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INCREASING FOOD CROP YIELDS BY MORE EFFICIENT USE OF FERTILIZERS

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ABSTRACT

A farmer spends from 15 to 75 percent of the cost of materials for his crop for fertilizers. Yet, because of poor practices and lack of knowledge, the farmer can reduce the effectiveness of the fertilizer he is using. It is the purpose of this paper to help the farmer improve his fertilizer use, so as to insure that he is receiving full value for the money he invests.

Proper application of fertilizer as related to quantity, time and method of placement can increase fertilizer efficiency. Soil factors such as texture, organic matter, pH, compaction, moisture and salinity can influence the amounts and efficiency of the applied fertilizer. Plant factors such as the crop, root system, disease and insect damage, plant density, weeds and rutrient balance can modify the fertilizer efficiency losses of fertilizer occur with improper storage.

INTRODUCTION

Fertilizers range from 15 to 75 percent of the cost of materials that a farmer spends for his food crop production. He buys and uses fertilizer because he knows that it will increase his production and bring him better economic return from his crop. He has soil and plant analyses made to choose the correct fertilizer formula to fill his particular soil and crop needs. He obtains help and guidance from trained agronomists of fertilizer companies and government agencies to insure tha he purchased the correct fertilizer.

Yet, because of poor practices and lack of knowledge, the farmer can reduce the effectiveness of the fertilizer he is using. It is the purpose of this paper to present salient points to help the farmer improve the efficiency of his fertilizer use, so as to insure that he is receiving full value for the money he spends for fertilizer.

APPLICATION

The root system of most food crops normally contacts about three percent of the total soil volume of the plowed layer. Unless the fertilizer can enter the roots of the plant, it is not effective. Proper fertilizer application insures its full use by the crops. Proper fertilizer application must consider such factors as: how to apply, when to apply, how much to use and its plancement.

How To Apply The Fertilizer

The farmer usually employs two methods of applying his fertilizer: by hand or by machine. Hand application can be very efficient for surface application for tree crops such as bananas and coffee if the labor is skilled. Supervision is needed to insure a uniform application on row crops, making sure that too much is not applied at the beginning of the row and too litle or none at the end of the row.

Machine application is preferred for a more uniform and faster aplication in row crops such as beans and vegetables.

When To Apply The Fertilizer

Fertilizer must be applied in sufficient time to be of use to the plant as it grows. Many times farmers with small areas delay their application of the fertilizer to the crop until it germinates and rains begin. This delay often prevents early and rapid growth of the crop so that it covers the surface and prevents weed competition.

Fast growing food crops of short duration such as corn, tomatoes and beans need their nutrients available very rapidly. They can not wait for the soil to release its stored nutrients. For such crops the fertilizer should be applied at time of planting.

If the soil is sandy or with little organic matter and the rainfall is high, small and frequent applications are preferred to one large application where part of the fertilizer may be leached out of the soil-root zone decreasing the nitrogen and potassium available to the plant. Casava production was increased by splitting the nitrogen application with 1/2 at planting and 1/2 at 2 months later as compared to

fertilizing 2-3 months after planting on a lateritic soil in the humid mountain area of Puerto Rico (10).

How Much Fertilizer To Use

Soil and plant analyses will help the agronomist determine what fertilizer formula is needed and how much to apply for a given crop. For hand application of fertilizer it is difficult to uniformly apply less than 400 kg per ha in row crops. Thus, low analyses fertilizer formulas are prefered. Where machines are used, application rates as low as 200 kg per ha can be achieved. High analyses fertilizer formulas are preferred. For example, for hand application to an onion crop, 400 kg per ha of a 10-10-8 would be good; where for machine application, 200 kg per ha of a 20-20-16 would supply the same amount of nitrogen, phosphorus and potassium to the crop with 50 percent less fertilizer to handle.

Placement Of Fertilizer

Unless the fertilizer can enter the roots, it is of little value to the plant. Thus proper placement of the fertilizer is necessary. Placing the fertilizer on top of the soil is easier and less expensive, but it can be inefficient. Heavy rains can wash the fertilizer away. In soils with pH values above 6.5, the nitrogen can volatilize as ammonia gas and be lost in the air. Only for pastures and certain tree crops where the fertilizer can not be covered is surface application of fertilizer advisable.

Placing the fertilizer in the soil is preferred. There is more moisture in the soil than on the surface. In the case of phosphorus, it is very important to place the fertilizer near the roots, bucause phosphate fertilizers move so little in the soil. In the case of phosphorus, it is very important to place the fertilizer near the roots, because phosphate fertilizers move so little in the soil. For example, Payne recommended for corn in Jamaica placement of the phosphate below the seed to avoid fixation in acid soils (7). In the acid ultisols in Puerto Rico, soybeans gave as good a response to 179 kg per ha of banded phosphorus (P) as 1120 kg per ha of broadcast P (3).

In cases where machines are not available for placing the fertilizer in the soil, applying it in the row and covering it with soil by hoes or discs is of great help to prevent losses of nitrogen by volatilization of amnonia from urea or ammonium sulfate or washing away of the fertilizer by rains. Covering an ammonium-base fertilizer with 4 cm of soil can minimize volatilization (12).

SOIL FACTORS

The soil is where the roots live and the fertilizer is applied. However, there are factors present in the soil which can prevent efficient fertilizer use. They are texture, organic matter, cation exchange capacity, pH, compaction, moisture and salinity.

Texture

In sandy or light-textured soils, the water passes through more rapidly than heavy-textured soils such as clays. Thus, with heavy rains, the fertilizer may be leached out of the root zone. For sandy soils, subject to leaching, fertilizer efficiency can be improved by several small applications rather than one large one to minimize losses.

Organic Matter

The organic matter portion of the soil acts as an absorbent of fertilizer nutrients helping to retain them against leaching caused by rain or irrigation. Soil organic matter holds nitrogen, phosphorus, calcium, magnesium and many minor elements in a form which the plant roots can readily absorb. Soils low in organic matter may require more fertilizer than those with medium to high amounts.

Large amounts of organic matter added to the soil when crop residues are plowed under may inmobilize soil nitrogen until it can be properly mineralized by soil microbes. For example, in Puerto Rico soybean crop residues when plowed under helped increase corn yields, but fertilizer nitrogen was also needed for best corn yields (8).

pH

Low soil pH, usually below 5.5, indicate very acid soils where soil microbes can not work well to mineralize nitrogen as organic matter or as fertilizer. Soils

with pH values above 6.5 may lose nitrogen if ammonia fertilizers (including urea) are placed on the soil surface. On soils with pH above 7 and with free lime in the soil, losses of nitrogen by volatilization can be high. Fortunately, covering the fertilizer with soil (4 cm or more) can eliminate this volatilization loss.

Compaction

Soils can become compressed due to the weigth of agricultural machinery passing over them, especially when the soil is humid. This compaction can form a layer or horizon so dense in the soil that it impedes water draining through it or penetration of the plant roots. When compaction occurs close to the soil surface (30 cm or less), it can interfere with proper fertilizer absorption and normal plant growth. For example, in Trinidad Gums and Ferguson (4) found that tuber yields of yams were reduced if soils were compacted to moderately low bulk densities.

Moisture

The amount of moisture in the soil has an important role in determining the rate the fertilizer nutrients can be used by the plant. Where rainfall is deficient, low mosture supply can decrease plant growth and use of fertilizer. When available, irrigation can boost production by increasing the fertilizer availability.

If the soil drainage is poor, excess water can harm plant growth by preventing the roots from taking in the fertilizer nutrients applied. Excessively drained soils can wash the nutrients out of the roots zone.

Both a deficiency or excess of soil moisture can reduce nutrient uptake by the food crop. For example, research in Puerto Rico indicated that for tomatoes, water deficiency (drought) reduced yields by 59 percent while water excess (poor drainage) reduced yields by 55 percent (11). For corn, the reductions were 65 percent for drought and 77 percent for deficiency of soil moisture.

Salinity

Where excess salts are found in the soil, be it due to poor drainage or sea water seepage, the results causes an unbalanced condition in the soil which prevents the fertilizer from being used properly by the plant.

PLANT FACTORS

The plant and factors associated with its growth can greatly influence fertilizer usage and crop yields. Some of these factors are: the crop being grown, its root system, disease and inset damage, plant population or density, weeds and balande of nutrients.

Not all food crops have the same fertilizer requirements and methods of application. Crops with short growing season, such as tomatoes or onions require their plant nutrients available very rapidly and their fertilizer needs are high over a short period of weeks. Long growing crops such as tree and some root crops have high nutrient demands, but they occur over periods of many months rather than weeks. Knowing these facts, fertilizer efficiency can be improved by proper timing and placement of the fertilizer for each crop.

The Root System

Plants absorb their nutrients via their roots be they supplied from the soil or from fertilizer. A healthy, abundant root system ensures a proper and efficient uptake of nutrients. Normally only about three percent of a plant's root system comes in contac with the soil in the plowed layer. The better the root systems is distributed, the better chance for more absorption of nutrients. A restricted root systems (be it due to soil compaction, poor drainage, insect or disease damage) must receive its nutrients in a limited volume and is inefficient in its fertilizer usage.

Disease And Insect Damage

The foliage of a plant is where the important process of photosynthesis takes place changing the inorganic elements into the food for which the crop is grown. The root system is where inorganic elements present in the soil are taken into the plant to be trasported to the foliage. Reducing the amount of either roots or tops of a plant by disease or insect damage reduces the growth of the plant and proper utilization of plant nutrients.

An axample of how inset damage to the roots can decrease fertilizer efficiency was found for soybeans in the United States (1). Nematodes, a microscopic insect

that destroys plant roots, when untreated allowed only 740 kg per ha of soybeans. However, when a nematocide was used with the potash fertilizer, maximum yields of 1614 kg per ha of soybeans were obtained. This was due to the fact that the nematocide eliminated the root demage allowing the potash fertilizer to work efficiently.

Plant Population Density

An often unseen enemy of fertilizer efficiency is the lack of proper plant population or density. Whether the number of plants in a field has been reduced or improper planting rate, the total effect is to reduce fertilizer efficiency. Remember, fertilizer can give an increase in the weight of each plant in the crop. It can not give this same increase if plants are missing.

The spacing and number of plants per ha in relation to fertilizer use have shown itself to be important. For example in Trinidad, it was found that closer spacing and higher fertilizer applications gave highest okra production (13). The same was found to be true for pigeon peas in Jamaica (5) and corn in Trinidad (9).

Weeds

In the field, weeds are intruders which make use of water and fertilizer that was destined for the food crop. Generally, weed growth is more aggressive than the crop, and can crowd out the small plants and retard their growth. The fertilizer is not selective as to what roots it enters to nourish the plant be it weed or food crop. A 10 percent weed infestation in a rice crop means that 10 percent, if not more, fertilizer destined for the rice crop is consumed by the weeds. Thus, the rice crop receives only 90 percent of the fertilizer and production is reduced proportionately. Research by CIAT in Colombia showed that yields of rice were reduced by 0.815 kg for each kg of weeds (dry matter/m^2 (20))

Balance Of Nutrients

Von Leibig's well-known, Law of the Minimum, still applies, although many fertilizer users forget it. In a soil, that fertilizer element in minimum supply

will limit the proper use of the other fertilizer elements present. Thus, if a soil is lacking in magnesium, no matter if the fertilizer formula applied is well balanced for nitrogen, phosphorus or potassium, it can not work effectively. Secondary elements such as calcium, magnesium and sulfur and the minor or trace elements such as boron, copper, iron, manganese and zinc if not available to the plant in sufficient quantities for the crop can limit the fertilizer efficiency. For example, Hernández and Lugo (6) found that when a minor element mixture was added to the NPK fertilizer, yields increased 56 percent for plantains growing in a ultisol in Puerto Rico.

An excess of an element, such as calcium in limestone derived soils, can "block-out" many important elements even if they are present in the soil. Care in selection of proper fertilizer materials and method of application is important in obtaining efficient fertilizer usage in calcareous soils.

STORAGE

Most of the time, when the fertilizer is delivered to the farmn it is not used inmediately, and it must be stored. If large amounts of fertilizer are stored and used, a fertilizer warehouse should be constructed. The roof, walls and floor should be waterproof to keep out moisture. Even if the floor is concrete, and especially if a dirt floor is used, the bags should be stacked on wooden pallets to allow for better air circulation.

Do not stack fertilizer bags higher than 10 to 12 bags or 1.8 to 2.4 m. The weight of too many bags compress the fertilizer in the bottom bags, forming a hard block instead of a free-flowing material. Make sure that the older fertilizer bags are used first and not left in the warehouse more than one year to become old and caked.

Many farmers may use a small shed in the field to temporarily store their fertilizer. If it has no walls, cover the fertilizer with a water-proof canvas or sheet of plastic to keep off the rain. Place the bags on boards to keed them off the ground or ditch the ground around the fertilizer bags to prevent water running in to the bags. Remember moisture is needed in the soil for efficient use of fertilizer. However, moisture can cause damage and reduce fertilizer efficiency if it gets into the fertilizer bag when in storage.

CONCLUSION

Proper attention must be given by the farmer to insure that all of the fertilizer nutrients he purchased goes into the plant to increase crop yields and quality. From warehouse to field, from the soil until it gets into the roots, there are opportunities for fertilizer efficiency to be lost. Be on your guard. Inefficient use of fertilizer can steal money from your fertilizer investment.

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