Advances in Soil Fertility

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Plant response to nutrients:

Plants like animals require food for growth and development. This food is composed of certain chemical elements often referred to as plant nutrients. At present, 17 elements are known to be essential for normal plant growth. An inadequate supply of one or more of these essential nutritional elements limits the yield of a crop. Soils are seldom able to furnish all the nutrients that a large crop requires.

Wide variations in the chemical composition of soils have been noticed and as such, some soils are deficient in one element, some in another and still others may be deficient in many or all of them. Besides, different crops have been found to differ markedly in their requirements of different nutrients. Apart from the soil and the type of plant, certain environmental factors, more particularly the moisture content of the soil, have been found to have a profound influence on the response of a crop to fertilizers. The response of a particular crop to a given fertilizer application cannot be foretold because a material so readily subject to change is placed in contact with the soil and the crop, which react with its both chemically and biologically, and thus affect its efficiency.

Factors affecting fertilizer response:

The large number of factors which affect the fertilizer use and consequently, the crop response to fertilizers the following may be considered the most important factors.

A. Crop characteristics:
1. Kind of plant and its root – system
2. Varieties
3. Plant population
4. Rotation and crop response

B. Soil characteristics:
1. Nutrient status of the soil
2. Soil moisture
3. Soil reaction
4. Soil temperature
5. Physical condition of the soil
6. Chemical properties of the soil
7. Effect of soil amendments

C. Fertilizer characteristics:
1. Type of fertilizer
2. Time of application
3. Method of application
4. Use of nitrate inhibitor
5. Use of chelating substances

Now we describe one by one

A. Crop characteristics:

1. Kind of plant and its root system:

The responses to the application of fertilizers may differ widely from crop to crop, because of a number of factors among which the yield level, and root characteristics are the most important. The yield level has a direct effect on the amount of nutrient removed from

the soil. The nutrient uptake by different crops is a fairly good guide for the response of crops to fertilizers, the root characteristics of different plant species might often modify the response to different fertilizers.

Example:

The extensive root system of corn exploited the soil more thoroughly then the limited root system of potatoes and, consequently the former used more phosphorus from the soil and less from the fertilizer, where as the reverse was true in the case of potatoes. Thus the response to fertilizer will be more in the case of potatoes then in the case of corn. Another important root characteristic affecting the response to fertilizer is the cation – exchange capacity of the roots. Very wide differences in the CEC of the roots of different plants have been noted.

The CEC of the roots of dicotyledonous plants is much higher than that of monocotyledonous plants. It also varies with the nature of the varieties of the same crop. The dwarf wheats have, as a rule greater CEC than the tall wheats, which may partly explain their higher fertilizers responsiveness. The magnitude of the exchange capacity affects the absorption of cation, those with a high capacity absorb more divalent cations, such as Ca, and less of monovalent cations, such as K. In contrast, plants with a low exchange capacity absorb less of the divalent and more of the monovalent cations. Thus the response to potassium may be higher in the case of dicotyledonous plants than that in the case of monocotyledonous plants. The legumes absorb more of Ca and P than the non-legumes. Root also vary in producing Co_2. Co_2 at the root surface combines with water to form carbonic acid which has a solubilising effect on the Ca phosphate. Crop realizing of high amount of Co_2 include buckwheat, sweet – clover and alfalfa and, consequently, there efficiency in removing P from a fertilizer is higher than that of other crops.

2. Varieties:

Marked differences in response to fertilizers have been obtained within varieties of the same crop. In many cases, these differences may be due to the differences in plant types. Some of the highly responsive varieties of cereals crops have got dark – green upright leave which do not shade the lower leaves, intercept the maximum amount of sunshine and, thus, make most efficient use of added fertilizers. In wheat and rice, there are the dwarf stiff – strawed varieties which resist lodging much better than the tall varieties and hence show greater response and have higher requirements of fertilizer than the tall varieties.

3. Plant population:

Sufficient plant population is one of the most important factors affecting responses to the fertilizer application.

4. Rotation and crop residue:

The crop rotation has a profound effect on the fertilizer efficiency and fertilizer requirements of the crops in the rotation. The legumes affect the nutrient status of the soil for the succeeding crop differently from exhaustive crops like jowar and maize. The crops requiring high levels of fertilizers, such as potato or hybrid maize, may not use the fertilizer applied to them fully and thus some quantities of nutrient element may be left in the soil and they may be available for the succeeding crop. Among the fertilizer nutrients, P is noteworthy in this respect because hardly 10 – 20 % of the applied phosphate fertilizer is utilized by the first crop. Though the crops have a tendency of luxury consumption for N and K, even some fraction of these fertilizer nutrients may be left unutilized owing to the sub – optimal growth of the crop due to drought, water – logging or frost etc,. On the other hand, if sub- optimal doses of fertilizers are applied to a crop, they may be leave to the soil in a much exhausted condition and the fertilizer requirement of the succeeding crops may increase. The legumes

leave nitrogen – rich root residues in the soil for the succeeding crop may increase and thus reduce its nitrogen requirement. It is general a experience that after jowar or bajra, the wheat crop is very poor and needsheavier doses of nitrogen than after paddy, maize and guar.

B. Soil characteristics:

1. Nutrient status of the soil:

The response to crops to fertilizer application directly depends on the chemical composition of the soil in respect of available plant nutrients.

On the basis of soil testing, the soils are arted as 'low', 'medium', 'high' in plant nutrients and suitable fertilizer doses are recommended. A 'low' rating in phosphorus means that crops on such soils should respond very readily to phosphate application. If the ratin is 'medium' the response is probable; and if the rating is 'high', there may be little or no response to the applications of the phosphorus fertilizer. Based on soil test values, it is possible to quantify the fertilizers needs of a soil for producing targeted yields.

Soil testing helps not only improving the efficiency and economy of fertilizer application but also is helpful in demarcating areas responding to different plant nutrients and also formulating the fertilizers scheduled for these areas. Soils may differ widely in their chemical composition because of differences in their parent material or in type of weathering.

For example: sandy soils are in, in general, deficient in potassium, because these soils are generally derived from those minerals that are deficient in potassium. Good response from potash fertilization is likely to be obtained on such soils. On the contrary, clay soils are usually derived from potassium aluminium feldspars. Which are rich in potassium and, consequently, normally show poor response to potassic fertilizers.

2. Soil moisture:

In most cases under irrigated conditions, fertilizers have greatly helped to increase crop yields by having favourable effects on the mass and distribution of roots.one of the most important points in this connection is the effect of soil moisture on the absorption of plant nutrients. Nutrient absorption is affected is directly by the level of soil moistureas well as indirectly by the effect of water on the metabolic activities of the plant, soil aeration and concentration of the soil solution.

3. Soil reaction (pH):

The micro – organism is responding very markedly in neutral pH therefore, soil reaction which has direct and indirect effects on crop growth. the most important secondary effects of high acidity or low pH in a soil are the inadequate supply of available calcium, phosphates, and molybdenum on the one hand, and the excess of soluble ammonium, manganese and iron, on the other hand, likewise in saline – alkali soil the deficiency Ca, Mg, P, Zn, Fe, Mn is very common.

4. Soil temperature:

The low soil temperatures, become a limiting factors in seed germination. The rate of nitrogen utilization by plants is modified by temperature. Though plants can absorb nitrate at low temperatures, both the translocation and the assimilation become limited under these conditions so that the rate of utilization of nitrogen is greatly slowed down.

5. Physical condition of the soil:

The physical condition of a soil largely determines the way in which it can be utilized by the plants. Soil nitrogen has been found to vary with the texture of the soil. Under similar environmental condition, the nitrogen supply usually increases as the texture becomes finer. Thus the response of crops to nitrogen is likely to be more on a sandy loam soil than on a silty clay.

6. Chemical properties of the soil:

It has now been fully established that some fertilizer materials leave acid residues in the soil, others a basic residues and still others might have no effect on the soil reaction.

7. Effect of soil amendments:

Lime is commonest material used for correcting the acidity of the soil. Lime affect plant growth mainly by correcting the soil pH and thus, making available a large number of plant nutrients. Thus on acid soils, even responses to fertilizers are very much reduced without the use of lime.the other liming materials, such as basic slag, paper – mill sludge also have been found to increase the response to fertilizers through their action on the soil pH. Likewise, gypsum and pressmud produce a beneficial effect in alkali soils in improving the efficiency of fertilizers.

C. Fertilizer characteristics and fertilizer manipulation:

1. Type of fertilizers:

Fertilizer may differ in their nutrient contents or in the form of nutrients. In case of nitrogenous fertilizers, the nutrient may be supplied in the ammonium, nitrate or amide form. Likewise, in the case of phosphatic fertilizers, phosphorus may be in water – soluble, citrate soluble or citrate in – insoluble form. The single super phosphate will supply only 16% P_2O_5, whereas the triple super phosphate will supply three times this amount. In general, all the sources of nitrogen have shown responses of the same order with most of the field crops. But in case of paddy, the responses to nitrates and amides form of N are lower than those to ammonium from. Incase of phosphatic fertilizers for most of the crops, in general, fertilizer containing phosphorus in water soluble forms ahve been found suproir to those containing this nutrient in the citrate – soluble or citrate in – soluble form.

2. Time of application:

The time of applying fertilizers has been found ipmprtant ony in the case of nitrogenous fertilizers which have a tendency to leach with irrigation or rains. In case of phosphatic and potassic fertilizers, all the quantityat applied at sowing time has given the best results with most of the crops. Split application of N fertilizers has been found more superior in comparison to total application at planting stage.

3. Method of application:

Placement of phosphatic fertilizer has been found to be beneficial almost universally. The response of phosphatic fertilizer was much higher when the fertilizer was placed in a band of 5cm wide to the side and 5 cm below the seed than that from the broadcast application of the fertilizer.

4. Use of chelating substances:

In case of micronutrients, low solubility has been found to be the greatest limiting factor. A recent breakthrough in this respect has been the development of chelates of some of the important micro – organic complex which , although soluble themselves, do not ionize to any degree. The metallic ions commercially chelated are iron, copper, zinc and manganese. Four most important compounds found useful in agriculture are EDTA, DTPA,CDTA and EDDHA.