

RESPONSE OF POTATO AND VEGETABLE CROPS GROWN SEQUENTIALLY TO PHOSPHORUS APPLICATION IN AN ULTISOL

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ABSTRACT

A field experiment was conducted on an Ultisol during four consecutive cropping seasons at Bandarawela, Sri Lanka. Four levels of P at the rates of 0, 25, 50 and 100 kg/ha were applied for each crop in the form of triple superphosphate. Tomato, pole bean, cabbage and potato were sequentially cultivated. Tomato in Maha 94/95, cabbage in Maha 95/96 and potato in Yala 1996 showed responses upto 100 kg P/ha. After cultivation of low P removal crops such as pole bean, the soil showed increase of available P in 50 and 100 kg P/ha treatments. However, the soil P content did not show much increase at the end of the experiment with an application of 100 kg P/ha per season. It appears that high yields of potato and vegetables could be obtained with the application of 100 kg P/ha per seasons without much build-up of P in the soil. These results suggest that the application of 100 kg P/ha to vegetable crops is necessary to maintain a reasonable P level under vegetable cultivation in the Ultisol.

KEY WORDS: Cropping sequence, Phosphorus, Potato, Ultisol, Vegetables.

INTRODUCTION

Traditionally, Ultisol which is the main soil group (Panabokke, 1996) in the upcountry at elevation over 600m is being exploited for potato and vegetable production in Sri Lanka. The environment in the upcountry areas is highly suitable for a year-round cultivation of potato and high quality and high priced vegetables. However, the land extent under potato and vegetable cultivation is around 60,000 ha which is comparatively low when compared to the area under tea plantation. Therefore, potato and vegetables are cultivated in the region on an intensive and commercial scale.

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The Ultisol in the upcountry region is strongly leached and acidic with a pH range of 4.0 - 5.5 (Wijewardena, 1995; Wijewardena, *et al.*, 1996). It is well known fact that due to the acidic nature of the soil, available P for plants will be reduced (Sample *et al.*, 1980; White 1981; Syers and Lu, 1990). In addition, uncultivated or virgin soils in this region are low in CEC, organic matter content as well as in many plant nutrients. Among plant nutrients, phosphorus is considered the most limiting plant nutrient in Ultisol (Wijewardena, 1995). Therefore, high quality phosphate fertilizers such as triple superphosphate application showed a good yield increase of potato and vegetables in Ultisols (Wijewardena and Amarasiri, 1990; Wijewardena, 1998; Wijewardena and Yapa, 1998; Wijewardena, 1999a). However, the application of potassium fertilizers does not have a major effect on the crop yield, when compared to P fertilizers because of the high content of available K in Ultisols (Wijewardena and Amarasiri, 1993; Wijewardena, 1996a; Wijewardena and Amarasiri, 1997).

Inadequate phosphorus supply for the plants may affect the growth (Wiskich, 1975), energy transformation (Ozanne, 1980), activity of various enzymes (Avdeeva and Andreeva, 1974), seed formation including root development and crop maturity (Stevenson, 1986). Hence, application of P fertilizers is rather important in commercial agriculture to obtain high quality produce and high yields.

Unlike the general pattern of low fertilizer use in the lowcountry of Sri Lanka, most farmers in the upcountry use high quantities of chemical and organic fertilizers (Wijewardena, 1993; Wijewardena and Yapa, 1999). The level of fertilizer applied by the farmers to the potato and vegetable crops is almost two to three times the quantity recommended by the Department of Agriculture (Rezania *et al.*, 1989). Use of high quantities of phosphorus fertilizers at high rates in the upcountry region has contributed towards the accumulation of phosphorus in vegetable growing soils (Wijewardena, 1995; Wijewardena *et al.*, 1996; Wijewardena, 1999b). The addition of excessive phosphorus fertilizers and subsequent accumulation of phosphorus in cultivated fields may reduce soil productivity (Maraikar *et al.*, 1996).

However, it should be noted that vegetables are quite different from most perennials in that they have a short growing period of about 2 -3 months generating a very high quantity of biomass by taking up large quantities of P from soils. In addition, they are shallow rooted and have thus to absorb their phosphorus requirements from a small volume of soil. Such characteristics of vegetables suggest that vegetables

should substantially receive a relatively large supply of P within a short time from the soil or added fertilizer to achieve high yields. This indicates that to prevent an accumulation of P in vegetable growing soils as well as to obtain high yields from potato and vegetable crops, the rate of P fertilizer application on long-term basis will have a major role to play.

However, there is hardly any reported experimental evidence on the effect of P fertilizer application on long-term basis on the yield of potato and vegetables crops in Ultisols. A field experiment was therefore, conducted to investigate the response of potato and vegetable crops grown sequentially to phosphorus application in Ultisols prevailing in the hill country of Sri Lanka.

MATERIALS AND METHODS

A field experiment was conducted in an Ultisol at the Regional Agricultural Research and Development Centre, Bandarawela, where four levels of phosphorus (0, 25, 50 and 100 kg P/ha) were tested on a cropping sequence; tomato (var. T-245), pole bean (var. Katugastota), cabbage (var. Hercules) and potato (var. Desiree) of crops in a randomized complete block design with six replicates. The plot size was 3m x 2.5m. The plan of randomization was not changed during the entire period of the experiment. Nitrogen and potassium levels were added for all treatments as recommended by the Department of Agriculture for each crop. Plant spacing and amounts of N and K added to crops are given in the Table 1. Nitrogen was applied as urea and K as muriate of potash. The crops were grown under rainfed conditions with supplementary irrigation whenever necessary. The experimental plots were maintained in a weed free condition.

Six composite soil samples were collected from each replicate (0-15cm depth) before commencement of the experiment. The chemical properties of the experimental soil (mean of 6 replicates) are pH (1:2.5, soil: H₂O) 5.5, total N 0.11%, Olsen's P 9.3 ppm and exchangeable K 151 ppm. Composite soil samples were also collected from each plot after each crop and analysed for available P by Olsen's method.

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RESULTS AND DISCUSSION

The effect of addition of P on the yield of crops is given in Table 2. Application of P at 100 kg P/ha significantly increased the yield of tomato (Maha 94/95), cabbage (Maha 95/96) and potato (Yala 1996). However, application of P at 50 kg P/ha resulted in a significant yield increase for pole bean (Yala 1995) over the control.

Results of this experiment showed a marked response to the addition of P for potato and vegetables in the Ultisol. The yield response to addition of P fertilizer during all seasons may be attributed to the low level of soil P at the experimental site. The significant response of tomato, cabbage and potato to added P at 100 kg/ha (Table 2) may be associated with high removal of P by these crops (FAO, 1984; Kemmler and Hobt, 1986). Wijewardena and Amarasiri (1990) also reported a response to the addition of P at the rate of 100 kg P/ha for potato and vegetables in this region. A yield increment in tomato (Maha 94/95), cabbage (Maha 95/96) and potato (Yala 1996) had shown a significant positive response up to the maximum P level of 100 kg/ha used in this study. Hence, their response beyond 100 kg P/ha level needs to be studied. However, it is clear from the Fig.1 that continuous P application to this soil had resulted in a slight P accumulation in soil when P has been applied at 100 kg P/ha per season. Hence, the results suggest that the application of P at 100 kg/ha is sufficient to obtain high yields and it also avoids the high build-up of P in the soil. Build-up of soil nutrients such as P and K could be seen in vegetable growing lands in this region (Wijewardena, 1995; Wijewardena *et al.*, 1996; Wijewardena, 1999b). This may lead to a soil nutrient imbalance, which in turn could result in the decrease in productivity than an increase (Rezanian *et al.*, 1989; Maraikar *et al.*, 1996). Hence, results of the experiment reported here suggest that the application of 100 kg P/ha per crop is sufficient for potato and vegetable crops grown in the Ultisol.

However, in pole bean (Yala 1995) crop the difference in yield between 50 and 100 kg P/ha was not significant (Table 2). This may be due to the low yielding ability and low P removal by the pole bean crop (Kemmler and Hobt, 1986). Therefore, the available P content in soil after the pole bean crop (2nd season) increased with the application of 50 and 100 kg P/ha. In addition, the experiment further revealed that the soil P content of the control plots as well as those receiving 25 kg P/ha showed a decline throughout the experimental period (Fig. 1). These results clearly show how

the P content in soil can be influenced by the type of cultivated crops. It is very important to note that low and high P-removal crops should be rotated in the cropping sequence to achieve high yields while maintaining soil P level without either depletion or build-up. Generally, the response of a crop to applied nutrients will mainly depend on the soil nutrient status and the amount of nutrients required by a particular crop species (Tandon and Sekhon, 1988).

Taking into consideration the results of this experiment, it could be concluded that the application of 100 kg P/ha per crop is needed to achieve high yields of potato and vegetables and also to maintain the soil P at a reasonable level. This will be an economical approach for the upcountry farmers who generally apply almost 3-4 times more than the required amount of P fertilizer.

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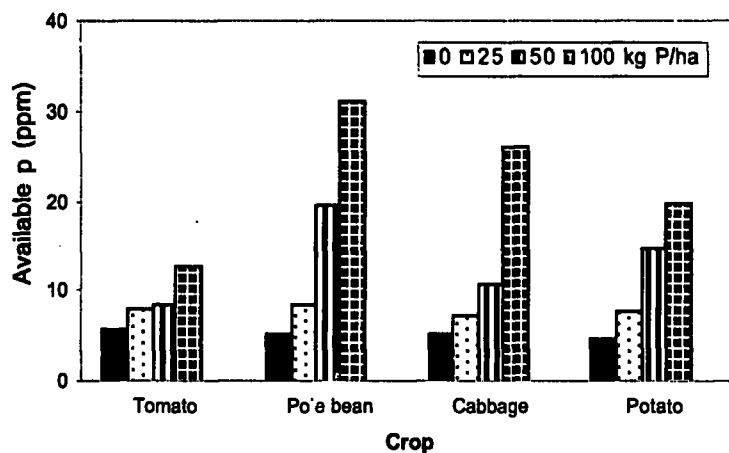


Fig. 1. Soil P after each crop

Table 1. Plant spacing and amount of nitrogen (N) and potassium (K) applied to crops.

Crop	Spacing (cm)	Nitrogen (kg N /ha)	Potassium (kg K /ha)
Tomato	50 x 50	90	65
Pole bean	50 x 50	100	75
Cabbage	50 x 50	150	75
Potato	60 x 25	150	125

Table 2. Effect of phosphorus on total crop yield (t/ha)

P level (kg/ha)	Tomato (Maha 94/95)	Pole bean (Yala 95)	Cabbage (Maha 95/96)	Potato (Yala 96)
0	10.4	3.1	1.2	4.3
25	21.3	4.5	13.6	5.1
50	27.4	6.3	31.7	6.6
100	37.2	6.6	50.8	9.0
LSD (P=0.05)	4.2	1.2	7.2	1.3
CV (%)	14.1	18.4	24.1	17.4