1901

Sugar cane: experiments in cultivation

William Carter Stubbs

SECOND SERIES, NO. 66.

BULLETIN

—OF THE—

AGRICULTURAL EXPERIMENT STATION

—OF THE—

Louisiana State University and A. & M. College

WM. C. STUBBS, PH. D., Director and State Chemist.

Sugar Cane. Experiments in Cultivation.

BY WM. C. STUBBS

ISSUED BY THE BUREAU OF AGRICULTURE AND IMMIGRATION,

J. G LEE, COMMISSIONER.

BATON ROUGE.

PRINTED AT THE TRUTH BOOK AND JOB OFFICE.

1901.

Louisiana State University

and A. & M. COLLEGE.

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LOUISIANA STATE UNIVERSITY AND A. & M. COLLEGE,

BATON ROUGE, LA.

HON. J. G. LEE, Commissioner of Agriculture and Immigration, Baton Rouge, La.

DEAR SIR:—I hand you a bulletin covering the results of cultivation experiments for the past two years. As a prelude to this bulletin and explanatory of the methods practiced, I have given a short treatise upon the principles involved in the preparation and cultivation of the soil.

I ask that this be published as Bulletin No. 66.

Respectfully submitted,

WM. C. STUBBS, DIRECTOR.

Preparation of Soil and Cultivation of Crops—Experiments in Cultivation of Sugar Cane at the Sugar Experiment Station, Audubon Park, New Orleans, La.

The successful raising of crops involves the proper preparation of the soil—the planting, the fertilization, and the cultivation of the crop. It is easy to enunciate the above facts, but difficult even for a trained scientist to execute them properly. To accomplish the above requires a knowledge of every science which underlies agriculture.

Drainage, and the relation of the soil and crops to water, air and heat, belong to the domain of physics. The ingredients of soils, plants and fertilizers are demonstrated by the chemist. The bacteriologist, by the aid of the microscope, reveals the myriads of microbes existing in every fertile soil in good tilth, busily engaged in transferring insoluble matter into available plant food. Physiology teaches how the plant takes in its food and transforms it into, first, the blade, then the ear, and after that the full corn in the ear. Botany differentiates the plants we cultivate, classifies them according to their common properties—of roots, stalks and leaves. It points out the difference between tap rooted and fibrous rooted plants, between netted veined and parallel veined leaves, between exogenous and endogenous stalks, between monoecious and dioecious flowers, between leguminous plants with nodules on their roots, through which the nitrogen of the air is ab-

sorbed and assimilated, and non-leguminous plants which must get all of their nitrogen from the soil.

Geology tells us of the origin of soils whether coming from the disintegration of rocks *in situ*, or whether after disintegration the materials have been transported and assorted by moving waters.

Mechanics gives us the laws which assist in the evolution of a plow, and in the construction of the double and triple trees by which the plow is drawn, as well as in the arrangement of the gear by which the mule or horse is hitched, so as to exert the maximum power with the least expenditure of labor.

The grand object of plowing and cultivating is to produce such conditions in the soil as shall conduce to the most rapid development of the plants under cultivation within a given time. Therefore, every factor producing these conditions should be clearly understood, and, if possible, made active in our operations. "Why we plow" and "why we cultivate," are questions easier asked than answered, and but few farmers appreciate fully the reasons for the work which they give their crops.

While every effort should be made to accomplish our work in such a manner as to wring from nature every assistance possible, there is, unfortunately, a practical money-getting side to farming, that compels us to do this work in such an economical manner as to leave a balance on the profit side of the ledger at the end of the season. Therefore, the successful farmer or planter must combine the scientific and practical in all of his work. He must first know why he plows, and then how to do it successfully, as well as economically.

Science teaches that there are ever present in nature two active series of forces—the one constructive, the other destructive. They operate alike upon the three great kingdoms—mineral, vegetable and animal. These forces are perfectly apparent in the vegetable and animal kingdoms. Pro-

pelled by the mysterious force of vitality, the plant or animal under suitable environment thrives; constructive forces are at work in both instances just as long as life exists. The vegetable kingdom transforms the minerals into fibre, leaf and fruit. The animal kingdom takes the products of the garden, field and forest and transforms them into flesh and blood, bone and sinew, hair and hoof—the most complex of organic substances. Remove the influence of vitality, death ensues, and the destructive forces begin at once the work of disintegration and decay. The more highly organized bodies are the earliest to begin dissolution and the quickest to reach absolute revolution into the simple forms of matter. This is evidenced by the rapidity of the decomposition of animal bodies after death. Vegetable matter decomposes more slowly, but is ultimately resolved into the same simple substances.

To the layman the operation of these two opposing forces in the mineral kingdom is not so apparent. The study of geology teaches us, however, that "by ceaseless changes all that is, subsists"—that the granite rocks of today may become the fertile soils of tomorrow, and the fertile soils of tomorrow may by natural forces be converted into rocks of the next geological day.

The forces at work may be classified as gravity, heat, water alone—either as a vapor, liquid or solid—water charged with carbonic or other acids—oxygen of the air—chemical affinity, and last but not least, vitality. Under the head of vitality must be included the ferments and microbes—so potential of wonderful results in their aggregate action. These forces have produced all the changes on the earth's surface, and are still acting with undiminished intensity, causing the shifting scenes in the natural spectacular drama daily exposed to the inquisitive gaze of a transitory humanity.

The internal heat of the earth, the deposition by moving water, of rock material, subsequently solidified or crystallized by pressure and other agents, are constantly producing "rocks." These rocks, whether of igneous or aqueous origin,

are assailed at once by the destructive forces, and the work of disintegration begins—preparatory to the support of vegetable life. Soon a few lichens appear, preceded perhaps by microbes, and followed in order by mosses, grasses, weeds, with finally shrubs and trees. To the unaided eye of the prospective settler, there is finally presented a more or less complete disintegration of rock into soil.

While this decomposition is in progress, the falling rains and moving waters are transporting, assorting and depositing much of this disintegrated material at lower levels, until finally large areas of alluvial soils have encroached upon the ocean's domain and enlarged the territory of cultivable soils. The increasing layers of alluvial material, superimposed the one above the other, will develop by its own weight sufficient pressure to begin again the process of rock making, and if undisturbed, will ultimately produce incipient slates, shales and sandstone. An illustration of this is found in the formation of hard-pan which frequently occurs underneath soils which are cultivated with shallow implements.

These preliminary remarks will doubtless throw considerable light upon the "why" we plow cur soils.

The first and primary object of breaking soils is to arrest this natural tendency to rock making, to open up the first twelve or eighteen inches of the soil to the disintegrating influences of air, water, carbonic acid, vegetable and matter microbes.

A hard pan forming near the surface is destructive to soil fertility. Bricks are artificial rocks hardened by pressure and heat. If they are finely ground, and seeds be planted in the powder, they will not grow—why not?

Study the decomposition of rocks "*in situ.*" No sign of vegetable life is apparent. Presently, by the forces already alluded to, a thin seam of crumbled rock is completely occupied by the lower forms of vegetable life. By the vital activities of these plants, aided by the microbes, which simultaneously begin their preparatory work, disintegration be-

comes more rapid, and soon a higher order of plants appear to be in turn supplanted or supplemented by still higher. Lichens give way to mosses, mosses to grasses and sedges, and these in turn to shrubs, until finally the majestic forest, sending its long tap roots down to the now deeply obscured rocks, covers the landscape and announces by its presence the fitness of the soil for cultivation. The woodman's ax clears the forest, and the farmer's work of retaining the conditions which nature has established, now begins. He must plow deeply and frequently. He must rotate his crops, using in the rotation a deep tap rooted plant, so as to maintain the permeability and fertility of the soil which nature through long ages has prepared for him, or else the constructive forces ever present will gradually restore his soil to incipient rocks, and make it unproductive.

Physically, the soil is the home of the roots of plants, and they must have air, moisture and nutrition. Deprived of any one of these, the plant dies. In our homes it is found that space is needed to give an abundance of air and freedom of movement, both essential to health and well being.

The plant, too, in its home must have room for the movements of its roots, and depth and permeability for the supply of atmospheric oxygen and capillary water.

The pulverized brick will not support, at first, plant life; but supply it with air, moisture, micro-organisms and organic matter, and a wonderful transformation in its producing power will be apparent. These are absolutely needed to transform the inert impalpable brick dust into soluble plant food.

By plowing the soils, air and moisture are admitted, and they go upon their heaven decreed mission of preparing plant food. An important fact must here be emphasized. This soluble food must be at once utilized by a growing plant, else it will be quickly resolved into insoluble forms or washed out by descending showers beyond the reach of plants. It is therefore of the utmost importance to keep our fields occupied as far as possible by some growing crop throughout the year. The amount of plant food available at any one time, even in

our most fertile soils, is relatively very small, and is dependent, as will presently be shown, upon "tilth."

The first object then in breaking land is to arrest the natural tendency of all soils (some more than others) to make rock, which is accomplished by letting in freely air, moisture and the roots of plants. In the disintegration of soil particles which results from the action of the above, plant food is eliminated.

The second object in breaking land is to destroy the weeds and grasses and thus relieve it of the foulness which an excess of vegetable growth always produces. This is usually accomplished with a turning plow, which inverts the soil while breaking it. Plowing is, then, a cleansing process. It is nearly always desirable to incorporate vegetable matter with the soil, to make "humus" which subserves a most beneficial purpose both from its physical and chemical effects upon the land. Leguminous crops are highly esteemed for such purposes, but in their absence weeds of any kind may be utilized.

The third object in breaking land is to control moisture. Lands long subject to overflow and which have become water sogged, may be relieved and made productive by drying, which is sometimes accomplished by throwing into high ridges and exposing the largest surface possible, with bare deep middles giving increased evaporation from lower depths and furnishing channels for the escape of flood waters in excessive rainfalls.

Evaporation is a cooling process, and no soil can be made productive which has an excess of water constantly evaporating from its surface. Therefore wet lands are frequently relieved of their excessive moisture by proper plowing. On the other hand, if the soil be drouthy and the rainfall unequally distributed throughout the year, breaking the land deep and flat, lapping each furrow on the preceding, forming a continuous mass of loose earth eight or ten inches deep, a reservoir is formed for the storage of water for dry periods and a blanket is spread over the subsoil to prevent rapid evaporation. Sandy and light loamy soils should always be thus

treated, while clays, naturally hydroscopic, had better be ridged to dispose of their excessive moisture.

Soils vary greatly in their capacity to hold water. At Audubon Park it has been found that the soils will carry over 50 per cent. of their weight of water without dripping. It has been further determined that growing plants will suffer on these soils when the moisture is reduced to 12 per cent. Sandy soils will rarely hold over 20 per cent. of their weight and will successfully sustain some plants where the water is reduced to two to four per cent. These differences are due to the different percentages of clay, silt and sand which these soils contain, and a knowledge of these different capacities frequently, in the absence of irrigation, determines the character of the crop to be grown upon such soil.

Grasses of all kinds revel in an excess of moisture. Being fibrous rooted, they gather their sustenance from the upper layers of the soil, and hence this upper stratum must furnish at least fifteen to twenty-five per cent. of moisture in order to render soluble a maximum amount of plant food. Clay lands readily supply this excessive amount and hence are specially adapted to grasses. Cane is a gigantic grass and enjoys in an intensified degree this love for moisture. Hence it is grown most everywhere upon clay or loamy clay soils.

Whatever the capacity of a soil for holding water, it has been found that fifty to sixty per cent. of this capacity is the amount best adapted to the rapid growth of those plants most suitable to the soil.

At Audubon Park repeated experiments have shown that twenty-five per cent. of moisture always present in the soils produces the largest and best crops of sugar cane.

CULTIVATION OF SOILS.

If the work of breaking the soil has been intelligently performed, subsequent planting and cultivation are simple processes. If badly done, then subsequent cultivation must be directed, not to cultivation proper, but to the securement of tilth, that is, obtaining the best conditions for the growth of crops.

Tilth should always, if possible, be obtained before

planting, and then the after cultivation is purely one of culture, that is the maintenance of tilth.

Unfortunately, such a happy condition does not always prevail with our planters. It too frequently happens that furrows of clods are thrown hastily together, and the seed deposited among the clods. Weeds and grass appear with the belated crop and contend for the mastery. Turn plows and hoes are used to remove the weeds. The young plants, already stunted, are left alone in the clods, surrounded by environments by no means conducive to rapid growth and development. Cultivation should have no such object in view as the destruction of weeds and grass. Sometimes our variable seasons fill our fields with grass and weeds in spite of our best efforts, and when filled must be removed by the plow and the hoe; yet the universal experience everywhere is that the crop is never improved by such treatment. It is simply a necessary evil, often brought about by neglect or overcropping, but sometimes by such extremely wet seasons as almost to defy human effort to prevent it.

True cultivation should look only to the preservation of tilth which a proper preparation of the soil has established. It involves *only two principles.* First, the maintenance of such conditions as will promote the most rapid and beneficial chemical changes in the soil, and second, the conservation of the proper amount of moisture.

The chemical changes in a soil are most complex. Until recently every soil was looked upon as a mass of inert matter, utterly devoid of life, and was treated with a view of reducing to a powder the material composing it, in order to release as much plant food as possible. To annihilate weeds and grass was the object of cultivation. Today an up-to-date agriculturist knows that every well cultivated and fertile soil is filled with living beings. The mineral portion of such a soil is simply the environment of living micro organisms, furnishing them with a portion of their sustenance. While air, water and mineral matter furnish the materials of plant growth, they must all be digested before they can be assimilated. The animal matter must suffer disintegration before assimilation, and the only forces so far known capable of ac-

complishing this work, are the secretions of the plants, the vital activity of the rootlets, organic acids, soil ferments and micro-organisms.

Micro-organisms are intimately connected with the rootlets of leguminous plants, and hence these plants are selected for soil improvement.

Again, every fertile, well tilled soil is swarming with other classes of microbes—some useful to vegetation, others positively noxious. Some prepare plant food directly, and are frequently accompanied by others whose chief function seems to be to destroy the work performed by the former.

Science is engaged in an earnest effort to discover a plan by which the former may be multiplied and the latter destroyed.

While there is a lurking suspicion that all plant food is perhaps the resultant of the action of micro organisms, bacteriologists have only so far succeeded in isolating and determining the character of those germs engaged in the preparation of nitrogen for plants. The process by which this nitrogen is thus prepared is called "Nitrification," and the process by which this preparation is destroyed is called "Dentrification." The importance of "Nitrification" can hardly be overestimated, when the relatively high prices of *nitrogen* are considered. It is the most important ingredient of fertilizers. It is also the most fugitive. The largest supply comes from organic matter, which by the process of nitrification is converted into Nitric Acid, the most soluble form of nitrogen and the form in which it enters into plants. The salts of Nitric Acid (called "nitrates") are extremely soluble, and if not at once appropriated by growing plants, are washed out by heavy rains. Hence a gradual development of Nitric Acid during the entire period of growth of plants seems extremely desirable and a cessation of "Nitrification" even in a fertile soil rich in nitrogenous matter is fatal to the plant growing therein.

In the process of Nitrification three distinct genera of micro organisms are recognized: First, those which convert nitrogenous matters into ammonia; second, those which convert ammonia into nitrous acid, and third, those that con-

vert nitrous acid into nitric acid. All are necessary to the complete transformation of Nitrogenous matter into Nitric acid, the form of nitrogen available for plant food. These ferments work together synchronously each waiting on the other.

It should be the aim of every planter and farmer to establish and maintain in all of his fields, conditions most favorable to the development and multiplication of these micro organisms, upon whose activities the abundance of his harvest so intimately depends. The following are the prescribed conditions:

1st. They are most abundant and active near the surface, diminishing in numbers and vitality as one descends. Hence the *importance of surface cultivation* for all crops when maximum yields are desired.

2nd. An abundance of air in the interstices of the soil. Hence the necessity of thorough drainage and a deep preparation of the land to insure a complete aeration.

3rd. A high temperature. The maximum activity is developed between 85 deg. and 100 deg. F. Plants grow rapidly when both days and nights are warm, while a fall in temperature frequently checks the growth.

4th. Absence of light. While the parts of plants above the ground require sunlight for their full development, these microbes diminish in activity even to the vanishing point as the sunlight increases. Shading the ground enables them to work near the surface, and warm nights are more propitious for their multiplication and work than warm days.

5th. A certain amount of moisture. Excessive moisture, as already remarked, excludes air, a needed factor in Nitrification, yet a certain amount of water present is indispensable to the existence of these germs. Experience has shown that one-third to one-half of the capacity of a soil for moisture is the proper amount for most rapid work.

6th.—An alkali, usually lime, to be present in small quantities. The final action of Nitrification is Nitric acid. Unless there be a base present with which this acid can unite, it would accumulate in the soil and destroy the germs;

a soil deficient in lime will support neither the microbes nor the crops.

7th. Presence of organic matter containing nitrogen. This condition is of first importance, and if the soil be deficient in it, must be supplied artificially in some form, as stable manure, cotton seed meal, tankage, dried blood, fish scrap, etc.

The use of stable manure or a compost containing it carries with it a double action, and therefore has a double value. It not only supplies nitrogen, but also the organisms for nitrifying it, and when incorporated in the soil, the latter exercise their activity also upon the inert nitrogen already in the soil, when the more nitriffiable portions of the manure are exhausted.

Hence stable manure frequently produces results far beyond the analytical contents given by the chemist.

Beneficial bacteria are often accompanied by others inimical to agriculture. These decompose nitric acid as fast as formed. A study of "dentrification" has developed the gratifying fact that under favorable circumstances the denitrifying bacteria are not propagated in alarming numbers, and therefore cannot be very destructive.

From the above it will be seen that frequent cultivations, provided no roots are cut, are favorable to rapid nitrification. It has also been demonstrated at this station that soils cultivated daily give a larger nitrification than the same soils cultivated weekly, and the latter more than those cultivated less frequently.

The second object in cultivation is to conserve moisture, and here, as with the other object already described, a shallow cultivation for the best results is required; in fact necessary, since it has been shown elsewhere that deep plowing will frequently relieve wet soils of their excessive moisture.

On the approach of a drought, cultivators should be run very shallow and almost continuously. By so doing, a thin layer of earth removed from the great mass of soil is laid as a mulch on the surface and the continuous upward movement of the water through the soil into the air is checked just be-

low the surface and the roots of the plants can then appropriate it. The continuity of capillary pores is broken and the water is arrested just below the surface, and is there retained for the use of the plant. By cultivating continuously during dry weather the mulch is restored as fast as the capillary action of the water in the soil destroys it. Again, finely divided soils have the power of absorbing hydroscopic moisture from the air, a not insignificant property in a prolonged drouth in a climate like lower Louisiana with heavy dews at night.

These are the reasons we plow and cultivate.

PREPARATION OF SOILS

should be accomplished by instruments best suited to the character of the land and the object of the cultivator. The implements used are turn plows, disc plows, harrows and rollers. Two fundamental types are found in turn plows. The one to produce tilth by going deep, pulverizing well and shearing the soil into the thinnest slices. All this is accomplished by having a steep mould board and a less oblique plow-share. The draft necessary to propel them is great, but the work accomplished amply compensates for the increased dratt. In an open porus soil, with large sandy particles, this plow is to be recommended, and the soil should be plowed a little wet and as deep as other conditions will permit. By so doing, a finer texture is obtained by breaking down the granulation. If the soil be already too close in texture, heavy and wet, a less steep mould used when the soil is dry, will tend to sheer it into layers and form larger granules.

The second form of turn plows is used to cut a clean furrow and turn it over as completely as possible, burying any cover of weeds and grass that may be present. The last form is extensively used in covering pea vines in this State. It usually has a revolving circular coulter in front, and a drag chain each end of which is attached to the ends of the doubletree, and of such a length as to pull down the weeds in front

of the plow so that the dirt may be thrown directly upon them.

Plowing soils when too wet has the tendency of destroying tilth and producing "puddling."

When a soil is the least too dry to puddle, it will sheer into the thinnest slices and produce the very best results in the securement of tilth. When the same soil is too dry, no shearing will take place and the furrow will be broken into large coarse lumps.

There is, therefore, a shape of mould board, a stage of soil moisture and a depth of furrow which will produce the best and quickest tilth in every soil. A variation in either factor may produce the opposite results. If plowing must be done when the soil is a little too wet, a less steep mould board is used and the furrow made as shallow as good work will permit. If a little too dry and the pulverization is not fine, a steeper mould board and a deeper furrow will generally pulverize the soil better and increase the tilth.

Deep plowing pulverizes more than shallow, and the work required is greater than the proportion of depth. Steep mould boards also pulverize the best, but the draft is greatly increased. Clay soils have more and larger granules which must be broken down, and hence require more power to plow than sandy ones.

The granules of a soil are not as strong in wet soils as in dry ones, and hence the former are easier plowed. If the soil is already too dry and must be plowed, every effort should be made to plow deeper rather than shallower, since deep plowing pulverizes better, reaches moist soil, which is brought to the surface, and places the upper dry soil at a depth where it will be quickly moistened, and in every way tend to produce an acceptable seed bed.

The sod plow is of the second form, and is constructed so as to require the least draft to propel it. It has a very slanting mould board, with an easy curve for bending and turning over the furrow slice. The shear is arranged so that its edge cuts off the roots with a drawing cut. It is easily managed by the plowman. The disc plow has found its way

to public favor in the last few years. When well managed, it is an admirable implement, breaking and pulverizing the soil well, and performing the work with the least draft. It will bury pea vines and other rank vegetation with the best results and least delays. It is especially useful for flushing or breaking land broadcast. Experiments at this station have shown that better and more economical results were obtained by turning under pea vines with this plow broadcast, and afterwards bedding the land with two horse turn plows than by bedding the land directly with a four horse turn plow. Nearly every implement manufacturer is now putting a disc plow on the market, and like the disc harrow and cultivator, it is yearly growing in popular use.

The *subsoil* plow is frequently used in Louisiana. Its use should be attended with extremely good judgment since it is liable to cause puddling when the soil is too wet. Again, the state of dryness in the soil is no criterion for the condition of the subsoil, and hence the latter is frequently stirred when far too wet, with disastrous puddling results. In the soils of the sugar belt, with the prevailing seasons, subsoiling, even when well performed, is of doubtful utility. Better far to let the cow pea roots do this work.

HOW DEEP TO PLOW

must be decided by every farmer after he has studied the requirements of his plants and the character of his soil. As a rule, it is hazardous to the next crop to turn up a large amount of unweathered subsoil, and the better way to secure a deep soil, a condition always promotive of large crops, is to gradually deepen, by an inch or more, the plowing each year until the desired depth is secured.

WHEN TO PLOW.

In every soil there is an exact condition of moisture at which the best tilth will be secured by plowing. As a rule, for general practice, this condition can approximately be de-

termined by squeezing the soil in the hand, and if after squeezing the soil will hold its form, but at the same time will easily crumble to pieces and not be sticky.

DRAFT OF PLOWS.

The draft of plows has been investigated in a series of trials in England and America. It has been found that it varies with the character of the soil, style of plow, and state of moisture. The results of these trials as given by Prof. King in his admirable work, "Physics of Agriculture," is:

English trials, 1840, mean draft 7.41 per square inch.

American trials, 1850, mean draft 5.81 lbs. per square inch.

This refers to the pounds required per square inch of the cross section of the furrow slice, e. g., a plow cutting 5 inches deep by 9 inches wide, has a cross-section of 45 square inches and if it required 227 lbs. to propel it, gives a draft per square inch of 5 04 lbs.

All plows should be so hitched that the line of draft should extend straight from the center of furrow slice on the mould board, through the traces to the connecting hook of the hames. If this line be not straight, the draft is heavier.

While a horse power in mechanics is taken at 550 foot-pounds per second, in farm practice the actual weight of the animal must be considered. A horse or mule can exert a pull of half of its weight for a short time, but in a steady pull, lasting all day, averaging 2½ miles per hour, it is not safe to require more than one-tenth of its weight. Therefore the mules used on a sugar plantation, weighing from 1,000 pounds to 1,250 pounds, each can pull steadily all day from 100 to 125 pounds each, may pull over hills twice this amount, and in emergencies, if well broken, may even quadruple this quantity. Taking the average plow and estimating that it will cut a furrow 8 inches by 12 inches, and that each square inch will require a draft of 6 pounds, there will be required four to five mules of 1,250 pounds each to pull it comfortably all day.

At a test at this station, the Hancock Disc Plow propell-

ed to a depth of ten inches, and cutting a furrow of fifteen inches showed a draft on the self-registering dynamometer of 550 pounds. These mules, weighing about 1,200 pounds each, pulled this plow with extra exertion and labor. It was a good pull for four mules. Doubtless one of the chief reasons for the rapid breaking down of the mules on a sugar plantation is to be found in the excessive, yea, unsafe work which they are daily called upon to perform.

HARROWS.

After the land is well broken with plows, it should be thoroughly pulverized with a good harrow of some kind, well ridged, well drained, and the middles and quarter drains well cleaned out.

If the work of preparation be done in the early fall and left (either planted or unplanted) until spring, it will be found in an excellent state of tilth, and cultivation of the crop, if it be properly done, will be an easy and rapid operation.

After once establishing this tilth, every care should be exercised to maintain it. If it be necessary to off-bar the land, to scrape the plant cane, or dig the stubble, the middles should be well lapped up. In fact, at no time during the cultivation should the land be left flat, since a heavy rainfall may occur on it which will in a short while destroy the tilth which previous heavy work had established. As soon as the cane is large enough, the middles should be split out, and plows sent to the house. The subsequent cultivation should be done exclusively with some of the improved cultivators.

ECONOMICAL CULTIVATION OF CANE.

The experiments begun several years ago to determine the economy and efficiency of the use of improved implements in the cultivation of cane have been continued through the years 1900 and 1901.

Though begun several years ago, the results for six years only are available, the freeze having destroyed the

experiment for the year 1899. The following is taken from Bulletin No. 59:

"Nine years ago Mr. Mallon brought to the station a cultivator designed to work the middles of the row at one passage. We were then using the disc cultivator and double-mould plow. Not having seen the results of the use of the implement, and valuing too highly the experimental plats in cane, to submit to measures whose effects then seemed to be problematical, we declined personally to use it, but consented to let him try it on a limited scale. Accordingly one plat, about one acre in extent, was assigned to him, and every time we cultivated our plats he cultivated his. His work and its effect upon both soil and cane were closely scrutinized, and we were agreeably surprised to find that during cultivation his soil was better pulverized and his cane more vigorous and verdant during growth than ours. At harvest all doubts were dispelled by the increased yield of tonnage without detriment to the sugar content. These results changed all of our plans for cultivation. We at once determined to discard all kinds of plows in cultivation and adopted the following general plan, which we have rigidly preserved ever since: the dirt is returned and the middles split out with a two-horse plow and the latter then sent to the tool room, to remain until the next season. The first cultivation is made by straddling the cane with the disc cultivator, using three unequal discs, running them very shallow and throwing very little dirt to the cane. The middle or diamond cultivator follows, working completely the middle of the row. In this operation both mules walk between the cane.

"The next cultivation is made in the same way, or if the cane has grown considerably and requires more dirt, the three unequal discs are removed and two or three of equal size are substituted. These discs can be dished to throw much or little dirt. Having displaced the three unequal discs with those of equal size, the cultivation continues with them followed immediately by the diamond or middle cultivator until "lay by" is desired. Then a single large disc is substituted on either side for the smaller ones on the disc cultivator, and the two forward shovels on the middle cultivat-

or are turned up, leaving only three f·: work, and with these the cane is laid by. This system of cultivation has been pursued for eight years on the station with most gratifying results."

Seven years ago a plat of land was laid off and devoted for two years to experiments in cultivation, using the above system in every alternate three rows and a two-horse plow in the rest. The results were a startling surprise to us all and were reported to the Sugar Planters' Associatian at one of their meetings in 1896.

"When reported it was suggested that we should compare other methods and not confine ourselves to the two-horse plow.

"Accordingly it was decided to extend the methods. A plat of ground containing seventy-two small experiments was selected. The cane was planted and an excellent stand all over the plat secured. Five different methods of cultivation were adopted, and were begun as soon as a stand of cane was secured, before breaking out the middles.

"1. The middles were split out with two-horse plow and all subsequent cultivations performed with this implement.

"2. The middles were split out with two-horse plow and the subsequent cultivation done with a disc cultivator and two-horse plow.

"3. The middles were split out with two-horse plow and all subsequent cultivation performed by disc and middle cultivators.

"4. The middles split out with double mould board plow and after operations done with disc and double mould board plow.

"5. No plow used at all. Middles split out with middle cultivator and after cultivation with disc and middle cultivators.

"These experiments were begun in 1897 with plant cane, continued in 1898 with first year stubble and left for second year stubble in 1899, but the freeze in February destroyed the stand and deprived us of the third years results. Here are the results for the first two years:

"PLANT CANE, 1897.

	Yield in tons per acre.	Sucrose.	Glucose.
Experiment No. 1	36.78	12.48	1.11
Experiment No. 2	39.54	12.36	1.05
Experiment No. 3	42.56	12.89	.96
Experiment No. 4	38.37	12.68	1.06
Experiment No. 5	41.20	12.17	1.03

"Here the sucrose in the cane is about constant, but the tonnage varies from 36.78 to 42.56. No. 3 leads, with No. 5 second; No. 2 is third, followed by Nos. 4 and 1.

"Here are the results for 1898—first year's stubble:

	Yield in tons per acre.	Sucrose.	Glucose.
Experiment No. 1	26.10	9.65	1.82
Experiment No. 2	31.05	9.65	1.74
Experiment No. 3	31.16	10.27	1.62
Experiment No. 4	31.24	9.80	1.81
Experiment No. 5	33.35	9.86	1.70

"This year is memorable for excessive rainfall and low sucrose content in cane. Here No. 5 leads, with 4, 3 and 2 following with almost identical tonnage. No. 1 is here the lowest as in 1897."

The same plat was used for the experiments of 1900-1901—the former year was in plant and the latter in stubble. There were the same number of cultivation experiments, with four rows to each, leaving one row between each experiment, not counted in the results, since this row received on either side a different cultivation. These four rows were planted in four varieties of cane—Seedling No. 74, Seedling No. 95, Purple and Striped.

The results of each year give, first, the results of each variety, and, second, the aggregate of four varieties, by the different cultivations. Only the aggregates are given here, since the full table of results would fill a large space and bewilder the reader.

The following are the results:

PLANT CANE 1900.

	Yield in tons per acre.	Sucrose.	Glucose.
Experiment No. 1	33.41	9.54	1.68
Experiment No. 2	35.74	9.66	1.63
Experiment No. 3	38.85	9.44	1.68
Experiment No. 4	36.20	9.40	1.81
Experiment No. 5	39.61	9.29	1.85

Here the sucrose is fairly constant, but the tonnage varies from 33.41 to 39.61. No. 5 leads, followed closely by No. 3; Nos. 4 and 2 are close together, while No. 1 is behind them all.

The result of first year stubble, 1901, are as follows:

	Yield in tons per acre.	Sucrose.	Glucose.
Experiment No. 1	29 61	10.93	1.71
Experiment No. 2	32.48	10.75	1.66
Experiment No. 3	34.00	10.78	1.58
Experiment No. 4	32.80	10.77	1.73
Experiment No. 5	34.48	10.38	1.83

Here there is a fair uniformity in the sugar content, but quite a variation in tonnage. No. 5 here leads, followed closely by No. 3. Again Nos. 2 and 4 are close together, while No. 1 is considerably behind.

An examination will show that in the plant cane, No. 5, gave

6.20 tons over No. 1
3.87 tons over No. 2
3.41 tons over No. 4
0.76 tons over No. 3

In the stubble, No. 5 gave

17.87 tons over No. 1
2.00 tons over No. 2
1.68 tons over No. 4
0.48 tons over No. 3

In plant cane, No. 3 gave

5.44 tons over No. 1
3.11 tons over No. 2
2.65 tons over No. 4

In the stubble, No. 3 gave

7.39 tons over No. 1
1.52 tons over No. 2
1.20 tons over No. 4

As before remarked, the freeze of 1899 destroyed the experiments of that year.

If the results of the other four years, two in plant, and two in first year stubble, be aggregated, it will be found that No. 5 is in the lead, followed by No. 3. Nos. 2 and 4 are very close together.

The following table will give the yields for the four years:

YIELD OF FOUR YEARS IN TONNAGE:

No. 1, 125.90 tons.
No. 4, 138.61 tons, gain of 12.71 tons over No. 1.
No. 2, 138.81 tons, gain of 12.91 tons over No. 1.
No. 3, 146.57 tons, gain of 20.67 tons over No. 1.
No. 5, 148.64 tons, gain of 22.74 tons over No. 1.

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Figures speak more forcibly than words. The true principles of agriculture require a deep and thorough pulverization of the soil, proper fertilization and shallow but rapid cultivation, and sugar cane is no exception to this general rule. If the soil be thoroughly broken in the fall and thrown into high ridges, the middles well opened and quarter drains cleaned out, spring will find it in excellent tilth. This tilth must be maintained, hence in off-barring cane or stubble, avoid throwing dirt flat, but always keep the middles well ridged up. When the latter are reversed it will be found that the tilth still remains and subsequent cultivation is but a maintenance of this tilth. With the disc cultivator much or little dirt can be thrown to the cane, while the middle cultivator can be regulated so as to run deep or shallow, and its shovels

arranged so as to have much or little ridge. By the use of these implements a minimum amount of roots are cut, moisture is conserved and microbic action encouraged. All plant food is prepared by microscopic organisms, which teem in fertile soils of excellent tilth. The tankage, the cotton seed meal, the stable manure, and all other kinds of fertilizers, must be converted into soluble forms before they can become available by plants. All this is accomplished through these organisms and it should be the aim of every planter to encourage their multiplication as rapidly as possible during the growing season. It is known that fine pulverization of soil, aeration and moisture (not standing water) contribute to rapid multiplication. These microbes must have air, and hence abound chiefly in upper layers of the soil. When soils are deeply inverted by the plow they are killed in large numbers. When soils are cloddy, their increase is necessarily checked, since moisture cannot circulate freely through them.

These are facts easily demonstrated, and in our experiments it was found that there were greater numbers of microbes in the finely pulverized soil of the cultivators than in the cloddy soils of the plow.

Again, the roots were less severely pruned and moisture better conserved with the cultivators; important factors during a prolonged drouth. The efficiency of the cultivators can hardly be questioned. The economy may be shown by stating that in five-foot rows our two cultivators cultivate ten acres per day, with twelve acres in six-foot rows. With this experience I have no hesitancy in saying that in average seasons two pairs of good mules will cultivate eighty acres of land.

I further believe that if every planter should adopt this method of cultivation to be used after a thorough preparation of his soil, that the yield of cane in the State would be increased from five to ten tons per acre.

CONDENSED WEATHER RECORD OF SUGAR EXPERIMENT STATION FOR YEARS 1900-1901.

Month	1900				1901			
	Average Temperature	Maximum Temperature	Minimum Temperature	Rainfall in Inches	Average Temperature	Maximum Temperature	Min mum Temperature	Rainfall in Inches
January	49.90	70.	24.	3.96	54.59	74.	34.	2.24
February	51.92	76.	24.	6.27	51.75	76.	31.	6.27
March	59.96	81.	37.	5.23	58.74	80.	30.	3.13
April	67.36	85.	44.	13.63	64.40	85.	44.	8.50
May	71.70	90.	58.	4.49	73.69	90.	55.	3.16
June	80.33	93.	68.	7.68	81.65	98.	66.	8.94
July	82.14	93.	70.	9.30	82.87	101.	71.	6.81
August	81.91	93.	71.	4.77	80.93	95.	71.	3.98
September	81.61	95.	66.	3.15	77.10	91.	54.	2.88
October	71.95	91.	50.	2.02	68.01	85.	46.	2.91
November	61.43	83.	36.	1.66	54.56	82.	36.	.22
December	52.70	72.	35.	8.64	50.30	78.	21.	4.98
Average and total	67.74	85.16	48.58	70.80	66.50	86.25	46.74	54.02

REMARKS.

The years given above were totally unlike. The rainfall of 1900 was rather in excess 70.80 inches; while that for 1901 was only 54.02. In 1900 no killing frosts occurred. The guavas, bananas and sugar cane lived through the entire winter, and yet the aggregate cold was nearly as great as a year of freezes. The spring of 1900 was extremely wet, the summer was fairly favorable while the spring of 1901 was very dry and in May crops were irrigated. The fall has been unusually severe giving us the coldest killing freeze within the records of this station. It was at the same time a prolonged freeze lasting over a week, and doing great injury to the standing cane all over the State. Both years were rather favorable to the growth and development of the cane crops, and but for the late freeze of 1901, the largest crop of sugar ever made would have been harvested.