Humus, Fertilizers, Lime and Fertilizer Inspection

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HUMUS

Before entering upon a discussion of fertilizers and their use, it is of first importance to speak of humus; since, if the soil is not adequately supplied with humus, plants cannot make their best growth, neither can fertilizers exert their maximum effect.

What is needed in Florida soils is not organic matter which has reached the most advanced stage of decomposition, but rather organic matter *in the various stages of decomposition.* I have known soils exceedingly rich in organic matter, a large part of which had decomposed to such an extent and was in such a state that it could be dissolved from the soil by treatment with ammonia water; and yet these same soils were very unproductive because of the need of organic matter in the earlier stages of decomposition. In general it is probably safe to state that the richer the plants are in protein, the chief nitrogenous constituent, the more quickly they decompose. On this account many of the non-legumes decompose rather more slowly and furnish organic matter in the various stages of decomposition for a longer time than the legumes do. Young and tender legumes decay very rapidly. In fact, they act almost as quickly as sources of available ammonia for plants as do certain of the well recognized organic materials, such as tankage and cottonseed meal.

I recall experiments made several years ago, in which I grew the perennial flat pea for two or three years on the same land and then turned the crop under and sowed barley. The barley was much better than it was on adjoining land where flat peas had not been grown previously, and the crop appeared to be abundantly supplied with nitrogen. The next year, however, there was no appreciable increase in the crop where flat peas had been turned under a year before as compared with the plot where no flat peas had been grown. This showed that the nitrogen contained in the flat peas had practically all been utilized by the crop which followed or that it had been transformed into nitrates which had leached away.

For crops or plants which may be injured by the presence of too much nitrogen, particularly toward the close of or just following the rainy season, it might be better in some cases to use non-legumes as cover crops, rather than legumes. It is generally recognized, that certain crops or plants are more affected by various diseases if the plants are over-fertilized with ammonia at certain stages of their growth, than if they are supplied with properly balanced plant food which does not carry an excess of ammonia.

Another point in connection with legumes ought to be mentioned. Everyone recognizes the importance of getting nitrogen out of the air and of utilizing legumes wherever they can be utilized to advantage. Until quite recently some mistaken notions have existed in regard to the amount of nitrogen which they fix from the air; since, as long as there is present in the soil an abundant supply of combined nitrogen in forms which the plants can utilize, they take it up instead of assimilating atmospheric nitrogen to any considerable extent. Recent experiments in the Middle West have shown where legumes and non-legumes have been grown side by side and then removed from the land, that the soil has been made poorer in nitrogen where the legumes were grown than where the land was devoted to non-legumes. Even if the crops are left on the farm and are returned in manure, a large percentage of the ammonia is finally lost before the plant residues in the form of liquid and solid manure are returned to the land. On this account, if one wishes to add to the soil the greatest amount of nitrogen from atmospheric sources, the legumes must be grown on land which is not already rich in combined nitrogen, and they must then be plowed under.

When plant residues are applied to the soil, the complex nitrogenous compounds which are contained in them are soon broken up through the activity of bacteria and the other naturally-existing micro-organisms of the soil. While these changes are taking place, some plants are able to assimilate directly certain of the more simple organic nitrogenous compounds, comparable to those produced from hair, wool, and other complex organic nitrogenous compounds when subjected to suitable factory preparation and treatment for fertilizer uses. The greater portion of the nitrogen, however, is transformed into ammonia by the agencies just mentioned, which in turn is transformed in the soil into nitrous acid and finally into nitric acid. This nitric acid then enters into combination with potash, soda, lime, or magnesia, from which it is taken up by plants unless lost in the drainage waters. In Indiana even aluminum nitrate has been known to be formed in soils to such an extent that it became poisonous to vegetation. In other words, this compound may act in the same way as certain of the other soluble aluminum salts.

The various changes in plant residues take place more readily in soil well supplied with moisture, and at fairly high temperatures, than in rather dry soil, especially when the temperature is low. The formation of nitrates is said to occur most actively at a temperature of about 98° F.; hence, in many cases soil near the surface in summer becomes too hot for the most rapid formation of nitrates.

It is not necessary from the standpoint of the plant that all of the nitrogen, aside from the small amount which is taken up in simple organic forms, be changed into nitrates; for at least many kinds of plants at certain stages of their growth are able to use some nitrogen while still combined as ammonia. On the other hand, if there is too great and sudden a formation of ammonia, owing to the conditions being unfavorable to its transformation into nitrates, there is a possibility that ammonia may in some cases accumulate in the soil to such an extent as to be injurious to plants. In a word, the most important problems in connection with the feeding of plants are the selection of the proper plant foods and the compounding of the various materials in such proportions as will insure a proper and adequate supply of all necessary plant foods to meet the plant requirements from seeding time until full maturity is reached.

Even if fertilizers are supplied in adequate quantities and of the right analysis, it is also important to have the right proportions of the different materials used in the mixtures. This may best be illustrated by citing my own experiment with fertilizers in Aroostook County, Maine. I found it possible to produce 30-40 bushels more of potatoes per acre with one fertilizer than with another, even when an analysis of both would show the same percentages of ammonia, available phosphoric acid, and potash. The factors determining the difference in yields in these cases were the kinds of materials and their availability. Thus the difference in the value of the product from an acre of land produced by the two fertilizers having the same analysis was enough in most seasons to pay the entire cost of the fertilizer used. It is because of these important considerations that a careful study of soil and climatic conditions and of soil and plant requirements is necessary in order to manufacture fertilizers which will give the best possible results.

FERTILIZERS

Ammonia.—I notice that the previous speaker spoke of ammonia as that ingredient of the fertilizer which "produces plant growth." I know it is a more or less common practice nowadays to speak of nitrogen, or ammonia, as that which causes growth, of phosphoric acid as that which produces the seed, and of potash as the fertilizer ingredient which causes the production of starch, sugar, and cellulose. We must not forget, however, that there are at least ten different plant foods, all of which are important to the proper functioning of the plant; and if any one of these is entirely lacking, the plant will not thrive. Therefore, iron, magnesia, and lime are as necessary to growth as nitrogen is. We are led, however, to think of nitrogen as especially necessary to growth for the reason that when it is deficient in a soil, plants generally take on a light or yellow color and present an unthrifty appearance. And yet, I have seen Indian corn which looked as light-colored and unthrifty as a plant possibly could, when supplied with everything a plant requires excepting iron, but which, as soon as iron was supplied, recovered its normal green appearance and throve perfectly.

Another important consideration in connection with the use of fertilizers is their effect upon the soil. Nitrates, for example, are subject to ready loss by leaching on sandy soils if heavy rains occur, and nitrate of soda in particular tends to deflocculate clay soils and seriously injure their physical condition. On acid soils nitrate of soda tends gradually to correct the acid condition; and if the soil is of such a physical character that it is not likely to be injured by the residual sodium carbonates, the after effect from the use of nitrate of soda is beneficial.

Sulphate of ammonia is not so subject to leaching as nitrate of soda; yet if it were used as the exclusive source of nitrogen on a highly calcareous soil, there is a possibility that so much ammonia would be liberated at once that some of it might escape into the air and be lost, or even, under such conditions, cause direct injury to plants, many of which are very sensitive to its presence in large quantities. Sulphate of ammonia also tends to make soils acid on account of the fact that the ammonia is largely changed to nitric acid in the soil, which further adds for a time to the marked acidity created by the residual sulphuric acid that was combined with the ammonia at the outset.

Calcium nitrate and potassium nitrate are both subject to ready loss by leaching in open sandy soils in case heavy rains occur. For crops which are greatly in need of lime, especially when they are grown on acid soils, calcium nitrate has distinct advantages; whereas for certain root crops which can use some soda, in case the supply of potash becomes deficient, nitrate of soda may be a more efficient or better source of nitrogen.

If calcium cyanamid is introduced into fertilizers in small amounts under certain chemical conditions, the nitrogen may be largely transformed into urea, a most valuable organic source of nitrogen for plants. On the other hand, if it is introduced into fertilizers under other conditions or in large quantities or if it is applied directly to the soil under the usual conditions, large amounts of dicyanodiamid are formed from it—a compound which is highly toxic to plants. It is on this account that calcium cyanamid of itself is usually considered unsuited for use as a top dressing or direct application to growing crops or trees. It is on this account, also, that it must be applied two to three weeks before the seed is sown in order not to injure the young rootlets.

There is a possibility that in the near future ammonium chloride may be placed on the market as a source of ammonia. If this occurs, it will have to be used with even more care than sulphate of ammonia, especially on acid soils.

The important feature in connection with fertilizers is to have such quantities and such proportions of various materials used as to exert the best and most favorable influence upon plant growth, taking into account, also, the effect of the fertilizers upon the physical and chemical condition of the soil. It is possible with a clear understanding of these points to use such proportions, for example, of certain nitrates, ammonium salts or other materials, as to avoid the ill effects which may arise from their exclusive use as sources of ammonia; for when combined in the proper proportions and in a proper manner, the various drawbacks mentioned may be largely or wholly avoided, by making the effect of one substance counteract the unfavorable effect of another.

A further interesting phase of the nitrogen problem is that of denitrification, or the destruction of nitrates within the soil. It has been proved by the most painstaking experiments that if a soil becomes water-logged up to a certain limit, nitrates instead of being formed or conserved in the soil, begin to undergo decomposition, especially if the soil contains considerable amounts of fresh manures and certain other kinds of organic matter in the early stages of decomposition. This change may go only so far that ammonia is formed; or it may even progress to such an extent that the major part of the nitrogen existing in nitrates already in the soil or applied to it in fertilizers, may be changed into gaseous form and thrown off into the air. The nitrogen would then be in the same form as the nitrogen in the air which we are breathing in this room at the present moment, and it would be of no more use to plants than the naturally-existing free nitrogen already in the air. A very small part of the nitrogen under these conditions is transformed into organic material consisting of the micro-organisms which bring about this change. Thus it is important that soils be properly drained. If they are not, organic material which has considerably decomposed or which has been well composted is far safer than organic material in a less advanced stage of decomposition, since the latter is capable of supplying a greater amount of nutriment to the denitrifying organisms.

Phosphoric Acid.—In regard to phosphoric acid, it is a well-known fact that in Europe in the early days no such thing as superphosphate, or acid phosphate, was known. Due, however, to the work of Von Liebig during the latter part of the first half of the preceding century, it was shown that the crop-producing efficiency of ground bone was very greatly increased by treating it with sulphuric acid (oil of vitriol). Still later phosphate rock, which is a far less effective source of phosphoric acid than bone when both are untreated, was also subjected to the same treatment, whereupon it was found that the available phosphoric acid, thus produced, was as efficient a source of plant food as if it had been produced by treatment of bone with sulphuric acid.

Ordinary bone and phosphate rock consist chiefly of tricalcium phosphate, sometimes called a "three-lime" phosphate. In the manufacture of superphosphate (acid phosphate) either from phosphate rock or from bone, it is customary to add enough sulphuric acid to combine with two of the three atoms of lime, so that only one atom of lime remains in combination with phosphoric acid. This remaining compound containing only one atom of lime is soluble in water, supplying what is known as *"soluble phosphoric acid."* The other two-thirds of the lime in the bone or in the phosphate rock are changed into land plaster, or gypsum, which remains in the mixture. This, therefore, the farmer secures without cost, since the charge for the superphosphate is based merely upon the percentage of available phosphoric acid.

It has been found in some of the states on the Pacific Coast and elsewhere that sulphur, even in such combinations as land plaster, or gypsum, is very helpful to the growth of certain plants; and it is not at all impossible that the sulphur contained in the land plaster, associated with acid phosphate, or dissolved bone, is often of some use to plants. It may not only serve as direct plant food, but, to a certain extent, the gypsum may act as a liberator of potash; and if ammonia happens to be present in the soil in the form of carbonate, it may react with the ammonia so as to change a part of it temporarily into sulphate, in which form it is non-volatile and cannot escape into the air and be lost.

Two great advantages are derived from the use of superphosphate, whether made from bone or rock, namely: (1) it is soluble in water and hence can be taken up immediately by the plants, and (2) it becomes better distributed in the soil if applied in soluble form than if applied in its untreated natural condition. To be sure, much of the soluble phosphoric acid, upon application of a superphosphate to the soil, is soon changed into less soluble forms, known as "reverted" or "back-gone" phosphoric acid. Its efficiency, after this reversion has taken place, is determined to a considerable extent by the character of the soil and the relative proportions of the various substances with which the soluble phosphoric acid can combine. For example, if the soil contains large quantities of aluminum and iron oxides, and little or no available lime, there is a tendency for much of the phosphoric acid to enter into combination with the iron and aluminum and for but little of it to enter into combination with lime. It is on this account that it is advantageous to make small or moderate applications of lime from time to time to soils where superphosphates are to be used, provided crops are grown which are not subject to injury by liming. For citrus fruits, unfortunately, lime must for other reasons be used with exceeding care and in very small quantities if at all.

Much has been said and written in recent years about raw rock phosphate, or, in other words, regarding phosphate rock which has not been subjected to treatment with sulphuric acid; and many extravagant claims have been made concerning its efficiency as plant food. It is of some agricultural value even without treatment, on certain soils, and its greatest efficiency is observed when it is used on acid peat or muck soils. The next best soils on which to use it would be upland soils which contain large amounts of acid organic matter. However, for most crops and soils throughout the greater portion of the United States and especially in the east along the Atlantic seaboard, no other form of phosphoric acid has proved equal to superphosphate prepared from bone or rock phosphate by treatment with sulphuric acid. It has been found, for example, that if the raw rock phosphate is used on land which has been recently limed or which naturally contains a considerable amount of carbonate of lime, its efficiency is very greatly reduced or in some cases practically nullified, for the reason that the acids of the soil or those contained in the rain water or produced as a result of nitrification and fermentation are likely to attack the carbonate of lime before they can exert any material solvent action on the raw rock phosphate. It is for this reason that soft phosphate, which generally contains much carbonate of lime, is often less efficient than it would be if it were entirely dissociated from carbonate of lime.

When soluble phosphoric acid reacts with lime, it first forms dicalcium phosphate or, in other words, a two-lime, or reverted, phosphate. This is still very available to plants; for even though it is not directly soluble in water, it is readily dissolved by the action of plant roots and by water containing carbonic acid, such, for example, as rain water and the natural soil waters, which derive their carbonic acid from the decomposition of the organic matter of the soil.

The chemist determines in the laboratory the amount of water-soluble phosphoric acid and also the amount of reverted phosphoric acid and refers to the sum of the two as "available" phosphoric acid.

Another source of phosphoric acid, which was used in this country somewhat extensively before the war, is basic slag meal, or Thomas phosphate. This was produced in the manufacture of steel from phosphate of iron by what is known as the "basic" process. The phosphoric acid in this material is largely combined with lime in a different combination from any of the other phosphates mentioned, and some iron, manganese, and free lime are also present. As concerns the availability of its phosphoric acid, it is somewhat inferior to superphosphate. It is, however, superior in this respect to untreated bone meal and is much superior to raw rock phosphate or soft phosphate. Its availability to plants depends very largely upon the conditions under which it is manufactured, and certain basic slag meals produced in some European works before the war had a very low availability as compared with that produced in others. Thus the source of the basic slag meal, or Thomas phosphate, may be a very important consideration from the purchaser's standpoint.

Another new source of phosphoric acid is the so-called "ammo-phos," which is a combination of ammonia and phosphoric acid. This is a material which is as yet but relatively little known in agricultural circles. It must be used experimentally under varying conditions and with a large number of different kinds of plants before one can state definitely the conditions under which it can be used to the best advantage, or can be sure of its real desirability and of the efficiency of its phosphoric acid as compared with phosphoric acid in superphosphate.

During and since the war many processes have been patented for the preparation of phosphates for agricultural use from raw rock phosphate by different methods involving fusion with various substances; but as yet none of these products has apparently been able to hold its own in competition with superphosphate, either by way of efficiency in crop production or economy of manufacture.

In connection with my experiments, especially in the Middle West, I have been astonished to find that as small amounts as 90-150 pounds of a relatively low-grade fertilizer, containing high percentages of phosphoric acid, have given increases of 8-15 bushels of wheat to the acre, 15-40 bushels of oats, and 10-25 bushels of corn. In one case 100 pounds of fertilizer were used to the acre for sorghum. The sorghum was then manufactured into syrup from both the fertilized and unfertilized areas with the result that where no fertilizer was used, the yield of syrup per acre was 67 gallons; and where fertilizer was used, the yield was 140 gallons. This syrup was worth at that time from 90 cents to $1.45 per gallon; hence, the gross gain even at 90 cents would be $65.70, from which there must be deducted only the very small cost of the 100 pounds of fertilizer in order to show the net profit from the fertilization.

Such increases often seem to be more than might be expected from the mere plant-food effect of the fertilizers; and it appears possible that in addition to furnishing plant food in immediately available form in close proximity to the young rootlets of the plants, the fertilizers may also have a corrective effect by way of overcoming the toxicity of certain substances which may be present to an injurious extent in some of these soils. Furthermore, it is now known that fertilizers have a very marked stimulating effect upon the development of certain of the soil bacteria upon which soil fertility is very largely dependent. In connection with the first point raised, attention should be called to the fact that Conner, Abbott, and their associates in Indiana, found that in some soils aluminum nitrate was present in sufficient amounts to be toxic to plants. This is a substance which is decomposed by either lime or superphosphates; and wherever such compounds are present in the soil, the application of fertilizer containing superphosphate would be expected to make the conditions more congenial to the development of young plants. Similarly, at the Rhode Island Agricultural Experiment Station, Hartwell, Pember, Damon, and their associates, have found that where sulphate of ammonia was applied to the soil for a series of years as the exclusive source of ammonia, aluminum sulphate had been formed in the soil in sufficient amounts to render the soil unable to longer support the growth of various kinds of crops. It had previously been shown by the author of this paper that the existing toxicity, regardless of its cause, could be entirely overcome by the use of lime. More recently it has been demonstrated by Hartwell, Pember, Damon, and their associates, that exceedingly large applications of superphosphate are also capable of overcoming or greatly reducing the toxicity of the aluminum sulphate; and this is due to the fact that the phosphoric acid upon combining with aluminum, changes it into a very insoluble form which the plant cannot assimilate. Ruprecht, while at the Massachusetts Agricultural Experiment Station, found soluble, or toxic, aluminum salts present in certain soils. It appears, therefore, that this is a condition which we have but just begun to recognize in this country. In fact, it is not improbable that certain soluble salts of the protoxid of iron may have similar effects, which superphosphates are able to correct.

Where sufficient quantities of soluble aluminum salts exist in the soil to prevent utterly the growth of onions, beets, lettuce, spinach, upland cress, asparagus, cabbage, cauliflower, and, in fact, a large number of other kinds of plants, there are still others which can thrive on such soils without difficulty. I refer particularly to one of the flowering perennials, *Silene orientalis,* which throve to perfection where most of the plants enumerated above died before they had made materially more growth than was possible from the stored-up food material in the seed. The blackberry, for example, grew well on such soil. The Lima bean was also able to make a fair growth, whereas the Golden Wax and other varieties of string beans were partial failures. Watermelons grew splendidly, whereas the cantaloupe practically failed. Other plants were found to range between these extremes.

Potash.—For most crops it is more or less immaterial what the source of the potash is, as long as it is soluble in water, or is available to the roots of plants. However, citrus fruits, tobacco, sugar beets, and hops are illustrative of noted exceptions. The usual potash sources are muriate, which contains about twice as much chlorine as potash; high-grade sulphate of potash, which contains little or no chlorine; kainit, which contains two or three times as much chlorine as potash; and the double manure salt, containing both sulphate of potash and sulphate of magnesia, and but relatively small quantities of chlorine. It is the aim of progressive fertilizer manufacturers to supply those forms of potash for special crops which are adapted to the kind of plant to be fertilized.

LIME

There are soils in Florida which contain a great abundance of carbonate of lime, in fact, far more than is desirable. On the other hand, there are some soils which are so acid and deficient in lime that its application is one of the first essentials to success. For citrus trees, as stated before, lime should be used with extreme caution, if at all, for we are well aware of its various ill effects on citrus trees of all kinds. But if any lime is used for citrus trees, one should probably employ only a small part of what is indicated as necessary to completely neutralize the soil; whereas, if one were growing cantaloupes, lettuce, spinach, beets, and many other truck and field crops which are greatly benefited by lime, liming approximately to the full limit of the quantitatively determined requirement may prove helpful.

I have been much interested in what one of the speakers has said regarding die-back; for in connection with an experiment which I have been conducting with oranges here in Florida, die-back was markedly increased where magnesian lime was used three years before at the rate of only one ton per acre. The disease was even worse when practically pure lime was substituted for magnesian lime. The die-back was also accompanied by wither-tip and frenching. The trees in the same experiment which received no lime were far less affected with die-back. Die-back was also present in an adjoining grove in which all the trees were subsequently treated with bluestone (copper sulphate). Since it was my desire to ascertain to what extent different lime and fertilizer treatments would affect die-back, no bluestone was used on the three experimental areas. Nevertheless, die-back has now very largely disappeared. If bluestone had also been used on the experimental trees, it might have been inferred that the disappearance of die-back was chiefly or wholly due to the bluestone. In view of the circumstances, however, it is evident that climatic or other conditions were responsible for a good part of the improvement observed.*

I do not mean by this that I would not advise the use of bluestone as a means of combating die-back, for it seems, at present, to be the best-known remedy for this disease. It must, however, be used with care and moderation or trees may be injured by it. I say this, notwithstanding that in some cases unusually large amounts have been used without injury. In the course of my travels for several years through the citrus sections of this State, covering in all many thousand miles and visits made at different times of the year, I have not found anyone who has been able to tell me positively *all* of the different causes of die-back nor how it can always and surely be avoided. Apparently, there may be several causes. At any rate, everything which can be done to throw light upon any one or more of these causes will be of material help to the citrus industry. It is for this purpose, among others, that the company with which I am connected is conducting several experiments in this State with citrus fruits on different types of soil. We cannot expect that the citrus industry of Florida will ever attain its highest and fullest development until the mysteries connected with the die-back problem have

*As the discussion following this paper was drawing to a close, one of Florida's authorities on citrus diseases, citrus culture, and especially on the use of bluestone, disputed the statement that die-back had largely disappeared without treatment, saying that he had visited the grove mentioned and found that this was not the case. I thereupon stated that what I said was based upon the report of a man also familiar with Florida and its citrus problems, rather than upon my own examination, although I had observed a marked general improvement in the grove. Soon after the meeting at Miami arrangements were made through Professor Newell to have the grove carefully examined and reported on by Mr. Gomme, county agent and citrus expert of Polk County, who reported as follows:

Section 1. No Lime.—Not as heavy growth as in Section 2 or 3. Slight indication of frenching. Hail has damaged young fruits—also young and old wood, causing the wood to split considerably. Fruit irregular in quantity. No S-shaped growth apparent. No indications of die-back by gum pockets or multiple buds. This section could not be recorded as having die-back.

Section 2. Limed Area—Magnesian Lime.—Hail damaged fruit and branches as in Section 1. Small amount of frenching. Growth in general is better than that in Section 1 or 3. S-shaped growth is present in almost all trees but there are no indications of die-back by gum pockets or multiple buds. This section shows vigorous and healthy growth.

Section 3. Limed Area—Non-Magnesian Lime.—Die-back present on a few trees which show gum pockets, multiple buds, frenching, and brown exudation on wood. This condition is not extensive, although it is marked on a few trees. The fruit and wood had been considerably damaged by hail. As in 1 and 2, the damage seems to be more marked on the younger wood.

The Grove Across the Road from the Above Three Sections.—This grove has been treated with bluestone. No die-back is apparent though a few S-shaped branches were noticed. There has evidently been die-back in this grove at some earlier period as some of the old wood is stained, but no gum pockets or multiple buds were found on the younger growth.

been more fully explained. Until we know more of the causes and of the means of avoiding this disease, we shall be in essentially the same position as the physicians and veterinarians who were attempting to combat yellow fever and malaria in the human family, and the Texas fever in cattle, before the relationship of the mosquito and the tick to the transmission of these diseases was definitely ascertained. Most thorough and careful experiments should be made on every different type of soil used in this State for the growth of citrus trees, and this seems to be one of the greatest needs of the citrus industry in Florida at the present time. It is not enough to have one experiment station, but experiments should be conducted in all of the important citrus districts in which different types of soil are represented.

FERTILIZER INSPECTION

Before closing, I wish to say a word about the fertilizer law in Florida. I trust I may be able to qualify as a competent witness for the reason that I was for four years connected with the fertilizer inspection in Massachusetts, and for more than twenty years had general charge of the chemical work connected with fertilizer inspection in Rhode Island.

I notice that there is a tendency in some states to require the manufacturer to name the sources of the materials used in his goods. In this connection it should not be forgotten that requirements of this kind are of no use whatsoever, unless the chemist can substantiate or disprove the claim of the manufacturer. Furthermore, such requirements are often contrary to the best interests of both the purchaser of the fertilizer and the manufacturer.

For example, there are a considerable number of materials rich in nitrogen which, in their natural, untreated condition, are generally known to have a relatively low crop-producing value, but when properly treated in the fertilizer factory, are capable of transformation into materials as valuable as or in some cases even more valuable than the best organic ammoniates with which we are familiar; such as, dried blood, tankage, and cottonseed meal. If the manufacturer is obliged to state that these materials are used, it is likely to create a prejudice against the fertilizer, whereas the fertilizer really will be of very superior quality if these same materials are subjected to proper factory treatment at the outset. Furthermore, after treatment, the nitrogen may be present in compounds entirely different from those existing before the treatment was applied. Such requirements are about on a par with the requirement that a manufacturer of turpentine must state that he used long-leaved pine in his product. It is true that special crops seem to be of better quality when certain ammoniates are used than when others are employed, and any manufacturer with his future at stake strives to furnish that which will give the best results. It is of great importance to know the availability of the ammoniates in the fertilizer; but it can do no one any good to state *what they were once, what they are not now,* and *what they never will be again.* A law of this character, which requires the making of statements that would be misleading to the purchaser, is in many respects worse than no law at all.

If I were to state that I used hair or wool in a fertilizer, the purchaser, knowing the low value of each in its raw or untreated state, would think that the fertilizer was inefficient. However, I can take the hair off your individual heads or the wool off the backs of your sheep (with your permission) and, by chemical treatment in the fertilizer factory, transform it into material as valuable as, or even more valuable than, the best organic ammoniate known. After such treatment it would certainly no longer be hair; but it would consist of a very large number of different nitrogenous compounds, many of which no chemist could practically hope to identify in making a fertilizer analysis, and much less determine quantitatively. In fact, if, under such circumstances, I were to state that hair was used, I should be telling you that something was there which was really not there.

I mention these points merely as illustrative of tendencies in connection with some recent fertilizer laws to require statements which are useless, absurd, positively misleading, and contrary to the best interests of the user of fertilizer. If you wish to know the source of potash in a fertilizer, a chlorine test in addition to the test for potash will usually tell all that is required. If you wish to know the real crop-producing value of a fertilizer, a determination of the percentage of available phosphoric acid and potash, and the availability of the nitrogen as shown by the most reliable chemical methods known, affords the best possible means of protection for the purchaser. In those states where this plan has now been in vogue for several years, the results have been most acceptable to the farmers.

I wish also to say a word about the collection of samples of fertilizers. It is to be presumed that the object of a fertilizer inspection is to set forth the actual facts as to the quality and analysis of the fertilizer. This being the case, it is of the utmost importance that samples be so drawn that they will truly represent the fertilizers which are being inspected.

If you were to make up a fertilizer containing bone, tankage, and various other materials, including potash salts, nitrates, sulphate of ammonia, and similar materials, you might find, no matter how accurately the mixture had been made, that some of the lighter materials in the mixture would tend to come to the top of the bag when shaken up in transit or handled in the storehouse. Consequently, the only way that a truly representative sample can be secured is to have it drawn with a sampling implement which extends the entire length of the bag. The sampler should not be opened until it has been fully inserted. It should then be opened throughout the entire length, filled, closed, and then withdrawn. Such sampling-rods are in existence and are used exclusively in many of the states. These secure a true core of fertilizer extending the entire length of the bag. A perfect mixture of such cores will give a true test of the character of the goods, if properly handled and analyzed.

It is also important that samples be drawn from such a number of bags as will properly represent any given lot of fertilizer. If there is a small number, all should be sampled; and if there are many bags, samples should be drawn from not less than 10-20% of those present. Great care must also be taken in properly mixing the samples after they are drawn, so that a uniform, composite sample can be secured for analysis. If I were merely to draw a sample of fertilizer with my hand from the tops of bags in a shipment and were to send it to your state chemist for analysis, the chances are that he would report that the analysis did not agree with the guaranty. Imagine for a moment that each of you is a manufacturer and I the purchaser. You will appreciate the position in which you would find yourselves, if I used such an analysis as a basis for non-payment of the goods and as a means of having the goods confiscated. It must be obvious that such a situation as this would add to your overhead costs in the manufacture of fertilizers and to the prices which you would have to charge me for them; or the alternative would be that you would be driven from business in the State.

My conception of a fertilizer inspection is that it should be conducted in such a way, and the law should be so drawn, that it affords protection to the purchaser and at the same time protects the honest manufacturer from injustice, imposition and the perpetration of fraud on the part of any dishonest purchaser; in other words, the inspector of fertilizers should be backed by a just law and should stand as an absolutely neutral party, seeing to it that absolute justice is done to both producer and consumer. No other plan is as good for either the purchaser or the manufacturer.

DISCUSSION

Question: Mr. Chairman, the speaker has already remarked that too much lime may be injurious to citrus fruits. Now I wish to ask if too much iron, too much magnesia or too much of other materials would be injurious, and at what point the limit should be set?

Answer: In regard to iron there may be a situation where, on account of large amounts of moisture and organic matter, an oxide of iron may be formed which, in certain combinations, may possibly be injurious to plants. We know, for example, that in some of the peat and muck soils of Holland and England, protosulphate of iron has been found in such quantities as to be destructive to vegetation. There are instances on record where soils contained so much magnesia as to be injurious or almost sterile; but this is doubtless inconceivable in the case of Florida soils, since most of them contain very little magnesia, so little, in fact, that I suspect some magnesia may be beneficial for some crops under certain circumstances. It is true that excessive amounts of certain plant foods may be injurious; but I do not think we have reason to fear the use of too much, especially in view of the present high prices, which have unfortunately placed too great a curb upon their purchase.

Plants differ very widely in their susceptibility to injury by excessive amounts of certain salts of iron, magnesia, and other substances, which may be present in the soil. A concrete illustration is afforded in connection with experiments which I made several years ago in Rhode Island. It was found that soil which had possibly never received any fertilizer treatment was exceedingly acid and contained substances so toxic to lettuce, spinach, beets, onions, asparagus, and many other crops, that they could not be grown successfully, and the application of a highly acidic fertilizer further accentuated the difficulty; yet other plants grew to perfection on this soil. I mention this merely as an illustration of the fact that we cannot conclude necessarily from the effect of a given substance or substances upon one kind of plant what the effect will be upon others.

Question: What do you think of cottonseed meal as a source of ammonia?

Answer: If you get meal which does not contain an undue amount of cottonseed hulls, it generally has a fairly high availability, although it is not so quick in its action as the ammonia in dried blood, tankage, and dried fish.

Mr. Beech: What can you say regarding calcium cyanamid? I am aware that it is considered to be destructive to plant nematodes. I also understand it carries a considerable amount of lime and that it should be applied some time in advance of the date of seeding.

Answer: It is undoubtedly true that this material is destructive to nematodes; but in order to prove highly effective in this respect, it would have to be used in far greater quantities than should be recommended in ordinary agricultural practice, especially in view of its high content of nitrogen and lime. The material does have the advantage of supplying some lime, providing the plants grown and the soils used require it. It is also true that dicyanodiamid is formed from it when it comes in contact with moisture in the soil; and this material exerts a poisonous action upon plant roots until it, in turn, is decomposed by the micro-organisms and by chemical changes taking place within the soil. In general it should be applied two or preferably three weeks before the seed is planted. It can be mixed with fertilizer in small quantities under such conditions that practically all of the nitrogen is transformed into urea, which is a most excellent source of ammonia for plants. Under other conditions of manufacture, dicyanodiamid may be formed, so that here again the skill and experience of the manufacturer come into play.

Calcium cyanamid has been found to be highly injurious to workmen who are brought extensively into contact with it in its natural state, especially if they have been imbibing alcoholic liquors. And I may add that I am not bringing this up as an argument in favor of prohibition, even in this dry city.

Mr. Gray: Just a question in relation to bluestone. There are thousands of barrels of it used annually in this State; and in connection with your experiment, you show that the recovery of the trees was not necessarily due to bluestone. Where there are thousands of dollars at stake in connection with die-back, what would you advise a grower to do if the disease appears?

Dr. Wheeler: I should by all means advise its use, until a time when something better is found as a remedy or until we know how to prevent the disease. However, I should also advise great care in its use and the application of relatively small quantities. I hope some day we may know more about it and how it acts. Until we do, we cannot use it most intelligently.

Question: I wish to ask what results would be secured by the application of sulphate of iron to the leaves of trees which show lack of color, or frenching?

Dr. Wheeler: I think it is impossible at this time to predict surely what effect spraying with protosulphate of iron would have. Pineapples have been sprayed with it successfully in an extensive way in the Sandwich Islands on soils which contained excessive amounts of manganese, and where the plants were not able to secure enough iron under the usual cultural conditions. Upon spraying the leaves, the plants absorbed the iron and developed a healthy color and normal crops became possible.

In Porto Rico, Gile found that lime caused chlorosis and a bleaching effect on pineapples, which was overcome by spraying with protosulphate of iron. This result indicates that the addition of lime to the soil rendered the iron so insoluble that the plants were not able to take up enough of it. Recent successful experiments have been made in spraying conifers with protosulphate of iron. Repeated sprayings with a 1% solution caused certain kinds of pine trees to develop normally and to develop good color, whereas the use of a 2% solution resulted in positive injury to the trees.

It should be determined at the outset by a few careful experiments what strength may be used on citrus trees without injury. The next problem will then be to ascertain whether frenching can be overcome to any extent by such spraying. Doubtless the results will depend upon what causes the frenching; for, according to many observations by our best authorities, it seems to be caused by several different conditions. It would be of the utmost interest and importance to have spraying experiments made with protosulphate of iron and possibly with ferric chloride wherever frenching has followed an application of lime, in order to ascertain if the condition can be corrected. In Porto Rico, Gile found that several successive sprayings were necessary in order to accomplish the wished-for results with pineapples; and obviously the finer the spray and the more generally it is distributed over the leaves, the better the results should be.

I should like to ask if anyone in this audience has sprayed with protosulphate of iron and, if so, with what result. I ask for the reason that about four years ago I suggested the idea of spraying with it to some of the members of this Society who were present at our meeting at Arcadia. I am not aware that any of them ever followed up the suggestion.

In general it has been found that when protosulphate of iron is applied to the soil, it is not so effective in overcoming chlorosis, or frenching, as it is when it is sprayed on the leaves, and very large quantities may often be necessary to cause material benefit if the application is made to the soil. This is probably for the reason that lime and other basic compounds in the soil may make the iron insoluble as soon as the two compounds are brought into contact with each other.

Answer from the Audience: I have made experiments in spraying with protosulphate of iron, where the trees were very much frenched and bore small fruit, and the result from one to three sprayings was excellent. In other cases it apparently did little or no good, but I presume the conditions giving rise to the frenching were different in the two cases.

Another answer: About four years ago, one or two acquaintances of mine had groves which showed frenching, and they suspected that this was due to a lack of iron; and after spraying them with protosulphate of iron from three to six times at rather frequent intervals, a marked improvement in the trees resulted.

Another answer: I have noticed cases of frenching in the Indian River region where it seemed probable that too much fertilizer had been used, and I am satisfied that you must have a satisfactory amount of humus in the soil in order to get the best results from fertilizer.

Dr. Wheeler: I have had my attention called to cases of frenching which may have been caused by too much water and also by too deep cultivation and injury to the feeding roots. This injury to the roots results especially in cases where a deep cutting disc or cutaway harrow is used instead of the acme harrow which works the soil only to a slight depth.

What has been said about the importance of humus in the soil is deserving of special attention, since it is fundamental to the best results in growing practically all kinds of crops, including citrus trees. The humus may also play an important part in connection with the assimilation of iron. It is well known that where great accumulations of vegetable matter come in contact with sands containing iron, the iron is often so largely dissolved out that the sands become greatly bleached. This shows that the humus has a solvent action on the iron. It is much better to maintain conditions in the soil, if possible, which will prevent frenching than to take the chance of curing it after it appears.

Another point concerning which I would utter a caution is in regard to making spraying experiments with protosulphate of iron on a large scale at the outset. My advice would be to determine in a small way on a few branches, or at least on a few trees, what strength of protosulphate of iron will be tolerated without injury to the foliage or trees. By proceeding cautiously in this way, no great damage can be done; and after this point is determined, you can then spray extensively with reasonable safety, provided you find it helpful.