MANAGEMENT OF SOIL RESOURCES TO MEET THE CHALLENGES OF THE FUTURE

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We are today faced with many challenges, while some developing countries have to produce more from less and less land, the developed countries are more threatened with the serious problem of environmental degration through industrialisation. The whole world is concerned with the global problem of the quality of life now and in the future. Therefore, there is an urgent need for careful consideration and thoughtful planning of the uses of agricultural resources, particularly the soil in developing countries like Sri Lanka.

After the second world war, a new era in science began, with greater emphasis on use of science and technology for peace and the prosperity of the human race. Its impact was felt in agriculture through scientific research in soil science, fertilizer use, water and crop management either to increase production from the land already under cultivation or to bring new areas under cultivation and improve the productivity of lands which were considered infertile and poor. This led to a dramatic increases in yield and production in many countries, particularly the industrialised countries and capitalised quickly on the advances in soil and crop sciences. The intensive use of fertilizer and high yielding varieties became the symbols of progress. Fertilizer consumption everywhere rose phenomenally and is expected to continue rising. According to projections on world fertilizer use by UNIDO, fertilizer consumption in the developing countires is expected to rise from approximately 30 million tonnes of $N + P_2O_5 + K_2O$ in the 80s to 53 million tonnes in the 90s and over 100 million tonnes in 2000 A.D. In Sri Lanka, it has been reported that the overall consumption of fertilizer increased by 107% during the period 1961 to 1982 with a 47% increase between 1970 and 1982. The highest level of fertilizer consumption had been in 1980 with 169, 300 tonnes followed by 154, 800 tonnes in 1982. The demand grew for soil testing, soil survey and classification which became important tools of modern agriculture.

Lately the world has became conscious of conservation of human, animal and plant resources, but there is not enough concern about the fast disappearing fertile top soil which supports all animal and plant life. It is therefore a paramount responsibility of all agriculturists to do something about timely global conservation and imaginative rational use of our ever depleting soil resources. The Indian National Commission on agriculture reported that out of the 328 million ha of total land area in India, 150 million ha are subjected to serious erosion by water and wind. John Pesek in his presidential address to the American Society of Agronomy stated that the USA is losing 1.2 million ha annually due to erosion. These estimates appear frightening, but erosion can be minimised, though not completely eliminated. Studies done at the RRI of Sri Lanka indicates that approximately 61.9 tonnes/ha of top soil can be lost from rubber replantings during first 3 years if the land is clean weeded and kept bare. But it would be possible to minimise this loss to approximately 1.32 tonnes/ha if suitable soil management practices such as mulching and growing of leguminous ground covers are practiced.

Increasing the productivity of cultivated lands is another aspect that needs priority. Lack of drainage and lack of proper nutrient and water management are serious problems. The gulf between possible yields obtained by researchers and innovative growers and actual national averages is very wide. Technically there are numerous possibilities for realising this unexploited potential. Rubber is mostly grown in the assured rainfall areas where moisture may not be a limiting factor, but in most of the areas nutrient.stress and soil physical environmental stress are the two other important factors affecting yields.

Though water is not a limiting factor in these areas as a good percentage of rainwater is also wasted as run-off, which besides being a wasteage of the resource, also cause erosion. Thus efficient management of rain water is an important consideration to increase production and to prevention of soil erosion in these areas. Agro-climatologists and soil scientists working together can provide valuable guidlines for making the best use of a given environment. Water, whether too little or too much, is a constraint to crop production. Soil scientists would be expected to develop appropriate technologies suited to the twin problems of moisture deficit and excess, which often exist in the same soils in the same year.

Soil scientists, irrespective of their specialisation, have been concerned with the understanding of processes and development of techniques for improving soil environments for crop production. The fuel crisis and the escalation of prices of nitrogenous fertilizers spurred the effort to improve the efficiency of these fertilizers and to find a biological means of augmenting N supply. Use of sulphur-coated urea, supergranules and nitrification inhibitors received greater attention from soil fertility specialists. Split application of fertilizers and use of legumes helped effecting savings on N bills. Application of phosphate to ground covers was found to be an effective means of improving the uptake of this nutrient by rubber, than its application direct to the rubber tree. This method of application gave significant residual effects on the main crop. The use of mycorrhizae for releasing phosphates from unavailable forms in soils opened up new possibilities for utilizing Eppawela rock phosphate, a locally available source of phosphate. Organic matter chemistry, through use of sophisticated instrumentation, has unravelled the mystery of the relationship between organic matter and nutrient supplies.

The last few years have witnessed great interest in the use of organic matter and agricultural wastes for supplementing fertilizers and improving soil properties. The soil physicists have successfully set up models to study the behaviour and movement of water and solutes in soils to predict the changes in soil environments in response to physical and biological factors. Acceptance of the U.S. Soil Taxonomy of soil classification, indicates the possibilities of transfer of technology to the same soil families around the world. It would not therefore be an exaggeration to say that soil scientists and agronomists have responded to the challenges of the times and seem to be receptive in taking greater responsibilities in the future. Expanding fertilizer technology; space-age techniques such as satellite imagery and remote sensing to assess agricultural resources; and genetic engineering are opening up new vistas in soils science research and practice as well.

Nutrient deficiency is the major limiting factor for crop production in most of the soils and the phenomenal increases in production obtained in the last two decades are attributable to a great extent to the removal of this constraint through use of fertilizers. Whatever strategy for increasing production is adopted, a constant watch on nutrient supply in the soil is needed. There would be a decline in soil fertility unless the input-output relationship is properly balanced. The expected crop yield is a function of soil productivity, climate and imposed management. As yields increase, larger quantities of all nutrients are required to support growth and development. Similarly, larger amounts of nutrients will be removed in the harvested portion of the plant. Nutrient replacement needs, increase at a faster rate than uptake and removal due to a limited root area for absorption, the necessity to maintain nurtient supplies at the point of slight luxury consumption, and increased losses through leaching and soil erosion. The soil bank cannot therefore remain solvent with this type of balance sheet.

One underlying difference between annual and perennial crops is the required nutrient uptake rate. The annual crop has to establish its root system and absorb an often very large amount of nutrients, within a short time. Perennials have a large existing pool of nutrients, which support growth for a period by interval depletion. For example, mature rubber plantations with agro-forestry systems of cultivation are likely to conserve and utilize the reserve nutrients more stringently than other agricultural systems. Nutrient re-cycling is comparatively efficient with relatively small loss of nutrients through the latex. Further demand for nutrients from trees under tapping are also expected to diminish in view of the reduction in tree biomass, resulting from intensified self-pruning and thining off of canopy. Therefore, annual plants are more critically affected by interuptions in nutrient flow. Apart from this there is unlikely to be any basic difference in their nutrient acquisition systems.

Leaf analysis is the standard method of control of fertilizer usage in most perennial crops. Two modifications to procedures of leaf analysis that might be of immediate practical benefit has been identified very recently. Firstly, analyses should be more complete and should include minor as well as major nutrient elements. In the case of potassium this would help to identify those situations where large responses can be expected because of lack of suitable replacement cation. Secondly, fresh as well dry weights should be determined because this allows calculation of nutrient concentrations on the basis of tissue water which can provide more reliable estimates of crop nutrient status. A fertilizer recommendation service to the rubber industry of Sri Lanka, based on the technique of leaf analyses was started by the RRI in 1973. This scheme helped effecting savings of fertilizer bills by over Rs.9.35 million in the last 5 year period.

Even where fertilizers are applied, their use may not always be efficient; thus another problem which we have to take note of is the low efficiency of applied fertilizers. Realising that N is the most expensive input and its manufacture requires a large amount of energy, agriculturists should give top priority to improving the efficiency of this fertilizer and to supplementing it thourgh biological N fixation and organic manures.

While fertilizer technologists have to modify the fertilizer products to suit the soil, the soil scientists should learn to modify the environment to improve fertilizer use efficiency. Controlled nutrient release to suit different soil and crop environments is a high priority. Additional work may be needed on useage and possible nitrification inhibitors and on ways to prevent ammonia volatilisation, de-nitrification and leaching losses.

Inadequate attention is being paid to organic waste and recycling of crop residues. The bio-gass generated from animal wastes and agricultural wastes provides a new avenue for augmenting energy supplied and manurial resources for agriculture. It is shocking to see large quantities of straw being burnt in the fields every year. Besides being a loss of valuable nutrients and organic matter for soil improvement, this burning can cause a serious problem of atmospheric pollution and health hazards. Robert Allen in an IUCN-UNEP-WWF document reports that 500 million tonnes of dung and crop wastes-badly needed for improving the soils are being burnt by the rural people in the developing countries.

Thus for optimising production per unit of land under cultivation, removing of soil constraints to production and using modern technology based on judicious use of inputs assumes highest priority in all areas. In the past, the philosophy had been to modify the soil environment to suit the plants. Because of the technological and economic difficulties of applying this technique in many areas a new philosophy of tailoring the plant, through genetic engineering to suit the environment has become necessary and would produce results of practical value. Thus the role of soil scientists and agronomists is to identify and categorise the environments for the geneticist and the plant breeder to develop genotypes suited to each environment.

The challenges to soil scientists and agronomists in the decades ahead are therefore:

1) Improving the agricultural productivity of the land that is already under cultivation,
2) improving the efficiency of agricultural inputs such as fertilizers, water and herbicides,
3) reducing soil erosion and surface run-off by efficient soil and water management systems,
4) monitoring changes in the productivity of soil/plant and developing a system of warning, treatment and care.

These challenges are common thoroughout the world; only their intensities and order of priority varies. The main plank of any strategy for increasing production in developing countries such as Sri Lanka, is through economic maximisation of productivity per unit area per unit time. In this strategy all three aspects, increasing productivity, restoring productivity and preventing deterioration of productivity, are important.