertaken till the rains have thoroughly wet down the soil, and then small roots are easily taken out with a grub hoe, while larger ones, that are well charred, may be easily removed by carabao.

It is only the largest stumps that should be left to decay. This process is so rapid in this climate that their early extirpation is an easy matter. Unless of extraordinary density of foliage, a few standing forest trees are seldom detrimental to field crops. To this the sugar cane is a notable exception. It rejoices in full, free, and unbroken sunlight at every stage of growth, and the greater its intensity and long continuance the greater the assurance of a good yield of sugar.

BREAKING THE SOIL.

The proper initial preparation of the soil presents probably the gravest difficulty with which the cane planter on these islands must contend. The lack of animals and implements adequate to open up and aerate the soil for all the depth to which it may be traversed by the cane roots, is indispensable to success, and further on, the only solution of this problem that now seems feasible will be presented. Where the initial preparation of

[1] The writer has lately observed some interesting experiments in clearing, where the brush was topped at three to four feet from the ground. The supposition is that, in the process of grubbing, the standing butts can be used as levers for the expeditious and easy eradication of the stumps.

the soil has been thorough there is little subsequent occasion for the use of implements of heavy draft. A few years ago the deep subsoil plow and the turning of the land for a foot or fourteen inches was considered essential. Now, the investigations of chemistry have demonstrated that the available, i. e., the readily assimilated plant food, is that which lies close to the surface, and that the deep burying of this surface soil and its replacement with elements not yet sufficiently disorganized to serve as plant food contained in the under soil is wasteful of both energy and material. As now understood, deep plowing serves only a mechanical purpose, and no more than to guarantee porosity and a free aeration of the underlying beds.

The subsoil plow has, therefore, been generally consigned to the things of the past (except for uses not pertinent to this subject) and it is regrettable to have to recommend its resurrection for some existing conditions in this Archipelago. These conditions are mainly found upon the clay cane lands, where for many years the soil has been lightly skimmed with a small plow for a depth of two or three inches, and at this depth the soil is crusted with a polished, impermeable floor, which is the reverse of what is desired, and which must be broken up and pulverized if these lands are to be made remunerative. That they bear unprofitable crops is no cause for surprise. The real cause of surprise is that they produce even half a crop of cane, and that they still do this speaks volumes for the wonderful adaptability of the climate and the remarkable fertility of the land itself. On such lands as these there seems no escape from the operation of the subsoiler, as no other implement will quite penetrate and open up this artificial hardpan. Upon virgin land any good, deep breaking plow will answer, although the modern disc plows that turn a furrow of any desired depth are preferred. In this plow, the rotating disc, instead of sliding along the furrow, leaving a compact bottom, releases the farmer forever from the perplexing question of future subsoilings. This disc plow, and the double-mold-board plow for the economical building up of beds and opening out drains, are the only heavy draft implements required for the cultivation of cane. All subsequent tillage is prosecuted with light draft disc harrows and cultivators of easy manipulation, and should properly be considered under the head of "crop cultivation" rather than that of soil preparation. In stiff soils the disc plow can not be used with less than three good American horses or mules, and it is doubtful if it could be well operated in such lands with fewer than six carabaos. At this time, when the sugar districts of the Islands have been almost depleted of their live stock, it seems inopportune to recommend the doubling up of draft animals by the use of heavy machinery. Still, it should be remembered that these plows throw a furrow slice of twenty to twenty-four inches, and will readily and properly prepare four to five acres in a day, which is more than six carabao will imperfectly accomplish in the same time with the small plow now in general use.

The question of the application of these useful implements to the preparation of cane lands, therefore, resolves itself into a question of motive power, and to the judgment of the farmer, who must decide if a possibly smaller acreage placed in a perfected condition does not offer greater inducements than a larger acreage illy prepared and fraught with prospects of crop failure.

Under the existing live stock conditions, no other suggestion can be made at this time than that given above of doubling up the available farm animals until the required motive power is secured, and it is recommended with the assurance that the farmer's gains from a smaller, well-handled acreage will more than compensate for the loss of acreage that this concentration of power implies.

In preparing valley land for planting, some provision must be made for times of food that does not apply to uplands. After the first heavy plowing the land is to be fined down with a good harrowing. If the soil is of free, open texture and handled at the time when still moist but not sticky, the common form of sectional harrow will do good work. If inclined to be cloddy the disc harrow will reduce the soil to the best condition of any tool in common use. The land is then to be laid off in 5-foot beds, the middles between them being opened up with a double-mold-board plow. In valley lands that have been kept in the best condition, it is here that the only occasion should arise for the use of the subsoil plow for the purpose of deeply opening up these middles, which will serve the double purpose of drainage, and of supplying soil for the elevation of the beds. The depth or shallowness of these furrows will be governed by the susceptibility of the land to overflow.

In many tropical regions, and in most of the Philippines, the cane beds are only made 3½ to 4 feet apart, but where the highest skill is exercised, and upon good soils the 5-foot planting should yield a tonnage equally large and at a great saving of expense in both labor and seed cane.

SELECTION OF SEED CANE.

The cane used for seed should always be well ripened and selected from such stools or "ratoons" as from mill tests show the most sucrose and the highest purity. Careful selection for a few years, and the reservation of a portion of the plantation for nursery purposes, will enable the planter to maintain his seed cane at a high standard of excellence. The varieties used here seem to be confined to the green and yellow sorts, of probable Javanese origin. These canes, though rich in sucrose, are generally small and insufficient in tonnage yield per acre. Further, and whenever there is a steady decrease in size from lack of proper cultural methods, the deterioration is accompanied with a relatively greater increase of fiber that, in its turn, represents another loss at the mill. The many useful striped, rose and purple canes, that have contributed to bring Hawaii to

the front as the most prolific and profitable sugar region in the world, have not, so far as can be ascertained, been planted in these Islands.[1]

Exhaustive tests have definitely established the fact that the upper two or three feet of the cane—the part least valuable at the mills—is well suited to seed purposes, and that no sugar deterioration has occurred from its long-continued use. These tops can be all used, except the extreme tips, which are sometimes inclined to "arrow."

PLANTING.

As soon as the ground is prepared a shallow furrow or trench is opened, down the center of the bed with a double-mold-board plow, and the cane laid down in the trench, the end of one piece touching the next throughout the whole row. It is the custom, here and in Hawaii, to cut the cane into single nodes a few inches long, and drop them at close intervals in the furrow. Such a practice undoubtedly assures a stand from every joint, but if the land has been brought to a fine condition of tilth, and the whole of the cane is in intimate contact with the soil, every joint in the piece should break into bud. It will also be seen that the process is more expeditious and labor saving.

Previous to planting, the seed cane should be soaked for two hours in lime water of the strength of 2 pounds of slaked lime to 1 gallon of water. This is recommended for the destruction of the eggs of pernicious insects, but in every instance a rigid scrutiny of the seed cane should always be made, and any piece that has been attacked by borers should be rejected. As a remedial measure, I would place more faith in a soaking of the cane in well diluted carbolic acid; but, in view of the fact that the lime dressing furnishes at once to the young plant an always-to-be-desired and necessary element of fertility, this time-honored custom of all countries may be generally adopted.

In this country the trench for planting may be shallow, and the soil covered back with a light plow or disc harrow. Where irrigation is not to follow, or where rainfall is so great that the water-carrying capacity of the middles is apt to be overtaxed, all subsequent plowing or tillage should be towards the cane row, with the end in view of having it always above water.

AFTER-TREATMENT.

The cane, when planted, if followed by good rains or by irrigation, should begin to sprout within a week of the time it is wetted down, and this is the time when the progressive farmer has recourse to the so-called mineral fertilizers for the increase of crop and the maintenance of soil

[1] Through the commendable enterprise of Capt. G. P. Ahern, Chief of the Forestry Bureau, an importation of these Hawaiian canes was recently made to this country, and efforts will be made, by their rapid propagation, and further introductions, to effect future distributions of the same to planters. F. L. S.

equilibrium. Aside from the humus and the means of providing for it that has already been discussed, there are two essential ingredients of soil fertility that exist in all rich lands, but upon which the sugar cane makes extraordinary drains, and the application of these in the most available forms not only meets with an assured response in a marked increase of crop, but is a guarantee of a continued state of soil fertility that leaves the farm capital always unimpaired. These ingredients are phosphoric acid and potash, and there are apparently no insuperable obstacles in the way of obtaining either. The former is probably to be had from the many deposits of bat guano that exist in the Archipelago, and wherever these deposits are found in caves, or have been protected from rain they are almost certain to be rich in this valuable element. If the planter is remote from any such source or from any known phosphate deposits, there seems to be no alternative than its purchase and importation from the Sandwich Islands or the United States.

These salts are more useful in the form of acid phosphates, and are commercially known as "superphosphates" and carry from 10 to 20 per cent of soluble phosphoric acid, and their cost is always based wholly upon the prcentage of the acid they carry. In any event, the amount required is small (200 to 400 pounds per acre) and at any reasonable cost it should be obtained.

The supply of potash does not appear to be of such pressing concern with the cane planter. Not only, if his land has been cleared and burned over, there has been returned a considerable supply of this element, but the indications are that most of the sugar lands of the Islands are already rich in potash. Without recourse to a chemical analysis, there is a simple, practical test whereby the farmer can determine this question for himself. Let him select two, or three, or more small plats typical of as many different soils as the farm shows, and lay them down for two or three years to different kinds of lucerns and clovers, giving them no manuring whatsoever. If the growth from these plats is luxuriant, and they only suffer from causes directly attributable to long-continued drought, he may reasonably conclude that his land is provided with enough potash to meet all the requirements of cane growing for many years.

In the use of acid phosphates or of bat guano, there is a process that is both effective and economical for its application. It may be scattered lightly in the furrow at the time of cane planting; or, if it is used in the form of bat guano, and where it is probably in combination with valuable nitrates, a furrow may be opened close to the cane, and the fertilizer scattered lightly and evenly along both furrow and furrow slice, and then all harrowed down smoothly with a disc harrow. There are drills now in common use that are adjusted to deliver commercial fertilizers directly where required and in precise quantities; but careful hand sowing can be made equally effective.

It should be remembered in the application of manures of this class that they are exceedingly soluble, and the greatest benefit from their use occurs at the time when light showers are prevalent. If applied at the time when the heaviest and long-continued rains are anticipated, a very large proportion of the valuable elements will be leached out of the land and carried away in the middles and drains. For the rest, all the subsequent cultivation to be given until the rows are crowded with suckers, and the cane ready to lay by and ripen, is a constant but superificial stirring of the surface with either hoe or cultivator.

After every rain, or so soon thereafter as the soil will admit of working, this cultivation should never cease. It is the keynote of the successful issue of the crop, and all the careful soil preparation and soil amendments that have been bestowed in previous months are largely nullified, if a hard, compact crust is permitted to form and remain upon the surface. When the rows are completely crowded with cane, and the ground well shaded, this surface induration will no longer occur, and the planter can await the ripening of his crop with the assurance that every hour of toil expended upon cultivation will be many times repaid.

HARVESTING THE CROP.

When the cane is ripe, and this is easily determined by the cessation of growth and a general deepening in color, it is ready for harvesting. It should be cut very close, or even with the ground in this climate, and the tops and leaves trimmed off, when it is ready for delivery to the mill. The tops are then gathered and buried in trenches of moderately dry soil until required for planting. The leaves and trash are gathered and burned, or else covered deeply in a furrow made by a double-mold-board plow and allowed to decay. Both processes have strong advocates among expert sugar growers; but the process to be most commended will depend on circumstances. If there be the slightest evidence of fungus growth, or the presence indicated of any sap-sucking or cane-boring insect whatsoever, there is no option. Every vestige of refuse should be burned. If such is not the case and there is, on the other hand, difficulty in obtaining stable manures or other humus-making ingredients, burying the trash will go a long way toward the maintenance of soil fertility, and is the best solution of the question of its disposition.

MANAGEMENT OF STUBBLE.

At one time three-fourths of all the cane grown on these Islands was from stubble crops. Now, by long-continued depletion of the land, in many districts it has become necessary to lay down the land to new seed cane every year, and this system, despite its wastefulness, seems to be the only one that affords planters any assurance of even a half crop.

Where the lands are not hopelessly exhausted, or facilities are at hand for their renovation, there is no excuse for this wasteful policy; and vir-

gin land, or land that is maintained in rotation, should be profitably handled for the second, or even a third year. The rational method of treating the plantation destined to be carried over a second season as stubble cane would be as follows: In the process of harvesting, the soil will be more or less compacted by the trampling of the cane cutters, by the cleaners, and by the carabao used in hauling away the crop. A thorough and deep plowing is, therefore, once more necessary, and to this must be added a complete forking over of the land *in the stubble row itself*. This may be effected by hand, although there is a machine now in common use, known as a "stubble digger," which has a revolving, cultivator-toothed attachment that works up the soil effectively and with remarkable speed directly in the row, and with a little care, rarely tears out a stubble root. From this point on, the manurial treatment and cultivation of a stubble crop is a practical repetition of that given to the seed cane crop. This, in fact, would be the outline indicated for continuous succession of crops were it not for the difficulties that confront the Philippine planter in the procurement of complete fertilizers and which imperatively call for a crop rotation, every third year, if he would preserve the maximum sugar yield for an indefinite time.

There is no reason why the third or rotation year should be operated at a loss, or be given up wholly to soil recuperation. The method practiced in Mauritius, Reunion, and most of the French colonies, would doubtless be successful and profitable here. The third year the same stubble is grubbed out, the land laid down as usual, and planted to corn. When this has made fair growth and begins to "tassel" out, the ground is sown broadcast to vetches, cowpeas, or some other quick leguminous soiling crop. A fair to good crop of corn is usually secured and the leguminous forage is pastured down till the season comes for plowing it under and reseeding the land to cane. This pasturing can only be done without injury during the dry season, and the farmer who turns carabao in to pasture in wet cane lands is inflicting incalculable mischief that will take years of reparative treatment to overcome.

DRAINAGE AND IRRIGATION.

There are two subjects pertinent to the matter under consideration, that will be made the subject of future bulletins, and that can only be briefly touched upon in this paper. They are drainage and irrigation. The former is indispensable to attaining a maximum of success upon the littoral lowlands of these Islands, and ultimately a comprehensive system of drains will control every well-equipped and well-managed plantation in the Archipelago. The evil effects of stagnant water have been already pointed out, and the indispensable necessity of deep, broad, middle ditches and laterals, for the rapid diversion of storm waters, has been insisted on elsewhere. These middles and laterals, however, are but makeshifts offered for the immediate amelioration of water-logged cane fields until

they can be otherwise properly reclaimed. Open drains, to be efficacious, must be constantly kept clean and in repair. This entails constant labor and a very considerable and unnecessary sacrifice of land. Stone-filled drains made of broken stone of graduated sizes are expensive, and in time are apt to become clogged with fine silt. Tile drains will be the final recourse, and the excellence and abundance of the clay and the skill shown by the Filipinos in its manipulation are additional reasons for advocating their use. The financial condition of the planters at this time justifies a recourse to the expedients previously mentioned, and the hope is expressed that the profits arising from a better scheme of cane growing may eventually enable them to place their fields in the highest and most profitable condition.

It is well known that a perfect system of tile drainage is almost a guarantee against the evil effects of drought. To those who lack full comprehension of the subject it appears paradoxical that a system primarily designed to dispose of surplus water in the soil will, at the same time, act as an agent for its restoration. Such is the case, however, and, on the principle that nature abhors a vacuum, there can be no evaporation of the surface waters without a supply constantly being drawn from below to replace it. Further, this, like all water that is in motion, is pure, sanitary, and drawn upwards through the cane roots in just such quantities as they can appropriate with the greatest benefit, and in dry seasons, unless in excess, never flows to waste in the drains. It is, in short, the auxiliary to the planter in the valley, that irrigation is to the cane grower on the uplands.

The uplands promise to be of long-enduring value, and, ultimately, more profitable than the valleys. The abundant water supply that prevails in all the districts where sugar is now grown, is available for the reclamation of immense areas to this purpose. Here the planter has positive and complete control of the situation. He is free from the ever-recurring possibility in tropical countries of disastrous flood or inundation, while the danger of protracted drought need not be considered as an element of crop failure. His control, in short, is so perfect that he can apply moisture at the times when it is most beneficial, and withhold it completely as his crop approaches maturity, when continued rain or moisture would increase the sap in the cane, at the sacrifice and loss of the sucrose he has patiently striven to elaborate.

Large areas of these uplands are frequently quite level, or with a gentle slope towards the sea, and consequently present ideal conditions for the ready distribution of irrigating waters. Some of the most valuable lands are, however, more or less undulating, and although susceptible to irrigation, the successful manipulation of the water requires attention to some simple engineering problems, which are, however, too extensive for treatment at this time.

CONCLUSION.

In conclusion, it may be said that the rational treatment of sugar cane involves that it be forced, and forced constantly, from the day the cane first sprouts till it is ready to lay by and ripen. This forcing process can hardly be overdone, and involves an adequate water and food supply, and such constant tillage and forcing as will enable it to assimilate every particle of the food and water given. A check of any kind is fatal to the fullest measure of success, and the cessation of the functions of growth for only a few days means the elaboration of starch and fiber in lieu of the sucrose we are after.

In common with every other form of vegetable life, vigor and luxuriance of growth affords more general immunity from the attacks of predacious insects or fungoid growths, and a consequent saving from the losses which these entail.

GROWING SUGAR CANE IN HAWAII.

[Extract from a report on the agricultural resources and capabilities of Hawaii, by William C. Stubbs, Ph. D., published in Bulletin No. 95, United States Department of Agriculture, Office of Experiment Stations.]

The dominant crop in Hawaii is sugar. * * * Few places in the islands where cane can be grown at all will yield less than 30 to 40 tons per acre * * *.

The table-lands surrounding the Islands at elevations of from 20 to 500 feet constitute the chief sugar areas. * * * There are about 60 plantations on the Islands, which yielded in 1898-1899 about 300,000 tons of sugar. These plantations have about 100,000 acres in cane, one-half of which is harvested every year. * * * Under irrigation as much as 10½ tons of sugar per acre has been the average of one plantation * * *.

Table showing expenses per ton of sugar grown, and per acre.

Plant cane.	Per ton.	Per acre.
Clearing	$0.54	$5.51
Mule and steam plowing	1.41	14.50
Ditches	.20	2.05
Cutting and hauling seed	.80	8.22
Preparing and planting	.88	9.04
Fertilizing	4.01	41.13
Watering	3.63	37.18
Hoeing and weeding	.76	7.85
Stripping	1.49	15.25
Cutting and hauling cane	3.48	35.62
Pumping expense	2.42	24.84
Sundry accounts (rent, interest, and all other expenses)	5.33	54.63
Manufacture	2.65	27.15
Containers	.99	9.77
Total	28.59	292.74

Plant cane:

Total yield of cane (tons)	117,835
Yield of cane per acre (tons)	78.9
Purity of juice (per cent)	87.07
Amount of cane required to produce 1 ton of sugar (tons)	7.71
Total production of sugar (tons)	15,289.5
Yield sugar per acre (tons)	10.24

On the leeward side of the Islands, where irrigation is practiced, the land is broken with steam plows to a great depth. Rows are laid off at 5-foot intervals with very deep double-mold-board plows. Into these deep furrows the tops of the cane are dropped in a continuous row, the soil is drawn in lightly with hoes, and a shallow stream of water sent over the buried tops. In six to seven days a continuous stand of young canes is obtained. For the purpose of economizing water the rows are laid off as nearly on a level as possible, and an open furrow for irrigating is maintained during growth. After each irrigation, hoes draw in from the adjoining ridges small quantities of soil in order to conserve the moisture applied. Save irrigation and its incident hoe work and the trashing of cane, no other cultivation is given. A contract is usually made with a head Chinaman to irrigate and trash the cane from planting to harvest at so much per ton of cane harvested. The contract is usually for 100 acres, the company furnishing the water. Contracts are also made by the ton for the cutting and delivery of the cane at the sugar house, the company furnishing the cars and engines. The breaking of the land and the planting of the cane is usually done with hired labor.

On the rainy or windward side of the islands the conditions require entirely different methods from those just described. The lands are broken in a similar manner but less deeply, and the tops are planted in an open furrow and covered. When the plants are large enough, the work of cultivation begins, which is usually done with plows, cultivators and hoes. This cultivation is continued until the

canes are sufficiently advanced to "lay by." Every operation is similar to the best practice in the cornfields of the West. Here reliance is placed entirely upon the rainfall for furnishing the needed moisture to canes. Sometimes the rainfall is excessive, at others deficient. Severe and protracted droughts which occasion great loss to the planters occur at rare intervals. As a rule, however, the rainfall is ample for good crops, and the extra expense of irrigation is avoided. Hence frequently the windward plantations are just as good dividend payers as the leeward estates, though the yields per acre are much less. Trashing of cane is practiced here as on the leeward side. In both instances the dead leaves are piled up between the rows, where they remain until after harvest, when they are burned. "Ratooning" or "stubbling" is not largely practiced. Only first-year ratoons or stubbles are cultivated. Whenever, in the judgment of the manager, these will not produce 30 tons of cane per acre they are plowed up and the land replanted. Just here is one of the secrets of the large success attending sugar growing on these islands. Two-thirds, if not three-fourths, of the area each year is in plant cane. In Cuba, Porto Rico, and other tropical islands cane is permitted to run for six to even sixteen years, with the unavoidable result of annually diminished acre yields, and a low average sugar output. Sugar planters elsewhere are disposed to doubt the accuracy of the large published yields of Hawaii. Let them consider their own enormous yields from plant cane, and then apply such results to their entire plantations before they begin to question outputs obtained in these islands. It is true that irrigation upon fresh lands, upon the warmer leeward sides, in a climate almost perfect for maximum growth, has greatly increased the average output of Hawaii, but the carrying of the largest portion of the crop as plant cane is unquestionably the main cause of the large yields. This is evidenced by the yield obtained on the rainy or windward side of the Islands, which are much larger than those obtained in Cuba and other tropical countries, even though much below the returns of the irrigated plantations on the lee side of the same islands.

The cane when harvested is delivered to the sugar mills by wagons drawn by oxen or mules, by rail, with horses or steam, by water flumes sometimes crossing deep gulches, and by trolleys. Plantations use either one of the above methods, to suit their peculiar environments.