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# Soils in their Relationship to Sugar Cane Culture

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# Soils in their Relationship to Sugar Cane Culture

## FORMATION AND COMPOSITION.

By H. W. KERR.\*

**I**N its broad meaning soil is that friable upper layer of the earth composed for the most part of mineral matter resulting from the breaking up and decay of rocks. It is thus the product of rock weathering, brought about by the action of the destructive forces of nature. These forces include the stresses set up in the rock mass due to alternate heating and cooling and the action of running water as an abrasive agent, assisted by the sand and gravel which it carries along. In cooler regions the water which enters the cracks of the rock may become frozen, and the force exerted in this way tends further to open up the cracks and hasten the break-down of the rock. Under humid tropical conditions the rock decay is effected chiefly by the chemical action of water, aided by gases such as oxygen and carbonic acid which it carries in solution. The products of decay of vegetation are frequently acid substances which also exert a solvent influence.

As a result of this complex, slow action, the solid rock mass is eventually reduced to small particles, and the minerals of the rock undergo a greater or lesser change in the process. The quartz particles are merely broken down to smaller sand grains, but other minerals may completely lose their identity in the process. An outstanding example of rock weathering is the decomposition of the hard, dark, compact volcanic rock or basalt which occurs at numerous points along the coastal area of Queensland. It yields a deep, rich red or chocolate loam such as is found at Bundaberg, Childers, Innisfail, and Atherton. In many cases the rock has been changed to soil to a depth of 100 feet or more. The weathering processes do not cease when the soil is formed, but continue to act indefinitely upon the soil itself. As we shall see later, this is most important, for the process provides a supply of materials most valuable to our crops.

In many localities, we may trace the changes from the mature surface soil, through the partially decomposed rock, to the solid, unchanged material. Such a soil is known as a residual soil, and is directly related to the underlying rock. The red volcanic loams provide an example of this type. However, the excessive rainfall which drains from the land surface during the wet season, carries with it a greater or lesser amount of fine soil material which may find its way into creeks and rivers. In times of flood these streams frequently overflow their banks. The rate of flow of the water is thus checked, and the load of sediment is deposited as a layer over the flooded land surface. In this way soils are built up which have no relationship to the underlying rock. These are known as transported soils, and are represented by our river alluvials, which constitute some of the most important sugar soils of the State. The sources of the sediments are mainly the uplands drained by our coastal streams; these are frequently areas of deficient rainfall,

\* In a series of radio lectures from 4QG.



so that the sediment has not been subjected to excessive leaching; and as a consequence it confers upon the alluvial soils a high degree of fertility, which is maintained in some measure by the renewed deposits during successive flood seasons. The rich alluvial soils of the Burdekin delta are an excellent example of transported soils of this character.

The term "soil" is also employed in a more restricted sense to designate that portion of the ground which is tilled, or which can be readily identified from the underlying stratum or "subsoil" by a definite colour change. The distinct transition from soil to subsoil may be traced very clearly in most of our forest soils, but with scrub soils there is often no sudden change, but a gradual transition extends over a depth of several feet. There is usually a definite relationship between the depth of surface soil and the fertility of the land, and it is for this reason that the deep scrub soils are preferred to the comparatively shallow forest lands.

A detailed study of the soil shows that it consists of a mixture of mineral particles of widely varying size. Let us add a portion of soil to water contained in a glass vessel, shake the suspension very thoroughly, and then allow it to stand. We would find, in general, that the coarser particles settle rapidly, and then follow the finer and finer grains, while certain of the extremely finely-divided material remains suspended almost indefinitely. The coarser particles are known as sand, while the finest material is known as clay. The grains of intermediate size are called silt. All soils contain these three grades in varying proportions, and the relative amount of each present has a most important bearing on the physical properties and the tilling qualities of the particular soil. One rich in sand is known as a sandy soil, while a soil rich in clay particles is known as a clay. Intermediate to these extremes we have the loams, which do not contain a preponderance of particles of any of these three grades.

The individual soil particles do not exist as a casual mixture in which every particle remains separate from every other particle. The finest soil material or clay exerts a cementing action which binds the soil into compound particles or granules, thus developing what is known as a "crumbly" or "granular" structure. This characteristic is an essential feature of a soil in a condition of good tilth; but frequently the land loses this characteristic, so that the soil becomes loose and dusty when dry, and runs together to form a hard compact mass after wetting. This soil condition is most undesirable, and methods for correcting the difficulty will be discussed in some detail at a later stage.

So far we have considered the soil as a conglomerate lifeless mass of mineral particles. Such a mixture would be quite incapable of crop production, and we have now to recognise that the soil contains, in addition, a greater or lesser amount of material not of mineral but of organic origin. As the plant and animal inhabitants of the soil perish, their remains decompose in the soil; and the residues from this decomposition constitute that important material—the soil humus. The process of decomposition or decay which these organic remains undergo, is effected by a complex population of myriads of minute organisms known as bacteria and fungi. When we speak of bacteria and fungi, the popular mind conjures up visions of certain of these organisms in their relationship to diseases of both animals and plants; but it is well to remember that there are but few of these organisms which are actually

our enemies; and, from the farmer's point of view, we must consider this great army of little workers as a never-tiring band of willing helpers who, given suitable conditions, bring about most important changes in the soil for the benefit of both farmer and crop. The plant and animal remains which are added to the soil constitute the food of these "microbes," as they are popularly called, and the by-products of their life processes are, firstly, the plant food materials which we shall consider shortly; and secondly, the undecomposed residue which remains to confer its important properties to the soil. This material—the soil humus—is a black, waxy substance, which exists as a fine coating surrounding the mineral grains, and assists the clay particles in binding the individual grains into that crumbly or granular structure so desirable in our agricultural lands. It also has an important bearing on the water-holding capacity of the land, and contributes in a large measure to its fertility.

The proportion of humus which is found in soils varies widely. In certain of the black earths of the Canadian prairies, famed for their prolific wheat productivity, as high as 20 per cent. of the weight of the soil is humus. Unfortunately, the humid tropical conditions of our coast are such as favour the rapid decomposition of the valuable soil organic matter, and it is seldom that we find more than 5 per cent. of humus in the best of our soils. The excessive leaching to which most of the sugar lands are subjected also results in a rapid loss of humus. Under intensive cultivation, the rate of loss due to these causes is intensified, and unless strenuous efforts are made to keep up the supply, by the ploughing under of all available crop residues, the soil suffers seriously from the point of view both of fertility and the ease with which it can be maintained in a condition of good tilth.

We must visualise our soil, then, as a body of lifeless, decomposed rock minerals, through which is infused the organic remains of plant and animal origin, carrying with it a busy population of microscopic life.

We have next to consider the importance of this complex mass of decayed rock and humus in its relationship to plant nutrition and crop growth.

#### FUNCTIONS OF THE SOIL IN PLANT NUTRITION.

Earlier students of agriculture were completely mystified by the process of crop production. That the soil was essential to plant growth was quite obvious, but of the nature of the substances which it absorbed in the process they were completely ignorant. As recently as three centuries ago it was thought that a plant was nothing more than water that had undergone a mysterious change in the soil; other workers contended that the plant roots actually fed on the solid soil particles, and the explanation of the value of cultivation was, that it helped to reduce the soil to the finest condition and thus assisted in the process of digestion by the plant. In fact, it is only during the past 100 years that the science of agricultural chemistry has given us a clear understanding of the principles of crop growth, and the true function of the soil in this regard.



Scientific studies have shown that the plant leaf is a marvellous factory in which the raw materials, carbonic acid gas and water, are manufactured into sugars, through the agency of the green colouring matter of the leaf. This substance—known as *chlorophyll*—has the power of absorbing the energy of the sun's rays, and utilising this energy to effect a combination of the raw materials. The water utilised in this process is absorbed from the soil through the roots of the plant. The carbonic acid gas, or carbon dioxide, is absorbed from the atmosphere by the inner surfaces of the plant leaves. Microscopic examination of a leaf shows that its surface is pitted with numerous small pores, through which air may enter and leave, and in this way a continuous supply of carbonic acid is maintained to the "leaf factory."

From the sugars manufactured in this way, more complex plant substances are built up. These include starches, fibre, proteins, and fats, which are essential to the economy and life processes of the plant. Our cane crop is particularly interesting in that it preserves large quantities of sugars in the storage cells of the stick, and these sugars confer upon the crop its economic value.

In addition to these organic compounds of the plant it contains, also, a certain proportion of mineral matter. This is clearly evident from the fact that when we burn the dried plant, a certain amount of ashy material remains. Analysis of the ash from a variety of plants shows that certain simple substances or elements as they are called, are always present, and it has been demonstrated that these are absolutely essential to plant growth. These essential elements, six in number, are phosphorus, potassium, calcium, magnesium, iron, and sulphur. They are usually called soil nutrients or plant foods, and if any one of these is entirely lacking in a soil, plant growth is quite impossible; yet in total quantity they may constitute no more than 1 per cent. of the entire weight of our plant. The mineral matter of the soil is the source from which these substances are derived, and they enter the plant through the roots, dissolved in the soil water which is absorbed at the same time. It is in this respect that the weathering action in the soil is so important; it maintains the decay processes which provide these nutrients in a form available to our crops. The nutrients bound up in the undecomposed soil particles are not available for plant feeding, as was once supposed, but are utilised only when the weathering processes release them in a soluble or available condition.

There is still one essential nutrient, nitrogen, which does not arise from mineral decay, but which is entirely associated with the soil humus. It has already been stated that a mass of decomposed mineral matter will not support crop growth, for the reason that it is not capable of supplying the essential plant food, nitrogen. Further, soil nitrogen becomes available to the plant only as rapidly as the humus decays; that is, conditions in the soil must be suitable for the feeding of the soil microbes on the soil organic matter, so that they in turn may release the available nitrogen as a waste product of their feeding. At the same time certain mineral nutrients which were contained in the original plant residues, when they were returned to the soil, become available once more in the process.

The nett effect of mineral and organic decay in the soil is, then, to provide a supply of plant foods to the crop. It is also reasonable to suppose that certain soils may not be capable of supplying these plant

foods in quantities adequate for the crop needs, and in this event we might expect crop growth to be handicapped as a consequence. This is, indeed, quite true, and the problem of maintaining the nutrient supply introduces the question of fertilizers and their use.

Fertilizers are used largely in Queensland, particularly by cane-growers; but there are still many farmers who have deep-rooted objections to them, which they consider as plant stimulants, the use of which will eventually ruin the land. Nothing could be further from the truth; for these substances are nothing more or less than concentrated supplies of essential plant foods. Let us look into this question a little more closely. It has already been stated that before plant growth is possible, a supply of the seven named soil nutrients is essential. Most agricultural lands contain at least four of the nutrients named; but it frequently happens that there is a marked deficiency in the supply of nitrogen, phosphorus, and potash, and that is the reason why artificial fertilizers contain only these three nutrients.

In preparing commercial fertilizer, it is possible to mix together a variety of proportions of the constituents which supply the individual plant foods. It will be quite obvious that, if fertilizer is to be used to the best advantage, the mixture employed should be so constituted that it supplies the three plant foods in the exact proportions in which they are lacking in the soil. In other words, we may determine that our crop requires nitrogen, phosphoric acid, and potash, in certain proportions. Sugar-cane, for example, shows something like the following:—One ton of cane contains 2 lb. nitrogen, 1 lb. phosphoric acid, and 4 lb. potash. A 30-ton crop of cane will then require thirty times these amounts or 60 lb. nitrogen, 30 lb. phosphoric acid, and 120 lb. potash.

If we could only determine the capacity of the soil to yield these three nutrients, it would be an easy matter to calculate, by simple arithmetic, the weights of each plant food to be added to the soil. Unfortunately, the problem is not quite so simple as that; but the essential point is, that in seeking the most suitable fertilizer mixture, we have to keep in mind firstly, the needs of the crop, and secondly, the nature of the soil supply. The latter factor involves a knowledge of the soil itself, and it is a well-established fact that soils vary widely in their ability to supply these nutrients. In this connection take our well-known red volcanic loams. These soils are derived from a rock which is notably deficient in potash, and, as we might expect, the soil very frequently yields a deficient supply of this plant food to the crop. The use of fertilizer mixtures rich in potash on such soils is therefore attended by good success. On the other hand, the alluvial loams of the Johnstone River area are derived largely from granitic rocks, which are notably rich in potash, but deficient in phosphoric acid. On these soils our experiments show that large increases in crop yields follow the use of fertilizers rich in phosphates, while little response is shown to applications of potash. Each particular soil type, then, exhibits its own peculiar characteristics with respect to its fertilizer needs.

With regard to the nitrogen supply, it has already been pointed out that this is closely associated with the humus content of the soil; and the soils of coastal Queensland are notably deficient in their content of this important soil substance. We might expect, therefore, that these soils will frequently be found to give



good results following the use of fertilizers containing this plant food. This is, indeed, a well appreciated fact; and the use of sulphate of ammonia (which supplies only the plant food, nitrogen) is a well-established practice, particularly with ratoon crops. This fact also explains in a large measure why the ploughing under of a green manure crop such as cowpea or Mauritius bean prior to planting the cane, is attended by uniformly good results. Peas and beans (which belong to the family of legumes) possess the special characteristic that they act as hosts for an interesting group of soil microbes which enter their roots, and live in a state of perfect harmony with their host. The legume supplies the sugars which constitute the food of these tiny organisms, and as they develop and multiply, they give rise to those well known nodules which are generally associated with the roots of peas and beans. In exchange for their food supply these bacteria build up a wealth of nitrogenous food of immense importance to our legume. The nitrogen utilized in the process they gather in the gaseous condition from the atmosphere, manufacture it into compounds which nourish their host; and when the green crop is finally ploughed under, the soil receives a nett gain of valuable nitrogen compounds which, when decomposed, provide an abundant supply for the succeeding cane crop. As high as 200 lb. per acre of nitrogen may be accumulated in this way; to supply this quantity in the form of artificial manure would necessitate the addition of almost half a ton of sulphate of ammonia per acre.

The absolute necessity for the application of heavy dressings of artificial fertilizer cannot be over-emphasised if the fertility of the land is to be maintained. The weights of plant foods removed by a ton of cane are apparently quite low; yet, when it is considered that over a period of even twenty-five years, 400 tons of cane may be removed from an acre of land, we find that it would require almost 5 tons of high-grade artificial fertilizer to supply the plant food which is lost from the land in this way. Coupling this with the fact that the best of the soils of our coastal area, even in their virgin state, are not over-well supplied with plant food, due to the excessive leaching to which they are exposed, we can readily appreciate how rapidly the fertility of the land will run down when fertilizers are not employed. For a farmer to admit that a good agricultural soil becomes worn out after only fifty years of cultivation, is to make the candid confession that he has failed in his capacity as an agriculturist.

### CONSERVATION OF MOISTURE.

Last issue we discussed the mode of soil formation, and the nature of the plant food materials or nutrients which are absorbed from the soil through the plant roots. It will also be remembered that the process of food manufacture by the crop leaves was described; water from the soil and carbonic acid gas from the atmosphere were stated as the raw materials from which the sugars and more complex foods were built up, and in this process the soil nutrients played a most important part. Now the supply of nutrients in the soil may be available in such limited amounts as to restrict the growth rate of the crop, but in that event the ready means of supplying this deficiency are at our disposal in the form of artificial manures.

We have no control over the carbonic acid supply of the atmosphere, and indeed this is one factor which need give us no concern; but the remaining raw material utilised in our factory—water—is one, to the supply of which we must give our very careful consideration. It is very evident to every farmer in Queensland how frequently the water supply of the crop is the factor most seriously limiting crop production. Except for those fortunate growers who have at their disposal an adequate supply of irrigation water to supplement the natural rainfall, the farmer is entirely at the mercy of the weather for his supply.

Water is the life-blood of the plant, and its importance as a raw product for food manufacture is but one of the many functions which it performs in our crop economy. If we had appropriate means for studying a growing plant, we would discover the very interesting fact that a vigorous stream of water carrying the dissolved soil nutrients is being continuously drawn in by the numerous fine roots, passing upwards through the water-conducting vessels of the stem, thence, firstly, into the main veins of the leaves, and finally through the finer network into the sugar-manufacturing cells. From these cells the water is passed out in the form of vapour through those same minute pores in the leaf surface which allow of the free entry of the carbonic acid gas of the atmosphere.

The quantity of water used in this way is not generally appreciated. Careful experimentation has shown that in the production of every ton of cane over 160 tons of water are pumped through the plant and evaporated from the cane leaf surfaces. In the growth of a 30-ton crop, then, practically 5,000 tons of water are demanded from each acre of soil. Expressed in terms of rainfall, we find that 50 acre inches of water must be made available to the crop for the purpose; or, again, each stool of cane must have access to almost 200 gallons of water during its growing period.

It must be clearly understood that to produce our 30-ton crop this quantity of water must actually be absorbed from the soil by the crop; and the relationship between this quantity and that which falls on the land surface as rain varies widely. In almost all of our cane areas the



average rainfall is well in excess of 50 inches a year; but it is well known that in times of heavy downfalls a greater or lesser proportion of the water drains from the land surface, and when run off in this way is obviously incapable of crop production. Then rainfall distribution is erratic, even in those cane areas most favourably served in this respect. For instance, in the Babinda-Innistail-Tully districts, where the average annual rainfall is round about 150 inches, long spells of weather are experienced in which vigorous crop growth is suspended, due to moisture deficiency in the soil. The question of the absorption of the maximum volume of water by our soils, and its retention for use by the crop during rainless spells, is one of the greatest questions confronting the Queensland agriculturist, and we will study in some detail the factors underlying the problem.

If we wish to store water, we must provide ourselves with a reservoir. The soil itself is the obvious natural storage reservoir for the farmer; and a study of the factors involved in the ready absorption of rainfall and the conservation of the stored moisture gives us a clear understanding of the true functions of all tillage and cultivation operations which are so essential to successful crop growth.

The farmer, in ploughing and harrowing his land, aims at reducing the compacted soil to a good, mellow bed, in which conditions are most favourable for the germination of his seed. This requires a moist, warm, well-aerated yet firm soil, in which the young roots will develop freely, and where the helpful little microbes are able to do, without hindrance, their job of helping to provide for the plant-food needs of the crop. These are also the conditions which favour the most ready absorption of rain which is received by the land; and the production and maintenance of these conditions is of paramount importance if the farmer would take full advantage of all that is possible in this regard. We must also keep in mind another factor in water conservation, and that is the capacity of our reservoir. Under the most favourable circumstances, 12 inches of loamy soil will hold only 3 to 4 inches of water. If a quantity in excess of this is received in one fall, the capacity of the soil to hold the added supply obviously depends on the nature of the subsoil stratum. If this consists of a tight clay, which has probably been further consolidated and compacted under plough action with tractor or horses, the rate at which it will absorb moisture is very slow, and the chances are that much of the valuable rain in excess of 3 or 4 inches will be lost by surface run-off. It is therefore imperative that a careful examination of the soil be made to a depth of 2 or 3 feet, in order that a cultivation system may be devised which will be most suitable to the particular conditions. At all times the cultural methods employed should aim at preventing the re-formation of these so-called "pans." The continued working of even light cultural implements to a uniform depth makes for the creation of hard pans; and the secret of successful tillage lies in varying the depth of cultivation, in order that the work of any implement will eliminate successfully any harmful residual effects of the preceding one.

We may conclude, then, that large quantities of moisture may be stored only when methods of deep cultivation are practised. That does not mean ploughing to excessive depths; in fact, many a farmer has discovered to his sorrow the harmful effects of bringing up too much raw subsoil at one ploughing; for this material might completely ruin the tilth of the surface soil, due to its high clay content, besides adding

a mass of material deficient in humus and plant food. The correct thing to do is to break up the hard-pan layer, without bringing any of the subsoil to the surface. This can be effected most successfully by the use of the subsoiler. The essential features of such an implement are a long blade coulter, terminating in a narrow chisel-shaped point or piercer. This implement does not entirely crumble the compact subsoil, but it does cut a narrow gash into which water and air can freely enter. Later, the crop roots follow down after the moisture supply, and, working around and through the cake, will ultimately disintegrate the most compact hardpan, making the entire mass mellow and friable.

The correct time at which to carry out this operation is when ploughing is in progress. With a second team, to follow in the furrow behind the plough, the subsoiler may be put down 6 inches below plough depth, and in this way the soil is brought into an open, absorptive condition to a depth of from 14 to 16 inches. The season at which the work is carried out is also important; for if moisture conservation is our ultimate object the job should be finished in advance of the wet season. November or December ploughing is most valuable in our sugar areas, and where a crop of green manure is to be grown the improved conditions effected by the deep cultivation will favour this cover crop as well.

It is not sufficient to provide only for the absorption of moisture, but we must guard the stored supply against loss through other channels than crop growth. A moist soil continually evaporates water from its surface, and if this process were allowed to go on unchecked much of our good work would be nullified. The growth of weeds and grasses on our ploughed land also dissipates the moisture required by our economic crop, and they must be eliminated as soon as they appear. The operation of surface cultivation implements is effective in overcoming these evils, and the value of a mulch of dry surface soil so produced is well appreciated in its influence on the conservation of soil moisture. Following every rain, therefore, light scarifiers or harrows should be brought into operation, when the surface soil is in suitable condition, and the surface mulch again restored.

Many of the soils of our tropical coast do not, unfortunately, give permanent response to cultural operations. When an effort is made to reduce them to a condition of good tilth much difficulty is experienced, and persistent and excessive working on the part of the farmer results in the production of a loose, dry mass, which can scarcely be considered as a favourable seed-bed. With the first heavy rains this dusty mass runs together, and on drying becomes a hard, impervious, concrete-like cake. The correction of this difficulty, which is an inherent property of the soil in most respects, is one which can be effected only with considerable effort. The most reliable and satisfactory method is to increase the humus content of the soil. In fact, it is with respect to its favourable influence on the physical condition of the land that a good humus supply is so desirable. In addition, it gives the soil the capacity to retain large quantities of water, by virtue of the fact that one part of humus might hold twice its weight of water, while soil minerals possess a retentive capacity of only about one-sixth this value.

At first sight, the problem of maintaining the humus supply in the soil might appear quite simple; a heavy mass of green manure ploughed into the land should undoubtedly result in a marked increase in the content of soil organic matter. As a matter of fact, the ploughing under



of even a very heavy crop of beans or peas results in the gain of a, comparatively speaking, microscopic quantity of permanent humus. This point is stressed, not with the object of discouraging the growing of these valuable crops, which bestow upon the soil a wealth of beneficial effects, but rather to show farmers that they must not delude themselves into the belief that by green manuring they are building up reserves of humus in the land. For the canegrower there is, fortunately, a valuable source of material at his disposal, the use of which will enable him to effect this desirable purpose; this material is the cane trash and tops which remain on the field after harvesting, and which are so frequently regarded by the grower as a nuisance which must be tolerated until such times as he can apply a firestick and send up the potential humus-forming material, together with its valuable nitrogen in the form of smoke. But the problem of trash conservation is receiving the very careful attention of the Soils Laboratory of the Bureau, and it is hoped that the practical difficulty which its conservation entails will be overcome before long.

To conclude this necessarily sketchy review of the important subject of soil moisture, it must be emphasised that the working out of a cultural system best suited to any particular farm or soil type must be left in the hands of the individual farmer. He must make a careful study of his particular conditions, and with the essential principles clearly in mind, he should adopt those methods which aim—firstly, at the creation of conditions most favourable to the ready absorption of the rainfall; secondly, at the maintenance of these conditions as far as possible throughout the lifetime of the crop; and, finally, to make every effort to conserve this moisture against loss through weed growth or free evaporation from the compacted moist land surface. He will find that practices which achieve these purposes will be those which make for the most economic utilisation of available moisture and the production of maximum crop yields. The provision of an abundance of plant food in the soil is one of the surest means at the farmer's disposal for ensuring that the soil moisture will be employed to the best advantage. Under otherwise identical conditions, the rich soil will always produce a heavier yield, for a given water supply, than one poorly supplied with available nutrients.

#### PRACTICAL APPLICATION OF PRINCIPLES.

In this, the concluding talk of the series, it is proposed to discuss certain important aspects of sugar-cane agriculture in the light of the principles previously outlined. The farmer's first consideration, in this respect, is the preparation of the land for planting. No hard and fast rules can be laid down for the number of ploughings, harrowings, or other preparatory treatment to be employed, for this depends so much on local factors. The grower must develop his own system in the light of his past experience. There are, however, several important points which should be kept clearly in mind. The objective is the production of a deep, moist, mellow seed-bed in which conditions are most favourable for rapid germination and ready development of the young crop. It may require six ploughings with intermediate harrowings to produce this, or it may be done by two. But it is well to remember that the minimum of work which is necessary to produce the desirable seed-bed, the better it will be for the land. We should be quite clear on this point; there is no virtue in ploughing the soil six times in an attempt to reduce it to a

state of good tilth. On the contrary, such a practice indicates either a difficult, intractable soil or lack of timely work on the part of the farmer.

It is well appreciated that a soil which necessitates this treatment is generally in an unsatisfactory final condition. Either it is still lumpy or has been reduced to dust. There is a definite time at which almost every soil can be worked most easily, when it will readily mellow and crumble under the action of the implement. This condition depends entirely on the moisture content of the soil, and growers could well pay more careful attention to this factor. If worked at a higher moisture content the clay particles run together, the soil becomes puddled, and breaks up in hard clods. If worked when very dry, the soil crumbs are broken up to give a dusty soil which exhibits those same undesirable characteristics with the first rains. With the more general use of the disc plough—certainly a very valuable implement in its place—it is felt that insufficient attention is paid to the condition of the soil for ploughing, and very frequently this important operation is deferred until the soil has become too dry.

With regard to the depth of working, it is doubtful whether any benefit is to be derived from ploughing to a greater depth than 10 inches of compact soil. For the second or subsequent ploughing, this would mean about 12 inches of loose soil. Certainly the soil should be opened up to greater than plough depth, but the breaking up of the subsoil should be carried out with the subsoiler, which brings none of this raw material to the surface. In its influence on moisture conservation, the value of subsoiling cannot be overstressed, provided the work is done in season. The correct time to carry out the operation is when the land is being broken up, in advance of the wet season. Besides the beneficial effects of large volumes of water which may thus be stored, to a depth of several feet, it must be borne in mind that cane is essentially a deep-rooted plant, which, under favourable circumstances, will send its feeders down to 5 and 6 feet. The value of a store of moisture in the depth of the subsoil will be readily appreciated in prolonged dry spells.

It should be the aim of every cane farmer to grow and plough under a crop of legumes before planting his cane. For this purpose, Mauritius beans are preferred in the northern and cowpeas in the central and southern areas. In this connection, the superiority of the Poona pea should be recognised. This legume, which is closely related to the cowpea, is now finding great favour in Southern Queensland, for it withstands adverse conditions much better than the cowpea, and usually takes three or four weeks longer to attain full maturity; incidentally, it stands up better to any attack from the bean fly than cowpea. The use of this legume cannot be too strongly recommended to those growers who have difficulty in obtaining a stand of cowpea.

Any special treatment given to the land for the benefit of the leguminous crop will be effort well spent; and, far from being wasted, will facilitate the final preparation for cane after the legume has been ploughed under. A good cover of beans or peas is very valuable in its influence in lessening the harmful beating effects of heavy rain. Every drop of rain during heavy falls acts as a tiny hammer which tends to drive the soil grains together into a compact mass, and the value of the cover crop in eliminating this effect is well appreciated by those who carry out the practice. The legume will, in general, be ready to turn under somewhere between February and April. In general practice, if



this is done when the seed pods are in the milk stage the best results will be attained. Under warm, moist conditions, the succulent material will rot down within six or eight weeks, and the land is then ready for planting to cane if weather conditions are suitable.

It is the policy of the Bureau to advocate strongly the planting of the cane crop at this time. Soil moisture conditions are then excellent; usually the ground is warm, and a good germination may reasonably be expected. Under these favourable conditions the crop becomes readily established, and although it makes no apparent growth during the winter months, it is ready to take full advantage of the first spring rains to push ahead, cover in the rows, and be out of hand before the wet season. Further, by autumn planting, an important job is finished in advance of the busy harvesting season. There are many growers who strenuously oppose the practice, and under certain special circumstances the objection is valid. The superiority of autumn over spring planting has been so frequently demonstrated that it can be accepted as the more desirable practice.

When planting time comes, the question of the plant food supply for our crop should be dealt with. If the farmer has ploughed under a leguminous crop, he may safely assume that he has provided for the nitrogen requirements of the plant crop of cane. But it should be remembered that the beans or peas do not effect a gain in the plant food supply of the soil with respect to any other nutrient but nitrogen. Any phosphoric acid or potash which becomes available from the decomposition of the green manure was originally absorbed from the soil; and therefore, if a deficiency in the supply of either of these plant foods has been established for the particular soil, steps should be taken to apply the appropriate fertilizer materials which supply these needs.

If the crop is to make the best use of the added plant food, it is reasonable to suppose that the earlier it receives it the better. The truth of this has, indeed, been demonstrated repeatedly, and it is our practice to apply any phosphatic or potash-bearing fertilizers in the drill with the cane plants. When green manuring has not been practised, it will probably be found that the soil is lacking in available nitrogen, and in this case a top dressing of sulphate of ammonia should follow the earlier drill mixture. Nitrogen is a costly plant food, and one which is readily leached from the soil before it can be absorbed by the crop. For this reason it is recommended that the sulphate of ammonia be applied at a time when the root system is fairly well established, and it is generally found most convenient to apply it when the crop is stooling vigorously. This fertilizer should be distributed on the surface of the ground, alongside and close to the stools. It will be readily absorbed by the soil with the first rains or even with a heavy dew. It is not necessary to await rainy weather before making the application, and if applied in dry weather it will not evaporate, as is often supposed.

The subsequent treatment which the plant crop is to receive will depend entirely on climatic conditions. After every rain surface cultivation will control weed growth and restore the surface mulch which is so valuable in moisture conservation. If the soil becomes packed by heavy rain, deep cultivation is essential. In this case the grubber or subsoiler should be used to restore the open, absorptive condition in the land.

Remember the principles which were laid down earlier in this regard, and aim always at preserving those soil conditions which make for the ready absorption of moisture and the free penetration of the crop roots, to take full advantage of everything that is possible under the prevailing environmental conditions. It may be argued that the deep cultivation here advocated will result in harmful root-pruning, and this is certainly true. But the farmer must weigh the disadvantages associated with this operation against the distinctly beneficial effects which will follow. In general, the grubbing will be done comparatively early in the growing period and the crop will readily replace such surface roots as are thus removed.

Another important subject which should be discussed at this time is the method of ratooning to be employed. There is no doubt that the falling off in yield as between the plant crop and the succeeding ratoon is much greater than it should be, and calls for immediate attention. The first important point is that the ratooning season coincides with what is usually dry spring weather; therefore the available soil moisture must be guarded most jealously, for every drop is needed to start off the young ratoons. Under these circumstances, it is fatal to plough away the soil from the stools as is so commonly done. This generally leaves the soil in large clods, which are rapidly dried out, as is also the exposed side of the cane stool. Unless rain supervenes, it is impossible to work this soil back to a condition of good tilth, and the ratoons suffer.

It is certainly essential that the soil should be worked in order to facilitate the young ratoon roots in their search for moisture, and the use of our subsoiler cannot be bettered for the purpose. When the trash is burnt off, as is the usual practice, it will be found that the compact surface soil is generally moist, even in dry weather. A suitable harrowing implement if employed immediately will restore a surface mulch and thus conserve what moisture is available. The use of the bumper discs for this purpose also destroys the uppermost eyes of the stool and promotes the germination of those lower in the ground. The importance of this feature cannot be over-stressed. The subsoiler should now be run along each side of the stools to a depth of 12 inches, by which operation the soil is reduced to a condition of good tilth without its being exposed to the sun and air to be dried out. We have produced those conditions which will best favour the development of the young ratoon roots, and our next operation is to provide them with the essential plant food to accelerate their growth. In this respect the need for fertilizer on ratoons is even greater than for the plant crop, and this is particularly true in the case of nitrogen. The mixed fertilizer should be applied at a depth of 3 or 4 inches alongside the stools, and the crop top dressed a few weeks later with sulphate of ammonia. As the crop develops, grubbing the interspaces with the subsoiler should be continued until finally the soil is restored to something approaching its original favourable tilth of planting time.

It is unfortunate that time does not permit of a discussion of many more of the important aspects of cane culture, particularly the consideration of such questions as trash conservation, land drainage, and the destruction of harmful substances such as acidity in the soil; however, it is hoped that these questions may be taken up at an early date.



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