https://doi.org/10.29321/MAJ.10.A04316

Recent Advances in Plant Nutrition*

by

S. VENKATACHALAM & A. MARIAKULANDAI
Agriculture Research Institute, Coimbatore

Introduction: The naive view has often been expressed that the chemist has only to determine the plant food by analysis of the soil and then by subtraction from the total need of the plant one can say how much more is needed for a given crop and at this the problem of plant nutrition is solved. This is highly erroneous as only an almost trivial fraction of the total amount of any plant food in the soil is available to crops at any one time and there are innumerable complicating factors preventing the simple solution to the problem of estimating the amount actually available to the plant. Years of research has shown that the nutrition of the plant is a very complicated subject. From the time Jon Baptista Von Helmont (3) conducted his classical experiments with the feeding of the willow tree some 300 years ago to the modern times, much field has been covered in this fascinating study of plant nutrition.

Plant growth has been shown to be not merely a question of supplying the necessary mineral nutrients; but has time and again been proved in recent times to be determined by the complex environment of the plant in which the mineral supply from the soil is only one factor. There are many changes and interactions taking place in the soil which finally determine whether or not the individual nutrients will be available to the crops in suitable quantities and in the correct proportion. The recent advances made in this field could be generally classed under the following heads of study:

(1) The power of the soil to fix nutrients.
(2) Effect of other factors like organic matter, lime status etc., of the soil in plant nutrition.

Much headway has been made in recent times in improving plant growth through a study of the above factors and it shall be the object of this paper to briefly outline the advances made under each, with a brief review of the related fields.

Nutrient Fixing Capacity of Soil: By virtue of the exchange cations and anions in the colloidal fractions of a soil, a proportion of the added nutrients may be fixed in the soil. This reaction is

* Paper read at the College Day and Conference, 1954.

both an advantage and a disadvantage. It is advantageous in as much as the fixation process prevents the rapid leaching out of the nutrients from soil. It is disadvantageous in many instances as in the case of phosphorus and potash when a considerable portion of these added nutrients in the soil is never recovered by the crop due to the fixation. Acid soils and those containing free hydrated oxides of iron and aluminium present special problems in phosphatic fertilization. In such soils, these free oxides fix the phosphates by a process of absorption to such an extent that it is unavailable to the plant. The laterite soils of Malabar and the lateritic soil of Nilgiris in this State are good examples of such soils. These soils have a strong acid reaction, the pH being 5·5. On these soils, owing to their property of phosphate fixation, high dosages of phosphates are needed for a good crop. Thus in the Nanjanad manure mixture used for the potato crop, the dose of phosphate is about ten times that required in neutral soils for any good crop. About 1,000 pounds of phosphatic fertilizer in the form of super or super plus bone meal to give about 200 pounds of P_2O_5 per acre are used. Attempts were made in this State and in other countries to tackle this problem of phosphate fixation. The application of lime and organic matter in addition to super, placement of phosphate at the root zone, etc., were the outcome of such investigations. These however did not help to reduce the dosage of phosphate to be applied. Experiments at Rothamstead showed that silicates can replace the absorbed phosphate. New phosphatic materials were produced with a silicate combination and work was started in the laboratories at Coimbatore to test this silico phosphate on laterite soils. Silico-phosphate was prepared and pot tests conducted to evaluate its usefulness on the lateritic soils of Nanjanad in Nilgiris. The results of these tests showed that the availability of phosphate in the soil could be doubled by the use of the silicophosphate whereas super-phosphate failed completely in this respect (5). To confirm the findings of these tests and to evaluate their worth in terms of monetary value, large scale experiments have been planned under field conditions at Nanjanad. Better yields of potato with smaller dosage of silicophosphate than when super is applied is expected and thus it will be possible to attain a reduction in the manure bill of the potato grower. Apart from this, the production of the silico-phosphate fertilizer will bring into use the 8 million tons of Trichy phosphate deposit which has hitherto been abandoned as useless for conversion to superphosphate and which has now been found possible to convert into silicophosphate (6).

Effect of other factors like organic matter, lime status etc.: Struthers and Sieling (9) discussing the new ideas on the fixation of phosphates in soil have indicated that certain organic acid anions could form compounds with the free iron and aluminium in the soil and thereby prevent the fixation of the phosphate, thus rendering it available to plants. Of the organic acids, like citric, oxalic, tartaric and malic which were tried, the citrate ion was outstanding, with power to influence the phosphate release at a wider range of pH viz., 4–9 for aluminium phosphate and 4–6 for iron phosphate than the other acid ions.

As the fixation of phosphate is high in acid soils, lime application to change the pH was the next solution tried by many workers. Hopkins (4) has pointed out that if an iron phosphate complex has been precipitated at a pH of 4·0, a change to pH 6·0 by adding alkali will release only 7% of the phosphate, which has been fixed while the citrate ion could release 89%. And hence lime application may owe this effect not to pH change but to its ability to increase bacterial activity which ultimately results in the polyuronides and increase in organic acid ion giving an effect similar to the polymers now on the market under the patent names Krilium, Aerotil etc.

These ameliorative measures have been tried out in the laterite soils of Malabar on a field scale embodying different combinations of superphosphate, lime and green manure with paddy as the crop grown. Three years' trials showed that the maximum production of grain and straw is obtained by the application of high dosage of superphosphate at 60 lbs. P_2O_5 per acre in conjunction with liberal dosage of green leaf at 7,500 lb. of Vengai leaf (*Pterocarpus marsupium*) per acre and lime at 3,000 lb. per acre (8).

From the above two factors discussed, it will be evident that feeding plants through the soil is not a simple addition of the required nutrients but is a complicated process involving many aspects of Soil Science. The newer methods to improve the mineral status of the plant tries to obviate the effect of the soil and its reactions and comprises of the following:

(1) Foliar spraying.
(2) Chemical injections.
(3) Presoaking of seeds.
(4) Soilless cultures.
(5) Plant hormones.
(6) Isotopic tracers.

Foliar sprays: Feeding through the roots is a slow process and is often faced with complication due to the interaction of the soil on the added nutrients whereas feeding through the leaves is claimed to give immediate benefit to plants. The assimilation is said to take place within a few hours. The Monsanto Chemical Company has put on the market a product known as Folium a 20–20–20 N-P-K water soluble concentrate which is claimed to produce excellant results on vegetables, flowers and meadows. An advantage with this mode of feeding is that the dosage per acre is only a fraction of what is applied to the soil. The use of foliar sprays of urea to fruit trees is well known. The leaf feeding can be taken advantage of for the phosphate nutrition in the laterite regions.

The role of micro nutrients, the so called trace elements such as iron, copper, zinc, boron etc., in the nutrition of plants is great. Some spectacular results have been obtained with citrus and other fruit crops by applying these as foliar sprays.

Chemical injections: Injections of iron and zinc salts to fruit trees like pears and peaches have been in vogue in California to correct these deficiencies and many elegant devices and recipes for feeding plants through injections of nutrient solution have been developed in recent years. Treatment of soil only, in the absence of information derived from other techniques could easily lead to erroneous conclusions. A case in point is afforded by a study of zinc deficiency in California (2). In a peach orchard showing zinc deficiency, it was computed from results of plant analysis that the trees and fruits removed about 8 ounces of zinc in seven years; yet an analysis of the soil showed 3,000 lbs. of zinc to the acre within root zone. In another zinc deficient soil, 1.500 lbs. of zinc sulphate applied to the soil failed to cure zinc deficiency in apples. It would be easy to miss the nature of deficiency in these cases if treatment were confined only to the soil. On the other hand, the essential status of zinc was demonstrated by techniques of foliar spraying or tree injections.

Feeding the seed before sowing: Presoaking the seeds in nutrient solutions before sowing is yet another method adopted lately in the feeding of plants. Thus presoaking of potatoes with a 5% solution of potassium phosphate has been claimed to increase the yield. Under local conditions, soaking of paddy in a molar or semi-molar solution of tribasic potassium phosphate has increased the grain yield by 13%. In groundnut, 2 to 5% of monopotassium phosphate

gave increased yields to a marked extent. Pretreatment with hormone solutions like β–Indol acetic acid also increased the yields though to a lesser degree than tribasic potassium phosphate (7).

Soilless cultures: A large number of species of higher plants have been grown successfully in artificial cultures with the roots furnished only with a solution of inorganic salts under suitable conditions of root aeration. Under normal conditions, these plants which include most of the Agricultural species, are fully capable of synthesizing the organic substances which they require. There has been no evidence that plants so grown are deficient in dietary essentials.

Plant hormones: Just as certain substances are essential for regulating and controlling animal growth, certain chemicals are necessary to accelerate or alter the course of normal plant growth. These are known as plant hormones. It was discovered in 1931 that human urine contains growth promoters for plants, known as Auxins. It has been observed (1) that there exists Auxins 'a' and 'b' both chemical compounds possessing the formula $C_{18}H_{32}O_5$ and $C_{18}H_{30}O_4$ respectively and structurally very similar to human sex hormones. Hetero auxin is β-indole acetic acid which is also found in animal urine and is a useful plant hormone. β-indole buteric acid has been found to possess properties with which root development in soil is greatly exaggerated. Sulphanilamide upto the concentration of 30 parts per million in soil improves tomato production. Likewise, chloro-picrine treated soils greatly increase the yield of tomatoes and in one case 378 percent of normal yield has been reported.

Use of radioactive isotopic tracers in the feeding of plants: The use of radioactive isotopes in the study of plant nutrition is worth mentioning here as a recent advance in the feeding of plants. The use of these isotopes though not used directly in increasing the yield of crops have been of much use in the study of the methodology of plant nutrition. By the use of the isotope of a mineral in the nutrient media the intake and the distribution in the plants of the particular mineral can be followed through.

Thus, the science of plant nutrition is definitely marching forward and is gradually developing into many interesting branches. As in the other fields of Agricultural Science, there are many factors influencing the nutrition of plants which needs more and more of intensive study in the near future.

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A Passion Fruit for the Plains

by

S. MUTHUSWAMY

Horticultural Section, Agricultural College and Research Institute, Coimbatore

Introduction : Several kinds of creepers known as "passion vines" are grown for their edible fruits as well as for their ornamental flowers in India. A few of these, commonly called "the purple granadilla", "the giant granadilla", etc., have been disseminated over a number of years in certain localities and are now growing as part of the natural vegetation. Recently there has been some effort to grow one of these, viz., the purple passion fruit, commercially in South India. This purple passion fruit is an important crop in Australia, New Zealand, Hawaii and other countries and in South India it grows luxuriantly and bears heavily in Coonoor, Ootacamund, Kodaikanal, Sheveroys and other places of high altitude. It needs a mild climate and at lower altitudes the vines are found to be extremely vigorous in vegetative growth but produce very little crop. Recently an yellow fruited variety has been introduced into South India from Ceylon and investigations on this variety have shown that it is of relatively easy culture and is well adapted to the plains