OUR SOILS CAN BE IMPROVED FOR BETTER PLANT GROWTH

by

RANJAN JAYARATNE

Soil has a special attraction, which seems to strike all of us at some time or the other. Farmers or horticulturists till it, engineers move it about, small boys dig in it, and mothers abhor it as being dirty. Unfortunately, for many people soil is synonymous with dirt. They should know better, for the soil has a vital and important role to play in the life of the world and mankind.

How does this soil form on earth's crust ? The famous Russian soil scientist Dokuchaiev suggested five soil formers which controlled soil formation. They were; parent material, climate, age of land, plant and animal organisms, topography. The thin covering of soil on the earths crust is formed from the underlying bed rocks by the process known as "weathering". This is a process which at best is a combination of physical, chemical and microbiological reactions causing decomposition of rocks and of plant and animal materials. It is estimated that it may take anything from a few hundred to a thousand years to form an inch of top soil depending upon the intensity of the weathering action.

The growth of plant on earth mainly depends on the properties of soil. Therefore the soil is indirectly responsible for all the life on earth. Plants obtain all the required nutrients and water from the soil. Improving the availability of nutrients, water and other factors, such as areation to desired levels will improve plant growth and thereby their productivity.

Some elements are found in soil more commonly and in greater abundance than others and also these are taken up in larger quantities by plants. These are referred to as the major plant nutrients or macro-nutrients. Nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, come under this group. Beside these, seven other elements are required in relatively small amounts for plant growth and are also taken up from the soil in small amounts by plants, accordingly they are described as micronutrients. These are iron, manganese, boron, copper, zinc, molybdenum and cholorine. All these macro and micro-nutrients are essential for plant growth. If any one of these elements is lacking or is present in insufficient amount, the growth of the plant will be retarded and in extreme cases killed.

Usually, plant growth can be improved by improving the availability of these essential nutrients in the soil. Application of chemical fertilizers has become the most popular method of improving soil conditions for better crop production all over the world. The use of chemical fertilizers in our country is fairly expensive. This is because most of the fertilizers are imported into our country. Therefore it is very important to use the minimum amount of fertilizers needed to give maximum plant growth. How can this be done? One would think that the chemical analysis of the soil would give all the information which could be required to prescribe the minimum amount of fertilizer to a given soil. Unfortunately, the results of chemical analysis of soil have not fulfilled the requirements necessary for assessing the fertilizer requirements. But the chemical analysis of plants has proved to be quite useful in assessing the fertilizer requirements in the soil.

When we consider the plant production practices in our country, they will fall into three major categories.

1) Shifting cultivation, more popularly known as "Chena" cultivation.
2) Agricultural farming systems.
3) Plantations.

Shifting cultivation is the oldest method of farming. Over 300 million people in the tropical world still depend on this method of cultivation. A plot of forest is slashed down, which is then burned, resulting weed free soil beneath, and onto this arable food crops are sown. This method of cultivation does not need any external inputs of nutrients, as the forest sites maintain a very good balance of nutrients through recycling processes. However, under the heavy tropical rains, the bare soils quickly erode, fertility declines and weeds become a problem, which means the farmer has to abandon the land and clear a fresh patch elsewhere. Although the shifting cultivation is being condemned by some people, it is not an unproductive technique, provided that there is large forest areas that can be utilized over the years, with effective reforestration programmes. Unfortunately, our forest resources are restricted and further it is diminishing very rapidly due to improperly implemented reforestration programmes. Therefore this method of shifting cultivation with a short-term high productivity will not be possible in future in Sri Lanka.

With the increase of the world population, agricultural farming systems, have gained prominance for food production. Currently 500 million to 1 billion people in the world have less food than is necessary for basic nutrition.

As mentioned earlier, use of more and more chemical fertilizers has become the accepted practice for increasing crop productivity. This is an expensive process. Therefore, the other alternate is to use naturally occurring organic fertilizers such as cow-dung, other organic waste products from industries and green leaves on the one side and to improve the biological processes that exist in the soil to utilize the soil nutrient resources that are present in the soil, more efficiently.

Mycorrhizal activity is one of the most important biological relationships that exists between soil and the roots of plants. What are mycorrhizae? The term mycorrhizae (meaning fungus root) is used to describe a structure that results from a mutually beneficial association between fine feeder roots of higher plants and a species of highly specialized, root-inhabiting fungi. The fungi derive most if not all of their needed organic nutrition (carbohydrates, vitamins, amino acids) from their symbiotic niche in the roots. Whereas the host plants will receive essential nutrients more efficiently via the fungus from the soil. Mycorrhizae can be broadly divided into two major groups depending on their morphology.

1. Endomycorrhizae
2. Ectomycorrhizae

Vesicular-arbuscular (VA) mycorrhizae are the most common type of endomycorrhizae present. The term vesicular-arbuscular is given to these mycorrhizas because there are two types of structures produced within the host cortex which are referred to as vesicles and arbuscules. Hyphae penetrate into the cortical region intercellularly, producing inter-or intracellular vesicles and intracellular arbuscules. Arbuscules are dichotomously branched finely divided hyphal structure resembling haustoria. These arbuscules are the important sites of this association because the sites of transformation of nutrients to the host are these. Hyphae outside the roots will ramify in soil to form a network of fine threads; but will never form a well defined structure as in Ectomycorrhizae. In Ectomycorrhizae there is always a well defined pseudoparanchymatous sheath external to the root epidermis.

It has been amply demonstrated the inoculation of forest trees and agricultural plants with mycorrhizal fungi can stimulate their growth in soils deficient in nutrients. These VA mycorrhizae occur in almost all the higher plant families except for one or two. Therefore their importance has been accepted all over the world. These mycorrhizae can be considered as much a natural component of roots as chloroplasts are components of green leaves. Ectomycorrhizas are mostly important to forest trees.

A number of mycorrhizal fungi can infect a plant species and therefore, one may be able to modify nutrient absorption by the plant considerably by judicious selection of the fungus. The efficiency of this association will mainly depend on the host-fungus relationship,

pH of the soil, light intensity, nutrient status of the soil, moisture stress etc. Such manipulations may be valuable in management of nutrient deficient soil and in plant breeding programmes which aim at selecting plant varieties tolerant to deficiencies.

Therefore, by introducing these highly efficient VA mycorrhizal species or strains to soil will reduce the application of fertilizers like super phosphate and rock phosphate which supplies phosphorous to the soil (slowly mobile ions). This will reduce the cost involved in the production of crops and also will save a considerable amount of foreign exchange which is being used to import these fertilizers. Further it has been estimated by the National Academy of Science, U.S.A., that the domestic supplies of phosphorous the world over will be exhausted in a few years and by 1990, three-fourths of the world's supply of phosphorous will come from the Middle East. Will this be another OPEC - Organization of Phosphate Exporting Countries ? Therefore it is very timely to explore these mycorrhizal associations of crop plants to get the maximum benefit out of them. It will be a very interesting thing if we can produce 'super' species or strains of mycorrhizae, probably by the use of genetic engineering techniques.

Mycorrhizal fungi can have an influence on disease severity of certain root inhabiting plant pathogens. These include certain pathogenic fungi, parasitic nematodes, viral and bacterial plant pathogens. The disease severity can either be increased, decreased or not affected by the presence of mycorrhizae. Therefore, it is essential to use these "biological fertilizers" very carefully in soils containing crops and pathogens on which they enhance disease, because this will result in considerable losses in crops. To minimize such losses, considerably more studies involving mycorrhiaze and plant pathogenic organisms are necessary.

The other important biological process between the roots of higher plants and bacteria is the nodulation of leguminous plant roots by the bacterium Rhizobium. These bacteria are capable of converting atmospheric nitrogen into NH_4 + salts which can be utilized directly by the plants. Among rhizobia too there are different species with different levels of activities. Therefore, as in the case of mycorrhizae, we should be able to manipulate these rhizobia by effective processes of inoculation to increase the efficiency of nitrogen fixation. This in turn will reduce the application of nitrogen fertilizers for better crop production.

Rotation of crops as done by some of our farmers is a very good method of improving soil conditions. A leguminous plant, which has both symbiotic association (bacteria & mycorrhizae) mentioned earlier, can be grown between cropping seasons. These plants are cut burried and allowed to decay before the next crop is planted. This process will enrich the soil with many nutrients necessary for better plant growth, specially nitrogen and phosphorous. Further, the roots in these leguminous crops will act as a source of inoculum production for VA mycorrhizae which will help to infect the next grown crop efficiently.

In conclusion, it is always best to improve our soil conditions for better plant growth by means of biological processes rather than by chemical processes which can result in an imbalance of microbial populations in the soil. This imbalance of microbial populations will lead to upsets in the nutrient cycles (N, P, C) that exist on earth. Further the prices of petroleum fertilizer products are increasing daily and there may come a day that the ordinary farmers in Sri Lanka may not be able to use these chemical fertilizers due to their high costs.