CONTRIBUTION OF PHOSPHORUS AND POTASSIUM FROM POULTRY MANURE APPLICATION TO POTATO AND VEGETABLES GROWN IN AN ULTISOL OF THE UP COUNTRY

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ABSTRACT

A long-term field experiment was conducted over a period of four seasons to study the contribution of P and K from poultry manure application to potato and vegetable crops at Bandarawela. Four levels of P (0, 25%, 50% and 100% of the recommended rates for cabbage, tomato, pole bean and potato in each season) and four levels of K (0, 25%, 50%, and 100% of the recommended rates for cabbage, tomato, pole bean and potato in each season) were factorially combined. Poultry manure was added at the rate of 10 t/ha to each plot. First two crops, cabbage in yala 1995 and tomato in maha 95/96 showed a significant response to 25% of the recommended level of P. Thereafter, there was a response up to 50% of the recommended levels of P for pole bean in yala 1996 and potato in maha 96/97. The first crop cabbage in yala 1995, did not show any significant yield response to addition of K fertilizer. However, there was a response up to 50% of the recommended level of K for tomato in maha 95/96, pole bean in yala 1996 and potato in maha 96/97. Increase of soil P and K was seen when either poultry manure or poultry manure + chemical fertilizers was added to the same soil. The study revealed that fertilizer P and K could be reduced by 50% of the recommended levels for potato and vegetables when 10 t/ha poultry manure was applied. This avoids the high build-up of soil P and K in potato and vegetable fields. Following such recommendations by farmers in the up country could reduce the cost of production, as they generally apply more than the recommended levels of P and K in combination with poultry manure.

KEY WORDS: Phosphorus, Potassium, Potato, Poultry manure, Vegetables

INTRODUCTION

The ultisols are the predominant soils of the up country (areas above 900 m) of Sri Lanka (Panabokke, 1996). A unique feature observed in the up country of Sri Lanka related to potato and vegetable cultivation is the use of animal manures such as cattle manure and poultry manure. Potato and vegetable farmers frequently apply animal manure concurrently with high rates of chemical fertilizers. The results of seasonal (Wijewardena, 1995) and long-term (Wijewardena, 1993; Wijewardena and Yapa, 1999) experiments clearly showed that combined application of organic and chemical fertilizers gave the highest yields when compared to individual application of organic or chemical fertilizers.

Chemical fertilizers are not the only source of nutrients. The value of organic manures as nutrient sources in agriculture is well known. Use of poultry manure as a source of organic manure at the rate of 10 t/ha is a common practice among the up country farmers (Wijewardena, 1993; Wijewardena, 1995; Wijewardena, 1997). The vegetables that are grown on the slopes of the mountains vary considerably in their nutrient absorption. In general, up country vegetables are heavily fertilized than the other crops grown in the rest of the country (Maraikar *et al.*, 1996). However, it is well known that vegetables are heavy nutrient feeders (FAO, 1984; Kemmler and Hobt, 1986; Wijesundara, 1990). Hence, fertilization is an essential component in any vegetable crop production system. However, vegetable growing lands in the up country often show

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accumulation of P and K rather than the depletion (Rezania *et al.*, 1989). As a result, the productivity of the soils in this region tends to be on the decline (Maraikar *et al.*, 1996).

Poultry manure contains large amounts of plant nutrients when compared to the other organic manures (Natarajan and Varghese, 1980; Japenga and Harmsen, 1990). In addition, poultry manure is considered to have intermediate fertilizing properties between chemical fertilizers and farmyard manure, and therefore is beneficial for obtaining high crop yields (Giardini *et al.*, 1992). Hence, there is a possibility to utilize this valuable source of plant nutrients for potato and vegetable production in this region. Indeed, these suggest that a large fraction of P and K requirements of a crop can be or are met from added poultry manure. This will be an economical advantage to the farmers who generally apply large quantities of both organic and chemical fertilizers to vegetable crops in the up country. Hence, the contribution of P and K from poultry manure application should be considered in any soil fertility management practices under vegetable cultivation in the up country.

However, there are no experimental data to quantify the contribution of P and K from poultry manure application to potato and vegetable crop production in the region. This paper reports the findings of investigations carried out to quantify the substitution levels of P and K using poultry manure for potato and vegetable crops on a long-term basis in an ultisol of the up country region.

MATERIALS AND METHODS

A long-term field experiment was conducted at the Regional Agricultural Research and Development Centre, Bandarawela. The experiment began in *yala* (south-west monsoon season) 1995 and concluded in *maha* (north-east monsoon season) 1996/97. The chemical analysis of soil from the experimental site at the commencement of the experiment is given in Table 1. Four levels of P (0, 25%, 50% and 100% of the recommended level for each crop) and four levels of K (0, 25%, 50% and 100% of the recommended level for each crop) were factorially combined and tested in a randomized complete block design with two replicates in each season. A constant level of 10 t/ha poultry manure (deep litter) per crop was applied to all treatment combinations. The chemical characteristics of the poultry manure were pH 8.0, N 2.9%, P 1.4%, K 2.2% and Ca 2.9%.

Recommended level of nitrogen for each crop was also applied to all treatment combinations. The recommended levels of N, P and K for each crop are given in Table 2. The plan of randomization was kept unchanged for all crops in the cropping sequence cabbage/ tomato /pole bean /potato so that the same plot received the same treatment combination during the entire period of the experiment. The plot size was 3 m x 2.5 m for all crops. Spacings and times of application of fertilizers for each crop are shown in Table 3. Nitrogen was applied as urea, P as triple superphosphate (TSP) and K as muriate of potash (MOP). The crops were grown under rainfed condition

with supplementary irrigation whenever necessary. The fields were maintained in a weed-free condition throughout the experiment. Soil samples were collected from each plot after each crop and analyzed for NH_4OAc extractable K and available P according to Olsen's method.

Table 1. Some chemical characteristics of the experimental soil

Characteristic	*Value*
pH (1:2.5 H2O)	4.70
Total N (%)	0.12
Organic matter (%)	2.20
Olsen's P (ppm)	11.50
Exchangeable K (meq/100g)	0.40

Table 2. Recommended rates of N, P and K for the crops tested

Crop	*N (kg N/ha)*	*P (kg P_2O_5/ha)*	*K (kg K_2O/ha)*
Cabbage	150	125	90
Tomato	90	100	80
Pole bean	100	125	90
Potato	150	125	100

Table 3. Plant spacing and time of fertilizer application for different crops

Crop	*Spacing (cm)*	*Fertilizer*	*Basal*	*3 WAP*	*4 WAP*	*6 WAP*
Cabbage	50X50	N	1/3	1/3	-	1/3
		P	All	-	-	-
		K	1/2	-	-	1/2
Tomato	50X50	N	1/3	1/3	-	1/3
		P	All	-	-	-
		K	1/2	-	-	1/2
Pole bean	50X50	N	1/2	-	1/2	-
		P	All	-	-	-
		K	1/2	-	1/2	-
Potato	60X25	N	1/2	-	1/2	-
		P	All	-	-	-
		K	1/2	-	1/2	-

WAP- weeks after planting

RESULTS AND DISCUSSION

Yield response to addition of P

The effect of addition of phosphorus on the yield of crops in the four season experiment is given in Table 4. Application of phosphorus at 25% of the recommended level for cabbage (*yala* 95) and tomato (*maha* 95/96) significantly increased the yield of both crops when 10 t/ha poultry manure was added. In the third cropping season pole bean (*yala* 96) and fourth cropping season potato (*maha* 96/97) gave significant yield responses to the addition of 50% of the recommended levels of phosphorus in the presence of 10 t/ha poultry manure.

Table 4. Effect of phosphorus on total yield of crops

P level (% of the recommended)	*Crop yield (t/ha)*			
	Cabbage (yala 1995)	*Tomato (maha 95/96)*	*Pole bean (yala 1996)*	*Potato (maha 96/97)*
0	26.0	43.3	15.6	6.5
25	41.6	56.4	17.0	6.4
50	33.3	51.5	20.9	10.3
100	39.4	52.7	17.3	8.8
LSD (P=0.05)	8.5	6.4	2.1	0.5
CV (%)	22.7	11.7	11.3	6.0

NS - Not significant

Yield response to addition of K

The effect of addition of K on the yield of each of the crops grown sequentially is given in Table 5. The first crop cabbage in *yala* 95 did not give a significant yield increase to application of K when poultry manure was added. However, application of potassium at 50% of the recommended levels for tomato (*maha* 95/96) , pole bean (*yala* 96) and potato (*maha* 96/97) resulted in a significant yield increase over the control.

Interaction effects between P and K for crop yields were not significant throughout the experiment.

The results clearly showed that P and K chemical fertilizer additions are still necessary when 10 t/ha poultry manure was added to potato and vegetables. It is a well known fact that the combined use of poultry manure and NPK chemical fertilizers is beneficial to increase vegetable crop yields in the ultisols (Wijewardena, 1993; Wijewardena and Yapa, 1999). Generally, vegetables are high P and K feeders owing to their high biomass production. Hence, response to added P and K even in presence of poultry manure was expected in this study. Therefore, poultry manure in combination

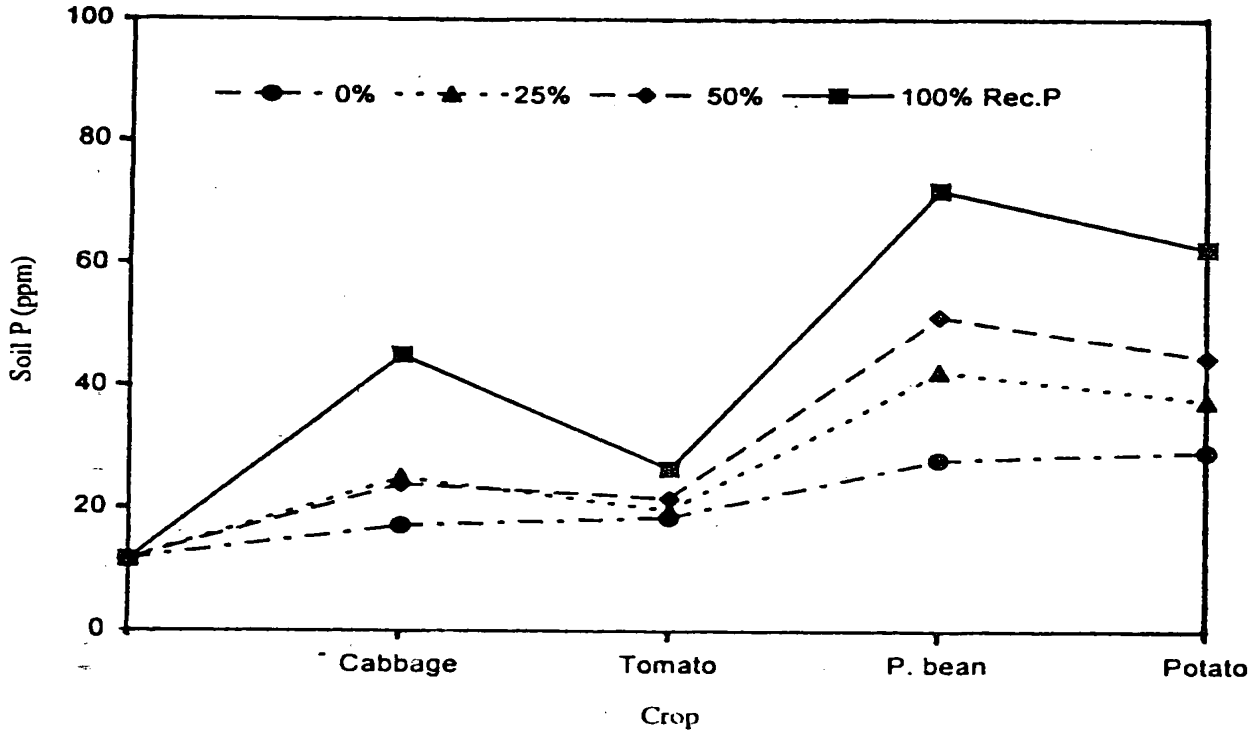

Fig.1. Available P content in soil after each cropping

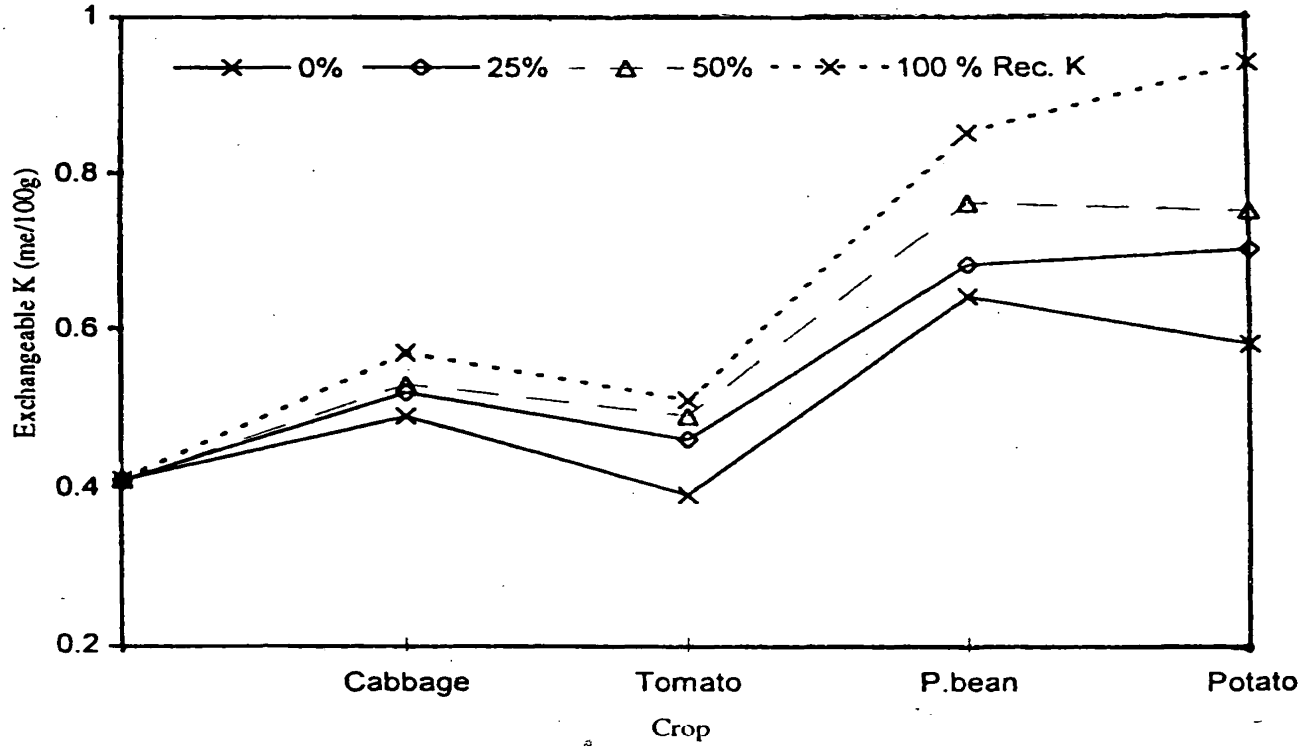

Fig.2. Exchangeable K content in soil after each cropping

indicate that the high soil P and K accumulations in vegetable fields could be due to over -fertilization by farmers in the region. Form this study it appears that both P and K fertilizer application rates for potato and vegetables can be reduced by 50% of the recommended rates when 10 t/ha poultry manure is added. Thus, the use poultry manure can also result in economical benefits to the farmers because the money spent

Table 5. Effect of potassium on total yield of crops

K level (% of the recommended)	*Crop yield (t/ha)*			
	Cabbage (yala 1995)	*Tomato (maha 95/96)*	*Pole bean (yala 1996)*	*Potato (maha 96/97)*
0	34.7	46.8	15.6	6.5
25	33.4	48.5	16.3	7.8
50	36.3	54.1	21.5	8.9
100	35.9	54.6	17.5	8.8
LSD (P=0.05)	NS	6.4	2.1	0.5
CV(%)	22.7	11.7	11.3	6.0

NS - Not significant

with chemical fertilizers had been recommended to potato and vegetable crops (Wijewardena, 1993; Wijewardena, 1995; Wijewardena, 1997; Wijewardena and Yapa, 1999). Though, poultry manure contains high amount of P and K (Giardini *et al.*, 1992; Wijewardena, 1993), it is a well known fact that chemical fertilizer is more efficient than organic manure in nutrient releasing ability. Therefore, high availability of P from added TSP and K from added MOP could be expected. This could satisfy the high demand of plant nutrients by vegetable crops. Hence, combined use of organic and chemical fertilizers is a suitable method of nutrient management practice for high nutrient removal crops such as potato and vegetables. In addition, organics are low in plant nutrients compared to chemical fertilizers. Previous studies revealed that organic manures including poultry manure couldn't meet the entire P and K needs of potato and vegetables (Wijewardena, 1993; Wijewardena and Yapa, 1999). In general, organic manures have to undergo decomposition before the nutrients found in them are released. Hence, P in poultry manure is not readily available. This indicates that for sustainable crop production, a combined use of organic and chemical fertilizer is an important factor to be considered.

The results of this study further revealed that an appreciable amount of P and K application as fertilizers could be reduced for potato and vegetables when 10 t/ha poultry manure was added. The present investigation also suggests that a large fraction of P and K requirements of crops could be met from added poultry manure even under intensive cultivation systems. This will be an economical advantage to the farmers in the region who generally apply more than 2-3 times the recommended rates of P and K to their crops in combination with organic manures. Such higher rates of P and K applications have resulted in an accumulation of high amounts of P and K in the soils of the region (Rezania *et. al.*, 1989). The P and K contributions from added crop residues, animal wastes and composted materials to the available pool of these nutrients have been previously reported by Olsen and Barber (1977). Notable P (Fig.1) and K (Fig.2) accumulations, by the application of poultry manure, and poultry manure + different levels of P and K can be clearly seen in this experiment. Similar results have been previously reported by several workers (Yoo and Jung, 1992; Wijewardena, 1993; Wijewardena and Yapa, 1999). Results of the soil analytical data (Fig.1 and 2)

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on fertilizers will be substantially reduced. This practice will further help farmers to reduce P and K build-up in the soil.

The failure of the first cabbage (*yala* 95) crop to respond to added K may be due to the high initial K content found in the experimental soil (Table 1). In general, ultisols, which is the main soil order in this region, contain high exchangeable K even under uncultivated conditions (Wijewardena and Amarasiri, 1993; Wijewardena and Amarasiri, 1997). Similarly, the lack of response to potassium, even during the first three seasons without poultry manure application has been reported earlier in a 10-season experiment conducted in a similar soil by Wijewardena and Amarasiri (1997).

CONCLUSIONS

The study indicates that potato and vegetables grown in the up country region with an application of 10 t/ha poultry manure need only 50 % of the recommended rates of P and K as chemical fertilizers to meet their P and K requirements. Adopting such a recommendation could reduce the build-up of soil P and K and increase the profit margin of the farmers of the up country region.

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Based on the findings of this survey, an experiment was carried out at the Agricultural Research Unit at Gabadawatta in 1995 to investigate whether there is any relationship between the use of poultry manure and non- availability of boron. Results of this experiment showed that, application of fresh poultry manure (both broilers' and layers') and, broiler litter stored for 1,2,3, and 4 months increased soil pH and induced bumpy fruit formation. Thus it appears that there is a correlation between the pH increase due to poultry manure use and bumpyness in papaya. Wijewardene (1993) also reported that application of poultry manure increases the pH of upcountry soils up to 6.5. Chapman *et al.*(1978) stated that availability of boron is influenced by the pH status of a soil. In alkaline conditions boron is fixed by Ca, and is not readily available to plants. Lucas and Davis(1961) showed that the ideal soil pH for boron availability is 5-6 and 5-7 in organic and mineral soils, respectively. It is also reported that occurrence of bumpy fruit disorder is overcome by application of borax (Munoz *et al.*, 1966; Wang and Ko, 1975; Chapman *et al.*, 1978; Atkinson 1991). In view these findings experiments were conducted with the objective of determining the effect of application of different types of organic materials on soil pH, and the effect of application of borax on bumpy fruit formation.

MATERIALS AND METHODS

Effect of application of organic materials on soil pH and occurrence of bumpyness

The experiment was located at the Regional Agricultural Research and Development Centre, Bombuwela. The experiment had the following 7 treatments: Broiler litter, Layer litter, Cowdung, Goat dung, Rice straw, Calcium oxide (CaO) and the recommended papaya fertilizer mixture (NPK - 11:10:25) as the control. The Department of Agriculture (DOA) recommended papaya fertilizer mixture (N:P:K- 11:10:25) was applied to all treatments. All manures were applied at the rate of 4 kg /plant at 3 month intervals and CaO was added at a rate of 1.75 kg/plant at 6 month intervals. Two papaya plants were taken as a treatment with a spacing of 4mx4m (625 plants/ha) and each treatment was separated by a 75x25cm drain in order to prevent nutrient movement between treatments. Seeds were collected from a hermaphrodite plant and seedlings were raised . Papaya plants were established according to DOA recommended cultural practices. All manure and rice straw were obtained from the same source throughout the experimental period and were used immediately after collection.

Broiler litter, layer litter and rice straw used for the experiment were analysed for N,P,K,Ca,Mg and organic carbon (Table 1). Visual evaluation on incidence of bumpyness in fruits was recorded. Monitoring of soil pH at 14 day intervals commenced at three months after application of different treatments. Boron content of leaf petioles, fruits and soils of deficient and healthy plants was determined.

Effect of application of borax on bumpy fruit formation

This experiment was conducted with the objective of eliminating the occurrence of bumpyness. Papaya cultivations of 1–4 year and 5-7 year old having 53–88% of