

RESPONSE OF VEGETABLE CROPS IN A CROPPING SEQUENCE TO K AND Mg FERTILIZERS IN THE UPCOUNTRY INTERMEDIATE ZONE

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ABSTRACT

A field experiment was conducted over a period of two and a half years to study the effect of continuous application of four levels of potassium (0,50,100,150 kg K₂O/ha) and four levels of magnesium (0,15,30,60 kg Mg/ha) on the performance of several vegetable crops grown in a sequence. Cabbage, tomato, bush bean, tomato and cabbage were cultivated in this sequence commencing in 1986 in a Red Yellow Podzolic soil (Ultisol) of the upcountry intermediate zone. Cabbage and tomato responded well to 100 kg K₂O/ha during the first two seasons. On the other hand, in the third, fourth and fifth seasons bush bean, tomato and cabbage responded to an application of 50 kg K₂O/ha. Yield increase to the application of magnesium became significant only in the fourth (30 kg Mg/ha; tomato) and fifth (60 kg Mg/ha; cabbage) seasons. Soil analysis indicated that with continuous cropping a steady depletion of K and Mg occurred in the control plots. It was also revealed that an application of at least 100 kg K₂O/ha and 30 kg Mg/ha per crop is needed to maintain the levels of K and Mg in this soil.

KEY WORDS: Cropping sequence, Magnesium, Potassium, Upcountry, Vegetables

INTRODUCTION

The upcountry intermediate zone of Sri Lanka lies between 600 and 1400 m above mean sea level. The topography comprises steeply dissected hills with rolling terrain. The mean air temperature ranges from 15 to 27°C while average annual rainfall varies from 1100 to 1400 mm. The soils are mainly ultisols with a pH range of 4.0-5.5 (Panabokke, 1967).

The farmers in this region grow a range of crops throughout the year. Tomato (*Lycopersicon esculentum* Mill.), cabbage (*Brassica oleracea* var. Capitata) and bean (*Phaseolus vulgaris* L.) are the main vegetable crops that occupy a major part of the cropping sequence. The levels of fertilizer applied by many of the farmers

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to these crops are almost two to three times the quantity recommended by the Department of Agriculture. This normally results in high accumulation of soil potassium and phosphorus (J.D.H. Wijewardena, Unpubl.).

Potassium is one of the essential elements in the nutrition of plants, and one that is commonly in short supply in the soil limiting crop yield. Hence it often needs to be added regularly to crops as a fertilizer. However, crops differ greatly in their responsiveness to potassium. Bean and tomato have been reported to be very responsive (Russell, 1973).

Introduction of high yielding varieties and intensive cropping have resulted in the depletion of soil K reserves (Roy *et al.*, 1978). This can be corrected by the use of organic and chemical fertilizers. However, potassium fertilizer should be applied in accordance with the needs of the different crops (Zhu, 1981), since crops differ in their nutrient uptake ability, nutrient uptake rate and market value.

Soil properties have an influence on the quantity and rate of nutrient supply to plant roots. Soil pH has a definite influence on potassium availability (Kemmler, 1980; Koria *et al.*, 1989). Low soil pH enhances weathering and release of K from primary as well as secondary soil minerals, and in the course of time results in loss of a large part of the original soil K by leaching (Von Uexkull, 1986).

Potassium deficient plants cannot use water and nutrients efficiently and they are less tolerant to environmental stress or pest and disease attack (Potash and Phosphate Institute, 1988). The role of K in photosynthesis and respiration and its involvement as an activator in the function of many enzymes were also reported by Lauchli and Pfluger (1980) and Steineck and Haeder (1980).

Magnesium is required by crops in considerably smaller amounts than other major nutrients such as nitrogen and potassium. Sensitivity to magnesium deficiency varies greatly between crops (Brayan Davis *et al.*, 1972).

Yadav and Swami (1988) reported that uptake of Mg decreased with increasing amounts of applied potassium. On the other hand, Mercik *et al.* (1981) reported that K application only slightly decreased the Mg content of plants. Therefore maintenance of the right soil potassium status by the correct use of fertilizers and manures seems important.

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There is hardly any experimental evidence on the effect of continuous application of K and Mg to vegetable crops in the upcountry intermediate zone of Sri Lanka. This experiment was conducted to evaluate the effect of addition of these elements in a cropping sequence in this region.

MATERIALS AND METHODS

A long-term field experiment was conducted at the Regional Agricultural Research Centre, Bandarawela, where four levels of potassium (0, 50, 100 and 150 kg K₂O/ha) and four levels of magnesium (0, 15, 30 and 60 kg Mg/ha) were factorially combined and tested in a randomized complete block design with three replicates. A constant level of 200 kg N/ha and 150 kg P₂O₅/ha per crop was applied to all treatment combinations. The plan of randomization was kept unchanged for all crops in the cropping sequence - cabbage (yala 86), tomato (maha 86/87), bush bean (yala 87), tomato (maha 87/88), cabbage (yala 88) - so that the same plot received the same treatment combination during the entire period of the experiment. The plot size was 3m x 2m for all crops.

Nitrogen was applied as sulphate of ammonia for the basal dressing and as urea for the top dressings. Phosphorus was supplied as triple superphosphate, potassium as muriate of potash and magnesium as kieserite. Phosphorus and Mg were added basally while N and K were added according to recommended times of application for each crop (Table 1). Plant spacing was 40cm x 50cm for cabbage 50cm x 50cm for tomato and 40cm x 20cm for bush bean.

Table 1. Nitrogen and potassium application schedule

<i>Crop</i>	<i>Nutrient</i>	<i>Proportion applied</i>		
		<i>Basal</i>	<i>3WAP*</i>	<i>6WAP</i>
Cabbage	N	1/3	1/3	1/3
	K	1/2	-	1/2
Tomato	N	1/3	1/3	1/3
	K	1/2	-	1/2
Bush bean	N	1/2	1/2	-
	K	1/2	1/2	-

* WAP = Weeks after planting

The crops were grown under rainfed conditions with supplementary irrigation whenever necessary. The plots were maintained weed-free throughout the experiment. The chemical analysis of soil from the experimental field at the commencement of the trial is given in Table 2. Soil samples were also collected from each plot after each crop and analysed for K and Mg.

Table 2. Some chemical characteristics of the experimental soil

<i>Property</i>	<i>Content</i>
pH (1:1) H ₂ O	4.5
Total N (%)	0.12
Olsen's P (ppm)	38
Exchangeable K (me/100 g)*	0.28
Exchangeable Mg (me/100 g)*	1.02

* NH₄OAc extraction

RESULTS AND DISCUSSION

Yield response to K addition

The effect of addition of potassium on the yield of crops is given in Table 3. Application of potassium at 100 kg K₂O/ha significantly increased the yield of cabbage (yala 86) and tomato (maha 86/87). In the third (yala 87), fourth (maha 87/88) and fifth (yala 88) seasons bush bean, tomato and cabbage responded significantly to the application of 50 kg K₂O/ha.

Percent yield increases over control to additions of K were very much higher for tomato (fourth season) and cabbage (fifth season) compared to the values obtained for crops grown in the first three seasons (Table 3). This appears to be due to the yield decline in the control plots, resulting from soil K depletion rather than owing to adverse climatic conditions or greater pest attack during the later seasons.

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,

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apart from other growth determining factors such as water availability, and soil and climatic characteristics (Tandon and Sekhon, 1988). Kemmler and Hobt (1986) found that cabbage and tomato crops remove very large quantities of K from the soil due to their higher biomass production during a season.

Table 3. Effect of potassium on yield of crops grown in a sequence

<i>K level</i> (kg K ₂ O/ha)	<i>Crop yield (t/ha)</i>				
	<i>Cabbage</i> (yala 86)	<i>Tomato</i> (maha 86/87)	<i>Bush bean</i> (yala 87)	<i>Tomato</i> (maha 87/88)	<i>Cabbage</i> (yala 88)
0	36.0	62.6	5.6	29.1	19.7
50	41.3 (15)	68.8 (10)	7.3 (31)	46.0 (58)	47.3 (139)
100	50.5 (40)	80.6 (29)	7.9 (41)	46.8 (61)	56.7 (188)
150	48.9 (36)	73.3 (17)	7.9 (41)	47.8 (64)	63.1 (220)
Crop variety	Gloria F ₁	T-244	Top crop	KWR	AS-cross
LSD (P=0.05)	8.1	10.9	1.1	10.5	8.7
CV (%)	22.1	18.4	19.2	29.6	22.4
Linear response	##	#	##	##	##
Quadratic response	ns	ns	##	#	##

Figure within parenthesis refers to percent increase in yield over control; # Significant (P=0.05); ## Significant (P=0.01); ns=not significant

The exchangeable soil K content in the control plot (No K treatment) showed a decline after each crop (Fig.1). This could be attributed to high K removal by these vegetable crops and depletion of K from the soil due to continuous cropping

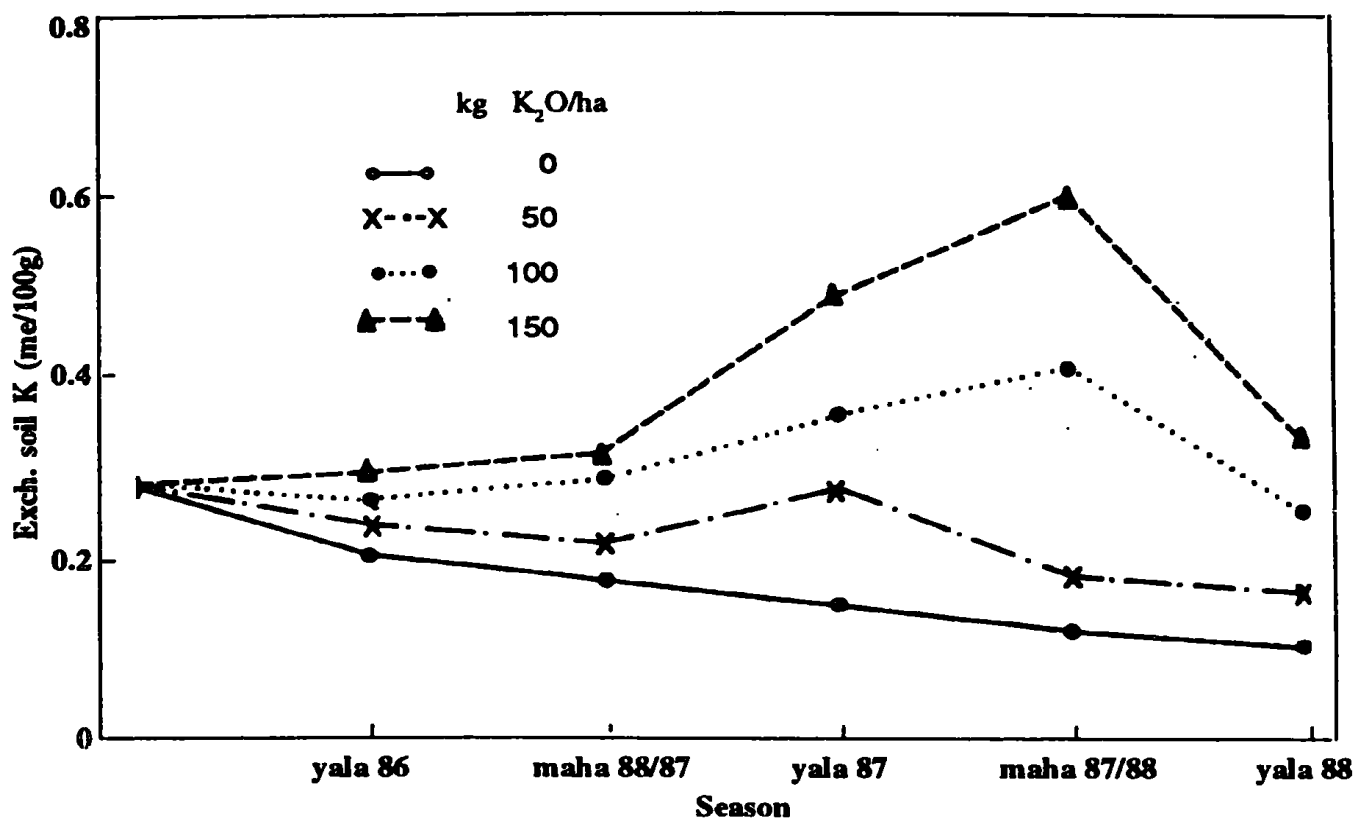


Fig. 1. Exchangeable soil K after each season

on the same land. The data in Fig.1 also revealed that an application of at least 100 kg K₂O/ha per crop is needed to maintain the soil K level in this soil. These results agree with the findings of an another long-term experiment conducted in this region (J.D.H.Wijewardena, 1986, Unpubl.). The results of the present study seem to indicate that addition of K fertilizers is essential to increase yields of tomato, cabbage and bean in this soil.

Yield response to Mg addition

The effect of addition of magnesium on the yield of crops is given in Table 4. First three crops cabbage (yala 86), tomato (maha 86/87) and bush bean (yala 87) did not show any significant yield increases to addition of Mg up to 60 kg/ha. However, tomato during the fourth season (maha 87/88) and cabbage during the fifth season (yala 88) responded well to 30 kg Mg/ha and 60 kg Mg/ha, respectively.

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Table 4. Effect of magnesium on yield of crops grown in a sequence

<i>Mg level (kg/ha)</i>	<i>Crop yield (t/ha)</i>				
	<i>Cabbage (yala 86)</i>	<i>Tomato (maha 86/87)</i>	<i>Bush bean (yala 87)</i>	<i>Tomato (maha 87/88)</i>	<i>Cabbage (yala 88)</i>
0	41.9	67.8	6.4	33.5	39.8
15	44.0 (04)	73.1 (08)	7.5 (17)	39.7 (18)	42.0 (05)
30	47.6 (14)	69.6 (03)	7.0 (09)	51.1 (52)	47.0 (18)
60	43.3 (03)	74.8 (10)	7.9 (23)	45.3 (35)	58.0 (45)
Crop variety	Gloria F ₁	T-244	Top crop	KWR	AS-cross
LSD (P=0.05)	ns	ns	ns	10.5	8.7
CV(%)	22.1	18.4	19.2	29.6	22.4
Linear response	-	-	-	##	##
Quadratic response	-	-	-	ns	ns

Figure within parenthesis refers to percent increase in yield over control; ## Significant (P=0.01); ns = not significant

If the experiment was conducted for only three seasons, the erroneous conclusion would have been reached that magnesium additions were unnecessary for vegetable cultivation in this soil. Therefore, the importance of carrying out long-term experiments in determining fertilizer requirements for crops is clearly evident from this study. The use of results from short duration experiments has sometimes led to incorrect fertilizer advice.

The absence of Mg fertilizer in the current fertilizer recommendation for vegetables may be due to the lack of results of long-term fertilizer experiments conducted in the past. Since most field trials were carried out for one season only, they did not lead to a significant depletion of Mg content of the control plots to show a yield response to addition of Mg. The results of the experiment reported here suggest the need to include magnesium in the fertilizer recommendations for vegetables in the upcountry region.

The exchangeable Mg content of soil indicates that there is a continuous decline of soil Mg in the control plot at the end of each cropping season (Fig. 2).

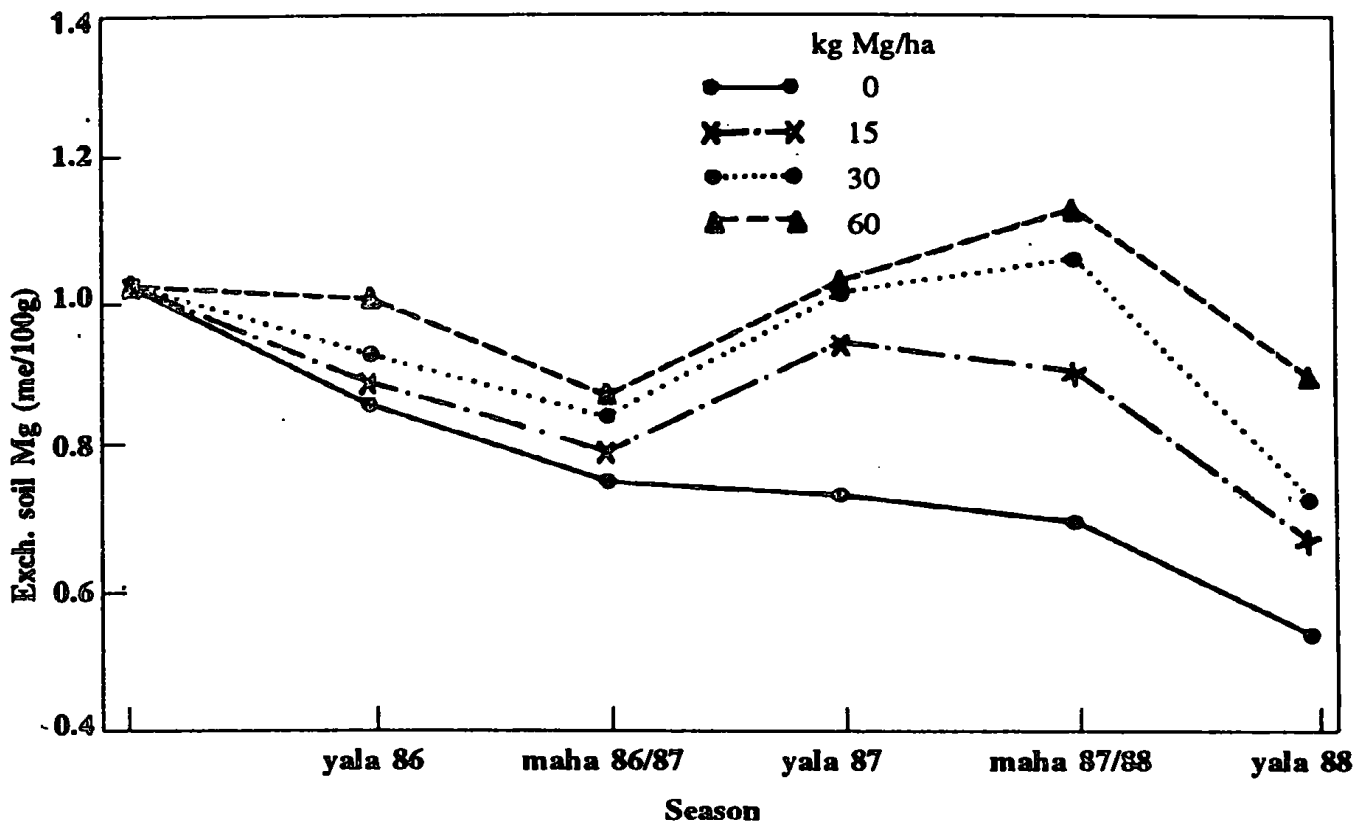


Fig. 2. Exchangeable soil Mg after each season

This could be attributed to Mg removal by these vegetable crops leading to depletion of Mg from the soil when continuously cropped on the same land. The addition of Mg, on the other hand has increased the soil Mg. Furthermore, Fig.2 reveals that an application of at least 30 kg Mg/ha per crop will be needed to maintain the soil level of Mg in this soil.

CONCLUSIONS

Application of potassium and magnesium fertilizers increase yields in vegetable crops. The yield increases to the application of Mg became statistically significant during the fourth and fifth seasons. With continuous cropping, the K and Mg content of soil was depleted steadily in the control plots.

The absence of Mg fertilizers in the current fertilizer recommendation for vegetables may be due to lack of results of long-term fertilizer experiments conducted in the past. The results of the experiments reported here suggest the need to include Mg in the fertilizer recommendations for vegetables in the upcountry region.

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Results also revealed that application of at least 100 kg K₂O/ha and 30 kg Mg/ha per crop is needed to maintain the level of K and Mg in this soil.

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REFERENCES

- Brayan Davies, D., D.J. Eagle and J.B.Finney. 1972. Soil management. Farming Press Ltd. 268p.
- Kemmler, G. 1980. Potassium deficiency in the tropics as a constraint to food production. *In* Soil related constraints to food production in the tropics. pp 253-276, Int. Rice Res.Inst., P.O.Box 933, Manila, Philippines.
- Kemmler, G. and H.Hobt. 1986. Potash a product of nature. K + S fertilizers from the Federal Republic of Germany. Landwirtschaftliche Forschungsanstalt, Buntehof. 112p.
- Koria, R.G., M.S.Patel and B.S. Yadav. 1989. Vertical distribution of forms of potassium in some soil profiles of dry farming areas of Saurashtra region in Gujrat. *Journal of Potassium Research* 5(2): 47-52.
- Lauchli, A. and R.Pfluger. 1980. Potassium transport through plant cell membranes and metabolic role of potassium in plants. *IPI Research Topics* No.6: 5-57.
- Mercik, S., B.Gutynska and H. Gozlinshi. 1981. The effect of potassium salt of varying granule size and coating on the yield of plants and their uptake of nutrients. *Roczniki Nauk Rolniczych* 104(4) : 67-78.

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- Panabokke, C.R. 1967. *The Soils of Ceylon and Use of Fertilizers*. Metro Printers Ltd., Colombo, Sri Lanka. 151p.
- Potash and Phosphate Institute. 1988. *Potash its need and use in modern agriculture*. Potash and Phosphate Institute, Saskatoon, Canada. 44p.
- Roy, R.N., S.Seetharaman and R.N.Singh. 1978. Soil and fertilizer potassium in crop nutrition- A review. *Fertilizer News* 23(6): 3-26.
- Russel, E.W. 1973. *Soil Conditions and Plant Growth*. 10th edition. Longman, New York, USA. 849p.
- Steineck, O. and H.E.Haeder. 1980. The effect of potassium on growth and yield components of plants. *IPI Research Topics No.6* : 59-81.
- Tandon, H.L.S. and G.S.Sekhon. 1988. Twenty years of research on soil and fertilizer potassium in India - Some highlights. *Fertilizer News* 33(10) : 21-31.
- Von Uexkull H.R. 1986. *Efficient fertilizer use in acid upland soils of the humid tropics*. *FAO Fertilizer and Plant Nutrition Bulletin No.10*, FAO, Rome. 159p.
- Yadav, B.S. and B.N.Swami. 1988. Effect of potassium fertilization on dry matter yield and composition, and uptake of nutrient by maize and change in soil potassium on cropping. *Ind. J.Soil Soc.* 36(4): 739-742.
- Zhu, W.H. 1981. Preliminary report on the study of rational distribution of K-fertilizer in a triple cropping rotation in one year. *Brit. J.Soil Sci.* 6:13-15.