SOIL FERTILITY MANAGEMENT FOR VEGETABLES IN THE ULTISOLS OF THE UPCOUNTRY OF SRI LANKA

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The soils at elevation over 900 m in the upcountry of Sri Lanka have been used mainly for potato and vegetable cultivation, which is intensive and highly commercialized. The environment in this region is highly suitable for year round cultivation of high quality and high priced vegetables. The Ultisols are predominant soils of the upcountry (Panabokke, 1996). Soils are generally strongly leached and acidic with a pH of 4-5.5 (Wijewardena, 1995a; Wijewardena *et al.*, 1996a; Wijewardena, 1999a).

Upcountry of Sri Lanka could be divided into 2 major vegetable growing zones namely, upcountry intermediate and upcountry wet zones. Potato is one of the most important cash crops grown in both zones. Commonly grown vegetables in the upcountry intermediate zone are tomato, cabbage, bean, capsicum and eggplant, while in the upcountry wet zone are carrot, beet, leek, cauliflower and radish. Farm holdings are rather small, ranging from about 0.2 to 0.4 ha. Due to the hilly nature, land available for vegetable cultivation is limited in the upcountry.

In the upland cropping system, potato is cultivated in both zones during wet seasons followed by vegetables in dry seasons if adequate water is available. The lowland cropping system, which is rice-based is practiced only in the upcountry intermediate zone. In these lands three crops are grown within a year, rice during wet season followed by potato and vegetables during the dry season. Generally, agriculture in the upcountry wet zone is more intensive than in the upcountry intermediate zone. Hence, to make maximum use of the available land, farmers particularly in the upcountry wet zone practice mixed cropping system.

Vegetables differ from most perennial crops in that they have a short growing period of about 2 - 3 months and generate a very high quantity of biomass rapidly absorbing large quantities of plant nutrients. Furthermore, they are shallow-rooted and have to obtain their nutrient requirements from a small volume of soil. Therefore, vegetables should receive a relatively large supply of plant nutrients in a short time from the soil or added fertilizers for adequate crop growth and yields.

NITROGEN

Due to the hilly nature and high rainfall in the upcountry, uncultivated soils are low in plant nutrients (Wijewardena, 1995a). Crop yields tend to be drastically reduced without N fertilizer application. The research revealed that the application of N at 100 kg / ha per crop significantly increased the yield of potato and vegetables (Wijewardena, 1997a; Wijewardena, 1998a, Wijewardena, 1998b).

PHOSPHORUS

Phosphorus is considered as one of the most limiting plant nutrients in Ultisols. A series of seasonal (Wijewardena, 1997b) and long-term experiments (Wijewardena, 1997c; Wijewardena 1998c) carried out in the upcountry revealed that there is a positive response to added P even during the first season. Therefore, to achieve high crop productivity application of phosphorus is necessary.

Potato and vegetables grown in the upcountry showed good responses to high-grade P fertilizers such as triple superphosphate. A number of experiments conducted in the upcountry have shown that rock phosphate is not suitable source of P for potato and vegetables and therefore, potato and exotic vegetables grown in this region need addition of "high grade" or "high solubility" P fertilizers such as TSP (Wijewardena and Amarasiri, 1990; Wijewardena, 1998c; Wijewardena and Yapa, 1998; Wijewardena, 1999b). Furthermore, an application of P up to 100 kg / ha per crop as triple super phosphate results in high yields of potato and vegetables (Wijewardena and Amarasiri, 1990; Wijewardena, 1997c; Wijewardena, 1998c).

POTASSIUM

Long-term experiments conducted in this region have revealed that the application of K fertilizers does not have a major effect of the crop yield because of the reasonable quantities of exchangeable K presence in Ultisols. However, an application of 100 kg K_2O / ha per crop is necessary to maintain adequate soil K level and also to obtain a high yield of potato and vegetables (Wijewardena and Amarasiri, 1993; Wijewardena, 1996; Wijewardena and Amarasiri, 1997).

MAGNESIUM

Potato and vegetable fertilizer mixtures that farmers use in the upcountry do not contain magnesium fertilizers. However, continuous cultivation of potato and vegetables depletes exchangeable Mg. Long-term studies (Wijewardena and Amarasiri, 1993 and Wijewardena, 1996) on the Ultisols of the upcountry have shown that application of Mg fertilizer significantly increases potato and vegetable yields. Hence, application of at least 30 kg MgO / ha per crop is necessary to maintain sufficient Mg levels in Ultisols.

SULPHUR

An experiment conducted in the upcountry revealed that poultry manure application increased soil sulphur content in Ultisols (Wijewardena, 2001a). However, another experiment conducted in Ultisols showed that application of sulphur at 60 kg /ha is beneficial for increasing potato and vegetable yields (Wijewardena, 1998d).

EXCESSIVE FERTILIZER USE

Farmers in the upcountry commonly use excessive quantities of chemical and organic fertilizers due to the high net returns obtained from vegetables compared to other crops (Maraikar *et al.*, 1996). They apply almost 2-3 times higher rates than the DOA recommended rates of NPK fertilizers (Wijewardena, 2001b).

ORGANIC MANURE

Among the organic manures, poultry and cattle manures are very popular. But, poultry manure is more effective than cattle manure, compost and broiler litter (Wijewardena, 1993; Wijewardena, 1995b; Wijewardena and Yapa, 1999; Wijewardena, 2000). Poultry manure is more popular in the upcountry intermediate zone, while cattle manure is more popular in the upcountry wet zone. Poultry manure is commonly used as an organic fertilizer at the rate of 10-15 t/ha per crop, while cattle manure is used as a fertilizer at the rate of 20-30 t/ha per crop. Poultry manure application at 10 t/ha is the most suitable level for vegetables to achieve high yield under the upcountry soil conditions (Wijewardena, 1998e). Application of poultry manure also increased the soil P and K contents in cultivated fields (Wijewardena, 1993; Wijewardena, 1995b; Wijewardena and Yapa, 1999; Wijewardena, 2000).

INTEGRATED PLANT NUTRITION SYSTEM

The integrated plant nutrition system (IPNS) is a common feature in the upcountry. The IPNS adopted in this region for sustainable crop production is mainly in the form of cattle manure + chemical fertilizer and poultry manure + chemical fertilizer. However, the best-integrated practice is the addition of 10 t/ha poultry manure in combination with NPK chemical fertilizers (Wijewardena, 1993; Wijewardena, 1995b; Wijewardena and Yapa, 1999; Wijewardena, 2000) to achieve economical high yields from potato and vegetables in this region. Studies conducted on nutrient management had shown that in many cropping systems, integrated nutrient supply and management through judicious use of organic, chemical and microbial fertilizers lead to sustainable crop production. Use of various kinds of organic manures (1997g) is advantageous as it helps to improve fertilizer use efficiency as well to as increase cost benefit ratio (Wijewardena and Yapa, 1999).

Though vegetables remove large quantities of plant nutrients (Wijesundera, 1990) from soils, use of organic and chemical fertilizers at high rates has resulted in the accumulation of soil P and K. This situation could be avoided by using substitution levels of these plant nutrients when organic

manure is used. P and K chemical fertilizer application could be reduced to 50% of the recommended levels for potato and vegetables when 10 t/ha poultry manure is used (Wijewardena, 1999c). This practice prevents the build – up of high soil P and K in potato and vegetable fields and also reduces the cost of production.

In addition, soil test based fertilizer recommendation porgramme introduced by the department of agriculture (DOA) has helped curtail nutrient build up in the vegetable growing soils in the upcountry and also showed a good economical benefit particularly to farmers in this region.

FOLIAR FERTILIZERS

Foliar fertilizer application is also a common practice in the upcountry. Farmers in the upcountry apply different kinds of foliar fertilizers during the growing period as high rates as 12 lit./year/ha at 6-7 days intervals to potato and vegetables. It appears to help obtain attractive vegetables to the market rather than yield increase. Since, foliar fertilizers have not been found to increase yield of potato and vegetables, the DOA has not included the use of foliar fertilizer in the fertilizer recommendations. The results of a long-term field experiment conducted recently showed that the application of foliar fertilizer is not necessary if poultry manure at the rate of 10 t/ha is applied in combination with NPK chemical fertilizers recommended by the DOA (Wijewardena, 1997d).

LIMING

Ultisols are generally acidic in nature. Therefore, application of liming materials such as burnt lime and dolomite is also a common practice among upcountry farmers. Although, DOA has recommended the application 2 t/ ha of such materials, farmers apply almost 650 kg/ha per year (Wijewardena, 2001b). Long – term experiments conducted in the upcountry revealed that poultry manure application could decrease the soil acidity (Wijewardena, 1993; Wijewardena, 1995b; Wijewardena, 1997e; Wijewardena and Yapa, 1999; Wijewardena, 2000 and Wijewardena, 2001c). Therefore, lime application could be avoided if poultry manure is used. This should be considered important

when poultry manure is used particularly in potato cultivation. When potato is grown with the application of poultry manure, liming materials should not be applied. This will minimize the scab incidence of potato tubers.

MICRONUTRIENTS

It is a well-known fact that vegetables are high micronutrient feeders. However, micronutrient deficiencies have not yet been reported in vegetable growing regions. This may be due to the application of large quantities of organic manures (Wijewardena, 2000). Under these conditions, application of micronutrients did not show any significant yield increase in potato (Wijewardena, 1997f).

SOIL TEST BASED FERTILIZER RECOMMENDATION

The DOA initiated the soil-test based fertilizer recommendation programme in 1993. This programme has contributed to some extent, to prevent the build-up of P and K in cultivated fields particularly in the upcountry. This programme helped farmers in the upcountry to save substantial amount of money spent on fertilizers (Maraikar *et al.*, 1996). This programme also helped to train farmers in the use of straight fertilizers instead of mixed fertilizers, which they have been using during the last few decades.

DRINKING WATER QUALITY

Due to the hilly nature of lands, high rainfall and high rates of fertilizer use in the upcountry; scientists expected the presence of a high concentration of plant nutrients in drinking water. However, in both upcountry wet and intermediate zones, sampled wells had water with NO_3-N content below 2.0 mg/l, which is an acceptable level of NO_3-N in drinking water according to WHO standards. Furthermore, appreciable amounts of plant nutrients such as potassium and magnesium were found in well water in the upcountry (Wijewardena *et al.*, 1996b; Wijewardena *et al*; 1997). Therefore, regular monitoring of drinking water should be carried out to prevent further contamination of drinking water by various plant nutrients.

FUTURE STRATEGIES

The land available for agriculture is continuously decreasing even in the upcountry of Sri Lanka due to development of industries, urbanization, housing projects, etc. Therefore, the future potato and vegetable production will have to come through intensive cropping on small extent of land, correct crop production strategies and the by improvement of soil fertility.

Combined use of organic manures and bio fertilizers helps to maintain long-term soil productivity even under intensive cropping systems. In addition, adoption of integrated plant nutrition system further increases yields of potato and vegetables when compared to chemical fertilizers alone. IPNS helps recycle the nutrients and correct deficiencies particularly those of micronutrients. IPNS also promotes efficient and balanced use of nutrients.

Hence, plant nutrition in future will require the judicious and integrated management of all sources of nutrients in agricultural areas. It is necessary to address the problems of plant nutrition in an integrated manner to maintain the overall balance and flow of soil nutrients, seeking maximum efficiency and reducing waste and losses. This is an economical approach as Sri Lanka imports more than 95% of its requirement of chemical fertilizers. Hence, the main emphasis has to be on increasing the use of chemical fertilizers in the right and balanced manner. Such methods will enable to bridge the gap between nutrient removed and nutrient addition in vegetable growing soils of the upcountry of Sri Lanka.

Therefore, upcountry vegetable growers should adopt the DOA fertilizer recommendations, IPNS technology, balanced fertilizer use and substitution levels of plant nutrients with organic manures for sustainable and environmentally friendly crop production. In addition, soil-test based fertilizer recommendation programme is helpful in this regard and it is also economically more beneficial to upcountry farmers than farmers in other areas in the country mainly due to the high rates of fertilizers used by upcountry farmers.

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