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THE EFFECT OF FERTILIZER SOURCE UPON PLANT RESPONSE

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Plants require sixteen nutrients for their growth and development. When these elements are deficient in the soil, they must be added to insure good growth and development. They are added in the form of fertilizers, either as mixed fertilizers or as fertilizer materials (carriers).

Plant response to added fertilizer materials depends upon many different factors. Some of these are: the plant species and variety, soil mineralogy, soil reaction, soil and atmospheric temperature, form of plant nutrient contained in the material, elements associated with the plant nutrient, reaction of the material with the soil, moisture conditions in the soil, atmospheric conditions such as cloudiness, wind, etc. and many others. It is the purpose of this paper to discuss briefly how the fertilizer source affects plant response.

When we refer to fertilizer source we are more concerned with the fertilizer material or carrier used than with the area from which this material originated. However, it should be realized that materials from different deposits and/or different manufacturing processes may have effect upon the nature of the material. For example, sodium nitrate from the deserts of Chile contain some potassium, manganese, iodine and other elements. This material would have a different effect upon plant growth than would the sodium nitrate manufactured from nitrogen fixed from the air. Therefore, one of the important factors which influence the response of the plant to the fertilizer source is the various elements contained in it. This is also known as the purity of the product. One reason so much has been said about the detrimental effect of "chemical" fertilizers is the improved processing or manufacture of fertilizer materials removing the impurities, many of which are essential for plant growth, from them.

The form in which the plant nutrient is present is another important factor in determining plant response. Nitrogen is taken up by the plant in the nitrate (NO_3^-), or ammonium (NH_4^+) form. When a material, such as fish scrap, containing the protein form of nitrogen is added to the soil, the protein must be broken down - or decomposed - into the simpler forms. Where the soil is well areated and moisture content is adequate this decomposition is accomplished in two weeks or more. However, when a nitrate source of nitrogen is added to the soil, it can be taken up immediately. So on a general basis, we may say that when nitrate nitrogen is added plants will show a response within 24 hours, if moisture and aeration and other conditions are favorable for plant growth. Response to the ammonium form is about 3 days and to the natural organics about two weeks. However, if nitrate is added to flooded soils, such as taro paddies, no response will occur as the nitrate will be reduced to the gaseous nitrogen form. Response to natural organics will be slow as decomposition will be slow and the type of decomposition will be anerobic. The ammonium form (and we include urea and cynamid as ammonium forms) is the only practical form to use under the flooded conditions. It must be applied and gotten into the soil or it will be ineffective also. The use of urea on

certain grasses, such as kikuyu, results in a loss of nitrogen due to urease activity on the leaves of the plant. When acid forming materials* such as ammonium sulfate are used in large quantities soil acidity increases and plant response decreases for those plants sensitive to pH levels in the soil. Plant response is greater when it can utilize all parts of the fertilizer source. In some parts of Hawaii, sulfur is deficient in the soil. Sugar cane gives a greater response to ammonium sulfate due to its uptake of both the nitrogen and sulfur contained in the material.

Plants can take up phosphorus more readily if it is combined with nitrogen. Ammonium phosphates are effective means of insuring rapid uptake of both nitrogen and phosphorus in the early stages of plant growth. For this reason these sources of nitrogen are frequently used as starter fertilizers for corn, sorghum and vegetables especially if temperatures are unfavorable for optimum growth of the crop.

Slowly soluble sources of plant nutrients, such as Magnesium Ammonium Phosphate, are less effective than more soluble sources on short term crops but are useful for crops that will be growing for extended periods. They do not produce rapid rates of growth but furnish a continuing supply of nutrients that produce good plants. This particular material has been found useful for container grown plants and for establishing forest trees. These slowly soluble materials are useful also for lawns and other turf areas where good color is desired.

Plants take up phosphorus as the monobasic ion ($H_2PO_4^-$) or dibasic ($HPO_4^=$) ion. The first is the water soluble source and most easily adsorbed by the plant. It is the form most often found in fertilizer materials, however, it is also the form most easily converted into "fixed" forms in the soil. There is generally severe competition between the soil and the plant for this phosphorus. For this reason, proper placement on the use of large quantities of this nutrient is required to obtain plant response.

Potassium is taken up by the plant in the ionic form (K^+). Plant response depends upon the ion associated with the potassium. The cheapest and most commonly used source is muriate or potassium chloride. For most crops this is a satisfactory source. However, some crops such as potatoes, vegetables and some flowers are adversely affected by the chloride in this source. The use of potassium sulfate is recommended for these crops as it produces better quality products. Where both potassium and nitrogen is needed potassium nitrate gives best results.

Calcium is often a problem in many soils of Hawaii, especially where ammonium sulfate has been used for many years and the soluble calcium leached from the soil. These soils are used mostly for sugar cane and pineapple so that the use of calcium carbonate at the rate of 1 to 1 1/2 tons per acre supplies the needs of these crops. Although the calcium carbonate provides calcium for sugar cane, there are some soils where calcium silicate is a better source. The soils are low in silicon and the use of calcium silicate produces excellent increases in yields. In celery,

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*For further information on effect of fertilizer materials upon soil reaction, see Hawaii CES Cir. 441 "Whats In That Fertilizer Bag".

calcium does not move fast enough in the plant, when the plant is under stress, to prevent heart rot. It is necessary to spray the plant with calcium chloride to prevent this problem occurring.

Most of the other nutrients are supplied in the sulfate or oxide form. Many are also supplied in the chelate form. Plant response is generally good to all of these depending upon how they are applied and the conditions under which they are applied.

Plant response to each form of fertilizer may be manifested in different ways. The most generally accepted response is that of increase in yield. The yield response may be very striking especially if the nutrient is very deficient in the soil and the particular species and variety has a high requirement for the nutrient being applied. Not all yield response is favorable, often reduction in yields may occur due to applying too much carrier, applying it too close to the seed or plant, to toxic impurities in the material or applying the wrong nutrient to the plant. Negative response is just as important as the positive response and should be recorded for information on management practices for specific plants. Often the response to a given fertilizer source will not be statistically significant. However, it may be economically significant. For example in an experiment utilizing the application of sodium molybdate to field beans at the rate of 4 oz per acre, the yield response was an increase of 1 to 2 bushels per acre. This was not statistically significant, however, the cost of the sodium molybdate was about 25 cents plus another 50 cents per acre for application, the value of one bushel of beans was $2.00, at that time, so that the net profit was $1.25 to 3.25 per acre from the application of this material. There are many experiments where this type of result is obtained but often these are not reported since they are not statistically significant.

Plant response to a given fertilizer source is often shown by a change in color of the plant. Perhaps from yellow to green. This usually indicates that there will be an increase in yield or perhaps in quality of the product. In many cases, however, a change in color will occur but no other response to the application of the material will be noted. One reason for this is that once the color change induced by the deficiency of the nutrient has occurred it is too late to correct the deficiency for the current crop. It is an indication that this nutrient should be applied for the succeeding crops grown.

Quality is a term often used to describe a plant response to a given fertilizer source. This is rather an illusive thing to try to define. In the case of the effect of chloride upon potatoes it is the reduction in the starch quality in the potato. When the potato is cooked the starch is gummy instead of the nice crumbly starch generally expected. In case of leafy vegetables, it may be the color and turgidity of the leaves. Often it is simply the personal preference of the evaluator of the product. Whatever it is, it is a very important factor in determining plant response to a given fertilizer source and may be the major criteria for judging plant response to the material.

Other plant response is shown by development of roots, seeds, leaves, and/or stems of the plant. The development of these parts of the plant then lead to better yields or quality or both.

In the case of some nutrients the plant response is evidenced by a greater uptake of that nutrient. The application of most nitrogen sources will increase the nitrogen content of the plant up to a certain level. Beyond this point the level of nitrogen does not increase or increases very slowly. This is true for most of the other nutrients as well. This has led to much work to determine what the critical level is for each nutrient in each plant. Plant analysis shows the level present and from this plant needs may be determined.

SUMMARY

Plants do show a differential response to different fertilizer sources. This response depends upon many factors. The major response is shown by differences in yield of the plant being grown. However, response may be shown in amount of the nutrient taken up, color of the plant, development of specific plant parts or by other means.