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EFFECT OF SOURCES AND LEVELS OF LIMING MATERIALS ON SOIL ACIDITY IN ULTISOLS OF THE UPCOUNTRY

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ABSTRACT

A long - term field experiment was conducted over a period of 3 seasons to study the effect of sources and levels of liming materials on soil acidity in Ultisols at Bandarawela. Two sources of liming materials viz. burnt lime and dolomite were used in this experiment. They were added at rates of 0, 0.5, 1 and 2 t/ha per crop. In addition, a treatment with 10t/ha poultry manure was also included in the experimental design. Potato, cabbage and pole bean were grown in a sequence. Irrespective of the crop, the highest yields were obtained by the addition of 10t/ha poultry manure. In addition, the application of poultry manure at the rate of 10 t/ha decreased the soil acidity. However, lime was more effective than poultry manure and dolomite in correcting the soil acidity. In addition, results revealed that the application of liming materials such as lime and dolomite at the rate of 2t/ha are needed to correct the soil acidity in Ultisols. These results indicate that application of poultry manure will be a viable option to increase vegetable yields as well as to correct soil acidity. This will result in a considerable monetary saving for the vegetable growers of the upcountry of Sri Lanka.

KEYWORDS: Dolomite, Lime, Poultry manure, Soil acidity, Ultisols.

INTRODUCTION

Of the total land area in Sri Lanka about 30 percent consists of acid soils. These occur in the wet and intermediate zones. The dominant acid soils in Sri Lanka are the Ultisols. The area above 1000m elevation is mainly under tea with an area approximately 60,000 ha of acid soils are under vegetable cultivation. The food crops cultivated in this area include rice, potato and exotic vegetables such as tomato, bean cabbage, beet, carrot, leak, radish, cauliflower etc. The Ultisols of the upcountry are low in exchangeable bases, strongly acidic in reaction (Wijewardena *et al.*, 1996; Wijewardena, 1999a) low in phosphorus (Wijewardena and Amarasiri, 1990; Wijewardena, 1994; Wijewardena and Yapa, 1998; Wijewardena, 1999b) and low organic matter but contain reasonable amounts of potassium (Wijewardena and Amarasiri, 1993; Wijewardena, 1996; Wijewardena and Amarasiri, 1997).

Upcountry could be considered as the major potato and vegetable-growing region of Sri Lanka. The climate in the region is suitable for year around cultivation of high quality high priced vegetables. Potato and vegetable production in this region is therefore important both nationally and at farmer's level. In addition, agriculture is the only economic activity of most of the small farmers in this region. Hence, any factor that would disturb the cropping system will adversely affect both the economy of the country and the farmers of this

region. In this regard, high soil acidity could be considered as an important factor, which adversely affect crop production in Ultisols. Hence, the correction of soil acidity will be an important consideration to improve the crop growth in Ultisols of the upcountry. Therefore, use of liming materials to reduce the soil acidity is an important soil management practice. At present, farmers in the upcountry areas use burnt lime or dolomite in different quantities to correct the soil acidity (Wijewardena, 1995a; Wijewardena, 1996; Maraikar *et al.*, 1996). However, farmers apply low quantities such as 650 kg/ha (Wijewardena, 1995a) of liming materials due to the high cost incurred with this practice. In addition, due to the high cost involved in liming practice farmers profit margin decrease very rapidly. It is therefore important to recommend suitable sources and rates of liming materials for potato and vegetable cultivation in Ultisols of the upcountry.

Farmers in the upcountry utilize chemical fertilizer mixtures containing N, P and K in combination with organic manures such as poultry manure and cattle manure. Poultry manure is a good source of plant nutrients compared with other organic manures (Wijewardena, 1993; Wijewardena and Yapa, 1999; Wijewardena, 2000). In addition, poultry manure also contains more Ca. Hence, the application of poultry manure increased the soil pH as well as plant nutrients in the soil. (Wijewardena, 1993; Wijewardena and Yapa, 1999; Wijewardena, 2000). An experiment was therefore conducted to find out the suitability of poultry manure as a source of liming material when compared to dolomite and lime.

MATERIALS AND METHODS

A long-term field experiment was conducted on Ultisols (Panabokke, 1996) at the Regional Agricultural Research and Development Centre, Bandarawela. The experiment began in December 1995 and was concluded in March 1997. Selected chemical properties of soil from the experimental site at the commencement of the trial are given in table 1.

Table 1. Selected chemical properties of the experimental soil.

Property	*Content*
pH (1:2.5; Soil: H_2O)	4.9
OM (%)	2.2
Total N (%)	0.14
Olsen's P (mg kg^{-1})	11.2
Exchangeable K (mg kg^{-1})	109
Exchangeable Ca (mg kg^{-1})	272
Exchangeable Mg (mgkg^{-1})	105

Two sources of liming materials viz. burnt lime (CaO) and dolomite ($CaCO_3.MgCO_3$) were used in this experiment. They were added at the rates of 0, 0.5, 1 and 2 t/ha per crop. In addition, a treatment with 10t/ha poultry manure (deep litter) was also included in the experiment. The experiment was laid out in a randomized complete block design with three replicates. Lime and dolomite were incorporated into the soil a week before planting the crop in each season. In addition, poultry manure was added 4 days prior to planting. Then plots were irrigated 2-3 days before planting. Nitrogen, phosphorus and potassium were added according to the rates and times recommended by the Department of Agriculture (table 2).

Table 2. Fertilizer application schedule.

Crop	*Nutrient*	*Level (kg/ha)*	*Portion applied*			
			Basal	*3 WAP*	*4 WAP*	*6WAP*
Potato	N	150	75	-	75	-
	P_2O_5	125	All	-	-	-
	K_2O	150	75	-	75	-
Cabbage	N	150	50	50	-	50
	P_2O_5	125	All	-	-	-
	K_2O	90	45	-	-	45
Pole bean	N	150	75	75	-	-
	P_2O_5	125	All	-	-	-
	K_2O	100	50	50	-	-

WAP = Weeks after planting

The plot size was 2.5mx3.0m. Potato (var. Desiree) cabbage (var. Hercules) and Pole bean (var. Katugastota) were grown in a sequence. The plan of randomization was kept unchanged so that the same plot got the same treatment combination during the entire period of the experiment. The crops were grown under rain-fed conditions with supplementary irrigation whenever necessary. The plots were maintained weed-free through out the experiment. The chemical characteristics of the poultry manure used in the experiment are given in table 3.

Table 3. Composition of poultry manure

Property	*Content*
pH (1:10)	8.4
Organic carbon (%)	29.5
Total N (%)	3.05
Total P (%)	1.45
Total K (%)	1.82
Total Ca (%)	3.40
Total Zn (mg kg^{-1})	254
Total Fe (mg kg^{-1})	940
Total Mn (mg kg^{-1})	370

RESULTS AND DISCUSSION

The effect of addition of liming materials such as lime, dolomite and poultry manure on crop yield is shown in table 4. In general, all crops gave similar yields with the addition of burnt lime and dolomite. However, the application of poultry manure at the rate of 10t/ha gave significantly higher yield of all three crops over the other two sources of liming materials.

Table 4. Effect of sources of liming materials on crop yield (t/ha)

Source	*Potato*	*Cabbage*	*Pole bean*
Lime	16.5	26.4	7.4
Dolomite	17.2	26.7	6.8
Poultry manure	24.3	47.1	11.3
LSD (P=0.05)	NS	NS	NS
Lime Vs Dolomite			
LSD (P=0.05)	3.7	8.1	1.4
Lime Vs. PM or			
Dolomite Vs. PM.			

The effect of different levels of liming materials on yield of vegetable crops is shown in table 5. In the first crop potato a yield increase was not observed with the application of liming materials up to 2t/ha. However, there was an increase trend in the yield of potato with the increasing level of liming materials.

Table 5. Effect of levels of lime and dolomite on crop yield (t/ha)

Levels of liming material (t/ha)	*Potato*	*Cabbage*	*Pole bean*
0	16.3	21.8	6.1
0.5	16.4	23.7	6.5
1	16.8	28.3	7.8
2	17.8	32.5	7.8
LSD (P=0.05)	NS	9.8	1.6
CV (%)	14.6	19.6	13.1

The second crop cabbage yields significantly increased by the application of liming materials at the rate of 2t/ha. However, the third crop pole bean showed a significant yield response to addition of liming materials up to 1t/ha.

The soil analysis after the first crop of potato showed that the soil pH of lime, dolomite and poultry manure treated plots were higher than that of the initial pH value (figure1.).

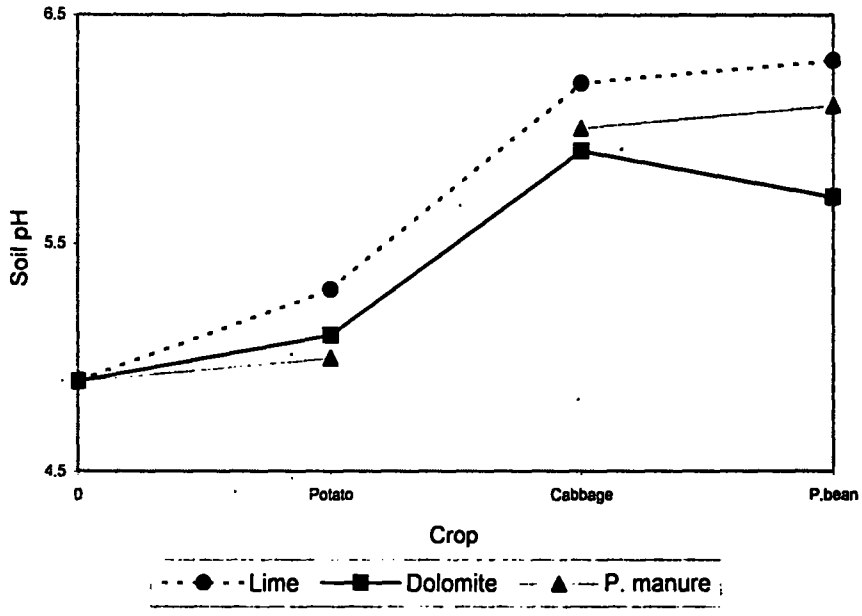

Figure 1. Soil pH after each crop.

In general, the highest pH value was recorded in the plots treated with burnt lime followed by poultry manure (with the exception of after first crop) and dolomite.

The results clearly showed that poultry manure has a beneficial effect on crop growth. This may be due to contribution of high quantities of plant nutrients (Wijewardena, 1993; Wijewardena, 1995b; Wijewardena and Yapa, 1999; Wijewardena, 1999b; Wijewardena, 2000). It is evident from table 3 that poultry manure contains appreciable quantities of major, secondary as well as micronutrients. In general, Ultisols are low in many plant nutrients. Hence, crops grown in Ultisols show response to N, P, K, Mg, S and micronutrients (Wijewardena and Amarasiri, 1990; Wijewardena and Amarasiri, 1993; Wijewardena 1994; Wijewardena, 1996; Wijewardena, 1997a; Wijewardena 1997b; Wijewardena and Amarasiri, 1997; Wijewardena and Yapa, 1997; Wijewardena, 1998a; Wijewardena, 1998b; Wijewardena and Yapa, 1998; Wijewardena, 2000). In this regard, contribution of various plant nutrients by poultry manure no doubt will have a major effect on crop growth as well as on crop yields. Hence, yield increase by the addition of poultry manure when compared to lime and dolomite could be expected in this study.

In addition, Ultisols are high in acidity (Wijewardena, *et al.*, 1996; Wijewardena, 1999a). Similarly, experimental soil was also high in acidity (table 1). Hence, increase of soil pH would have been an important factor for improving crop yield. In addition, an increase of soil pH by the addition of poultry manure may be due to high content of calcium compounds in poultry manure (table 1). Increase of soil pH by poultry manure application previously reported by Wijewardena (1993) and Wijewardena and Yapa (1999). The increase of soil pH by the addition of poultry manure could be considered ideal for most plant nutrients to become available for crop growth. Since, Ultisols are acidic, lime or dolomite often applied to potato and vegetable crops by the farmers in the upcountry (Wijewardena, 1995a; Wijewardena, 1996; Maraikar *et al.*, 1996). Results of this experiment revealed that if poultry manure is used then lime should not be applied for crops grown in the Ultisols. This will result in a considerable saving for the vegetable farmers of the upcountry. Hence, poultry manure application at the rate of 10 t/ha facilitate to increase the yield of crops as well as lowering the soil acidity in Ultisols.

The results indicated that lime is more effective than dolomite and poultry manure as a source of liming material. This may be due to reactive CaO present in burnt lime as a result of high temperature, which occurs during the lime production process. In addition, results further revealed that dolomite was inferior to both lime and poultry manure as a source of liming material. It is a well-known fact that dolomite contains low reactive $CaCO_3$. Hence, this could have been a reason for low reactivity of dolomite when compared to lime.

Similarly, Ca compounds present in poultry manure may be reactive than dolomite due to various reactions and digestion processes, which could be expected in the body of birds. Hence, poultry manure could be considered as a more effective source of liming material when compared to dolomite.

CONCLUSIONS

The results of this study indicate that application of poultry manure as a viable option in vegetable cultivation to increase the vegetable yield and also to decrease the soil acidity. Therefore, lime application could be avoided if poultry manure is used. Results further revealed that burnt lime was more effective than poultry manure and dolomite to correct the soil acidity. However, lime should be applied at the minimum rate of 2t/ha per crop to change the soil acidity in Ultisols. Hence, the use of poultry manure will be an economical approach to correct the soil acidity as well as to increase the yield of vegetable crops grown in Ultisols of the upcountry of Sri Lanka.

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