At Seabrook, cover crops get a great deal of fertilizer. Plowed down, they yield the equivalent of a ton of high grade fertilizer for cash crop that follows

Fertilizing for Optimum Crop Production

FRANK APP, Seabrook Farming Corp., Seabrook, N. J.

Local soil laboratories, financed by farmers and supported by industry and government, are in the cards, if farmers are to take advantage of new research on the chemistry of soil fertility

THE PROPER source, kind, and amount of plant food to be applied for optimum crop production are governed by the particular crop, the selected field, and the availability of plant food already in the soil. The amount and quality of organic matter are also very important. Genetics, soil moisture and structure, lime, minor and trace elements—all at times have a major influence. We have a large accumulated reservoir of chemical information pertaining to the feeding of plants. We also have a large amount of information on how plants grow. Optimum crop production depends upon understanding the requirements of each crop in terms of plant food, and finding the best procedure for supplying these requirements. But the application of chemistry to determining the most desirable farm practice for feeding plants is still in the research stage.

Issuing general recommendations for the use of fertilizers is an out-moded approach. Fields on the same farm will differ in their requirements. Some particular crops prefer particular sources of nitrogen while some soils require sources of nitrogen that are less likely to leach. For leafy vegetable crops, ammonia sources of nitrogen produce higher quality. On the other hand, when these same crops need additional nitrogen after they are planted, some nitrate nitrogen is usually applied because it is quickly available.

Implements for Plant Food Management

Soil analysis, when properly used, furnishes an inventory of the plant food available in a particular soil at a given time prior to the planting of the crop. Plant tissue analysis furnishes a record of plant food supplied to the growing

plant. Both furnish valuable information for feeding plants. Their interpretation into farm practice depends upon knowledge of how crops grow and how best to furnish these requirements.

In 1941, Seabrook Farms organized its soils laboratory for the purpose of analyzing its soils and determining why crops of the same variety, grown on the same soil type, given the same fertilizer and lime, and planted at the same time, yielded differently. Also portions of the fields showed differences in production without any apparent difference in the soil type itself. By taking soil samples from the commercial fields and correlating the fertility level with the crop yields, we arrived at an understanding of the fertility level required to grow each crop produced on the farms. These samples were taken before the crop was planted and at different times throughout the growing season. A definite correlation was found between the availability of the essential plant food elements and the crop yield.

A series of carefully planned and controlled plots was laid out; in each, optimum fertility levels were provided for all but one element, which was added in different amounts. In this way each element was again checked against the requirement for a given specific crop. In addition some greenhouse trials were run, paralleling the work in the controlled fertilizer plots themselves. All three methods of research showed practically the same results, namely, for each crop definite fertility requirements must be met to produce the optimum crop essential for the greatest profit. These are today used as fertility standards, or measures for interpreting soil analysis into plant food use through the application of fertilizers.

Establishment of the required fertility levels and relationships for each crop is the first essential of research for the translation of soil and plant analysis into use. Research to determine how best to provide these requirements through the most effective farm practice is the next essential.

Under certain conditions, selection of the source of nitrogen is highly important from the standpoint of efficient use of this element and the quality of the resulting crop. Source and amount of potash have some influence on the quality of potatoes. The fineness of applied lime bears a definite relationship to the amount of leaching and loss of calcium for some particular soils. The selection and production of cover crops has a definite relationship to requirement for additional plant food in the form of fertilizer. Selection of the cover crop also influences soil structure.

Farm practice must provide for the availability of plant nutrients throughout the growing season. The time, amount, and method of application, and the sources of various forms of plant food, must be determined through the research route until they are effectively established in farm practice.

Farm Practice

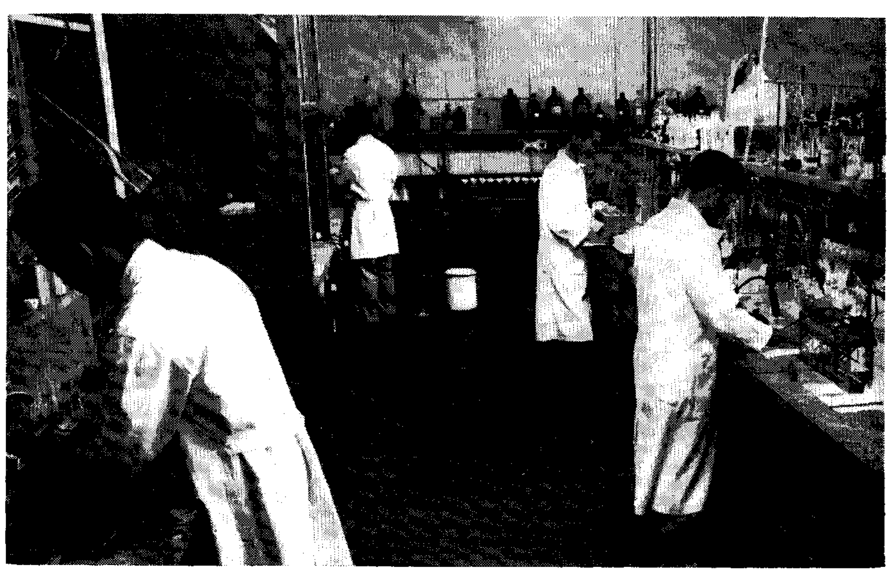
Some crops require more nitrogen than it is practical to apply before they are planted. These are usually short term, rapid growing crops. At Seabrook Farms, whenever nitrogen levels in spinach fields, for example, are less than 50 lb. available nitrogen per acre, additional nitrogen is applied —usually by airplane. This is ammonium nitrate when temperatures are low, and urea when temperatures are high. Applications are usually 50 lb. of actual nitrogen per acre.

The size and number of these applications depend upon the extent of heavy leaching rains and the rate of crop growth. Leaching is more serious on the lighter soils. However, the heavy Sassafras silt loam soils having clay subsoils will leach so that additional nitrogen must be applied following a rainfall of 3 inches or more, even though prior to the rainfall nitrogen level was satisfactory. If we were attempting to make a blanket recommendation to grow a crop such as sweet corn, we would apply 80 lb. of nitrogen from cyanamide or urea, and 100 lbs. of 5-10-10 or 8-8-8. Selection of the mix grade would depend upon the cover crop as well as a soil analysis. The fertilizer applied would be plowed under with the cover crop. Anhydrous ammonia and liquid nitrogen solutions may change this selection.

For the past three years, we have obtained no increase in crop yield by side-dressing corn with more nitrogen. No fertilizers are applied in the row. For a crop such as spinach, where leaf quality is highly important, we use cyanamid at 300 lb. per acre on the heavier soils and 400 lb. per acre on the lighter. In addition, we apply another 1000 lb. of 8-8-8 or 5-10-10, all of which is plowed under. If there is not much leaching, one additional application of nitrogen usually is sufficient. However it ordinarily takes 200 lb. of N, 100 lb. of P_2O_5, and 100 lb. of K_2O per acre to raise a crop of quality spinach.

Lima beans, on the other hand, are quite different. These require a high

Broadcast application of fertilizer has proved to be the most efficient placement method at Seabrook. Properly organized and operated soil laboratories will become the dominating factor in use of fertilizer for all crops, the author predicts



level of P_2O_5 and K_2O with only sufficient nitrogen to start the crop. For baby lima beans, 20 to 25 lb. per acre is ample. The phosphorus level, based upon the Morgan soil test, should be brought up to not less than 25 lb. per acre and the potash not less than 300 lb. per acre. The lighter soils of Cape May County require annually approximately 1000 lb. of 4-16-16 to grow an optimum crop of beans. On the heavier soils, phosphorus and potash accumulate. Consequently we reduce the amount and change the formula to a 1-2-2 ratio or whatever ratio is desirable.

Organic Matter—An Appraisal of Value

Early in the development of Seabrook Farms for the production of vegetables for processing, we learned it was essential to have not less than 1.5% of organic matter in the soil for the production of peas and spinach. Hence, fields of highest organic matter content were chosen for these particular crops. Later this information was obtained by analyzing the soils and correlating yield with organic matter regardless of the fertility level. Higher yields were obtained from organic matter not only with peas and spinach, but also with other crops. With this information, we decided good fertility management required the production of cover crops on a basis similar to that of the production of cash crops.

A cover crop research project was organized to determine the kind of cover crops to grow for the following cash crops, and the value of such cover crops when grown under optimum fertility conditions. Values were measured in terms of plant food and organic matter and influence on the yield of the following cash crop, and in terms of tilth and conservation of plant food residues left from the preceding crop. Information developed through this research led to a cover crop practice that satisfies optimum organic matter requirements for each cash crop, protects the soil throughout the fall, winter, and early spring months from wind and water erosion, and accumulates a large amount of plant food in the organic matter. A large portion of this organic plant food is available for the following crop, permitting a decrease in the amount of fertilizer applied to the cash crop itself. We have always known organic matter to be one of the important phases of soil fertility. However, the information for the proper maintenance, production, and use of organic matter through cover crops had never been developed to a point where it could be made an important part of our farm practice. The substitute for cover crops has been crop rotation. This substitute may or may not be the best farm practice.

Cover Crop Practice

Seabrook Farms now analyzes all its soils each year when the last crop is harvested. As soon thereafter as possible, a cover crop is seeded. The soil analysis prior to planting shows how much fertilizer to apply to the cover crop. When there remains a high residue of P_2O_5 and K_2O, a cover crop such as rye, rye grass, wheat, or barley needs no additional P_2O_5 and K_2O. It will need approximately 100 lb. of nitrogen. This is applied to the early seeded cover crops in October. For late seeded cover crops, nitrogen is supplied in March or early April the following spring. The early seeded cover crops are used for the earliest planted cash crops such as peas and spring spinach. These cover crops make practically all of their growth in the preceding fall whereas the late seeded cover crops grow in the early spring prior to plowing in late April.

FRANK APP has had a varied career. With a Ph.D. from Cornell (1919), he served as professor, later a newspaperman, and (beginning in 1929) as general manager of Seabrook Farms. In 1935, Seabrook made him director of research and development, a position he held until 1954. At Seabrook, he organized its well known soil laboratory. His interests encompass the whole range of agricultural chemicals.

Part of the cover crop program includes the use of crimson clover. This is seeded up to the second week of September with or without rye grass, rye, barley, and wheat. When crimson clover is used no nitrogen is applied. However if phosphorus and potash levels are reported low by the soil test, 500 lb. of 0-20-20 would be applied. The crimson clover furnishes sufficient nitrogen for itself, and when grown with a companion crop with ample P_2O_5 and K_2O, it will furnish the additional nitrogen for the companion crop.

Cover crops grown in this way will yield annually the equivalent, in terms of plant food, of a ton of high grade fertilizer per acre. Usually we will obtain at least the equivalent of 30 units or more per ton of fertilizer per acre of cover crop. The highest we have obtained is 61 units per acre ton, for an area that was highly fertilized. It shows the potential of providing plant food to the cash crop through the cover crop. The cover crops accumulate a large amount of plant food from fertility levels lower than that required for the following cash crop. The use of fertilizer on the cover crop makes it more efficient in accumulating plant food and furnishes a much larger amount of organic matter, a larger amount of plant food, including essential minor elements, and a more uniform availability throughout the growing season.

Many research workers report a cover crop should contain not less than 1.5 to 1.7% of nitrogen. In actual practice, we find it should be approximately 2% nitrogen. If less than 2%, the cover crop will take some of the nitrogen from the soil for a period of four to eight weeks. This requires a heavier application for the cash crop than would otherwise be necessary. This system of feeding crops splits the amount of fertilizer applied so that the cover crop shares with the cash crop. The total amount of plant food is no more and in some cases is considerably less. Either the amount of plant food is reduced or there is a marked increase in crop yield with the same amount of plant food applied through fertilizers. The net result is a larger yield per unit of plant food used, as well as a larger yield per acre. By comparing results in periods of five years before and after this system of fertilizing cover crops was inaugurated, the yield on the main crops was found approximately 40% greater with no increase in fertilizer per acre. In addition, the crops suffered less during extremes in weather, because rooting systems and tilth were markedly improved.

Fertilizer Placement

A large amount of research, as well as education, has been and is being devoted to fertilizer placement. We found at Seabrook Farms that broadcasting and plowing under the major part of our fertilizers was the most efficient method of application measured in terms of crop yields, convenience, kind and amount of equipment and management. We ordinarily place no fertilizer in the row at time of planting and are not yet convinced that it is necessary to side-dress row crops, when they are properly fertilized before they are planted. We are still checking on this practice for corn but have shifted our commercial application away from side-dressing to broadcasting before the crop is planted. Anhydrous ammonia and liquid fertilizers may make a change in this practice if their cost as applied to the crop is less than that of the same nitrogen materials in solid form. We have found anhydrous and other forms of ammonia less subject to leaching than nitrates.

The Contribution of The Fertilizer Industry

The fertilizer industry has made a substantial contribution to agriculture by furnishing better plant food for feeding farm crops. It is one of the major farm supplies that has not advanced in price so much as most other commodities. The profit margin per unit of production is small. The competition within the industry is keen. Many distributors not only furnish fertilizer of varying analyses but will also apply it to the farmer's field. This is excellent service. There is, however, one important aspect in which the fertilizer industry differs from suppliers of other chemicals the farmer buys, namely, recommendations for use. Herbicides, insecticides, and fungicides have specific, research-based directions for use against particular insects, diseases, or weeds. Fertilizers, on the other hand, are sold almost entirely on the basis of their analysis. Under the present system, most fertilizer distributors have no means of knowing whether a farmer should use 5-10-10, 10-10-10, or 4-16-16 for a particular crop in a given field.

A few distributors are analyzing soils and trying to furnish the grower with definite recommendations for fertilizer use on his particular crop and soil. Soil analysis, however, will not furnish the information necessary to make such recommendations unless it is backed by a comprehensive research program. Such a program must establish standards of fertility necessary to grow each crop in the area in which the fertilizer is distributed. It should recognize the importance of organic matter and show how it should be used. It should indicate the methods which such organic matter should be supplied and maintained. It should furnish information on the fertility levels available throughout the growing season, so that the grower can at all times be sure that his crop has sufficient plant food. This requires trained, experienced personnel, highly expert in the use of soil analysis to prescribe plant food for crops. The same individual must distinguish other factors that may prevent optimum crop production, such as poor tilth, improper placement of fertilizer, improper selection of sources of nitrogen, and bad timing of applications.

Most fertilizers are used without knowledge of the requirements of a given crop on a given field. This places a tremendous burden of inefficiency on the use of fertilizers.

Spinach, for instance, is one of the most exacting crops in its demands for plant nutrients. Before the Seabrook Farms soils laboratory was organized and had obtained information from research, about 1000 lb. of N, P_2O_5, and K_2O per acre was being applied on spinach. This has since been reduced to 400 lb. per acre. With less fertilizer, the yield of spinach has improved along with the quality. Over-fertilization is not unusual among vegetable growers. On the other hand, under-fertilization is quite general on the more extensive crops such as corn, small grain, and grasses.

On my own farm, I produce alfalfa for my dairy. Ordinarily I apply 200 lb. of P_2O_5 and 200 lb. of K_2O, along with borax, per acre annually. This

usually is sufficient to maintain a reasonably high level of P_2O_5 and K_2O. The life of an alfalfa stand is greatly prolonged with a high fertility level. Last year rainfall was well distributed so as to make optimum growth. My expected yield of 4 tons per acre was instead 8 tons. At the end of the last cutting, the alfalfa was slow to start. Three years ago when this field was seeded, it was seeded with brome grass. The latter lived but never showed in the alfalfa, except a few inches of growth, and did not show in the hay. At the end of the last cutting, the brome grass came up much more luxuriantly and vigorously than the alfalfa. I immediately took a sample which showed P_2O_5 was down to 6 and the potash down to 80 as I expected. I immediately applied another 200 lb. of P_2O_5 and K_2O last fall. This spring I have a very heavy stand of brome grass with alfalfa. After this first cutting I shall give it another 200 lb. each of P_2O_5 and K_2O. This demonstrates the fallacy of making general recommendations for the feeding of grasses, legumes, and other farm crops.

I find that my mixed pastures, consisting largely of grasses with some legumes, require 200 lb. of nitrogen per acre, along with a moderately high level of P_2O_5 and K_2O, to provide the desired quality and quantity of pastures throughout the growing season. A pasture ratio of 1-1-1 or 2-1-1 meets the requirements of most mixed stands. A second application of nitrogen is usually necessary in late June or early July to carry through the summer and early fall. Consequently 100 lb. of nitrogen is necessary for the spring production and 100 lb. of nitrogen must be applied in midsummer to carry throughout the year. Quantities such as this are not ordinarily used. Nevertheless they represent the optimum requirement for a large portion of our hay and pastures. If all our dairy farmers would apply the optimum amount of nitrogen to their hay and pastures, present nitrogen production would be quite inadequate.

Farm Soil Laboratories

Soil laboratories convenient for the farmer's use, properly organized and operated, will in the near future be the dominating factor for the use of fertilizers in growing all our crops. I believe these should be operated on the same principle as our cow testing associations. The farmer should pay for the actual operation. Our agricultural institutions should furnish the techniques and the research necessary for their proper operation and use. The fertilizer industry should participate in furthering such a movement because it is a part of the services essential for the feeding of plants and animals.

However the soils laboratory without a carefully planned program of research cannot furnish the information necessary for translation of soil analysis into use. Fertility management and the efficient use of plant food are the most complicated and technical operations on the farm. Each crop has specific requirements. These are influenced by the nature of the particular variety or hybrid, by the quality and quantity of soil organic matter, the farm practice to furnish such organic matter, and tillage practice based upon the requirements of the specific crop. The amount of plant food that must be added through fertilizers can be appraised only from knowledge obtained by research into farm practices. Far from being confined to a single discipline such research demands co-application of the physical, chemical, biological, and genetic sciences.