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Effects of Lime on Weed Species Diversity and Yield of Sweetpotato [*Ipomoea batatas* (L.) Lam.] in Swaziland

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ABSTRACT

An investigation was conducted in 2006/2007 cropping season to determine the effects of different lime levels on weed infestation and sweetpotato [*Ipomoea batatas* (L.) Lam.] yield. Results showed no significant differences in weed density among the lime levels, but weed species composition varied among treatments. With no lime, there were seven weed species spread over five families; at one tonne ha^{-1} of lime, there were 12 species spread over nine families; 2 t ha^{-1} and 2.5 t ha^{-1} gave rise to nine weed species each, whereas 1.5 t ha^{-1} resulted in eight weed species spread over seven families. Weed density was negatively correlated ($r = -0.307$; $n = 20$; low correlation) with tuber yields, which reduced tuber yields by 9.4%. Marketable tubers yields did not significantly differ among the treatments. Applying lime to a near neutral soil did not increase yields. Soil testing is recommended as the best guide to lime application.

Keywords: Dolomitic lime; Marketable yields; Small-scale farming; Soil acidity; Sweet potato; Weed species

INTRODUCTION

Sweetpotato [Ipomoea batatas (L.) Lam.] is a major storage root crop commonly grown in Swaziland (Ossom *et al*., 2004). Together with Irish potato (*Solanum tuberosum* L.), cocoyam (*Colocassia antiquorum* L. & *Xanthosoma saggitifolium* L.) and cassava (*Manihot utilissima* Pohl.), sweetpotato constitute the major energy sources from roots and tubers in Swaziland. Sweetpotato is often planted as a monocrop, but can also be intercropped with groundnut (*Arachis hypogaea* L.), sugar beans (*Phaseolus vulgaris* L.) or any other crop that the small-scale farmer considers to be important. Sweetpotato is a short-season crop, which reliably provides food on marginal and degraded soils, with little labour and few or no inputs from outside the farm (Ewell & Mutuura, 2004).

Soil acidity is a major problem in most agricultural soils of tropics (Brady & Weil, 2002). Though there are free soil-testing facilities provided at Malkerns Research Station, Malkerns commercial farmers are the major users of these facilities, while small-scale farmers do not routinely test their soils. In the absence of a specific recommendation based on soil tests, it was advised that Highveld and Middleveld farmers in Swaziland could apply 1 - 2 tonnes ha^{-1} of dolomitic lime every 3 - 4 years (Anonymous, 1991). Highveld and Middleveld are two of the four agro-ecological zones in Swaziland. Small-scale farmers in Swaziland simply grow their crops from year to year without soil testing. Such farmers abandon their farms when crop yields decline below the level that the farmer judges to be non-compensatory to the labour input on the farm, or when weed control becomes un-affordable. Weed infestation was identified as one of the major factors that force small-scale farmers to abandon their farms (Ruthernberg, 1980; Hobbs & Bellinder, 2004) Farmers leave the fields to fallow for many years, depending on the human population pressure in the locality and the availability or non-availability of alternate farms. Some farmers who have access to some money could buy agricultural lime and apply any amounts, depending on the market prices of the lime with the result that either too little, or too much lime could be applied.

Lime is important, because it can improve soil pH, making nutrient elements more available to plants. It would be beneficial to find out the effects that different amounts of lime could have on sweetpotato performance, if a farmer applied any amounts that were available. Therefore, the objective of this investigation was to determine the effects of different levels of dolomitic lime on weed infestation, growth and yield of sweetpotato.

MATERIALS AND METHODS

Site and experimental design. The field investigation was conducted at the Crop Production Department Experimental Farm in the Faculty of Agriculture, University of Swaziland, Luyengo (26.34°S, 31.10°E; 732.5 m above sea level; mean annual rainfall range, 850 - 1000 mm; mean annual temperature, 18°C) in the Middleveld agro-ecological zone of Swaziland. The soil type was an Oxisol (M-set) of the Malkerns series (Murdoch, 1968). The experimental design was a randomized complete block of five lime treatments, replicated four times. The treatments were: no lime (control); 1.0, 1.5, 2.0 and 2.5 tonnes lime ha^{-1}. Initial fertility status of the soil was as follows: pH in water, 6.9; pH in calcium chloride, 6.3; organic matter, 3.3%; cation exchange capacity, 0.7 cmole kg^{-1} exchangeable Al, 2.5 cmole kg^{-1}; and exchangeable H, 1.5 cmole kg^{-1}. The soil texture was a coarse loam.

Land preparation, planting and fertilization. The plots were prepared using a tractor-mounted mouldboard plough, followed by disc harrowing, after which 1.0-m ridges were prepared using disc ridgers. Before marking out the plots, a composite soil sample of the experiment site was taken (15-cm depth) using a soil probe. There were seven ridges per plot; each plot measured 5.0 m x 6.0 m. Each plot and each replicate was separated from others by a 100-cm space; a 100-cm perimeter space also surrounded as non-experimental area. Before planting, dolomitic lime (CaMgO) was broadcast and mixed on the ridges according to the respective lime treatments. Planting was done on 25 September 2006, using 30-cm, terminal vines ('Kenya' variety, obtained from Malkerns Research Station, Malkerns) spaced at 30-cm along the row and 100-cm between rows, giving 33,333 plants ha^{-1}. At planting, 350 kg ha^{-1} (Anonymous, 1991) of mixed fertilizer [N: P: K, 2: 3: 2 (22)] that also contained 0.5% Zn, was applied, 10-cm away from the planting rows. Single super-phosphate (10.5% P) at the rate of 50 kg ha^{-1} was also applied to all plots at planting. At six weeks after planting (WAP), a side dressing of a mixture of 10 parts urea (45% N), and muriate of potash, KCl (50% K) was applied at the rate of 120 kg ha^{-1} (Anon, 1991) to all plots. All fertilizer applications were made using the same method of banding and incorporation. For the first two WAP, overhead sprinklers were used to irrigate the plots to field capacity, till rains became regular. Thereafter, the crop was routinely managed, with general weeding done at four WAP.

Recording and analysis of data. Weed species distribution and weed density (four readings $plot^{-1}$) were determined at 12 and 20 WAP, using a 50-cm^2 quadrat. Weed infestation was estimated visually using a weed score scale of 1 to 6: 1, no weeds on soil within the quadrat; 2, sparse weed coverage; 3, intermediate weed coverage; 4, general weed coverage; 5, severe weed coverage; and 6, total weed coverage (Daisley *et al*., 1988; Orluchukwu & Ossom; 1988; Ossom *et al*., 2001). The major weed species encountered were enumerated. Disease infestation was also determined in the plots (four readings $plot^{-1}$) using the 50-cm square quadrat. The infestations were scored using a scale of 1 - 6: 1, complete absence of disease; 2, sparse disease coverage/presence; 3, intermediate disease coverage/presence; 4, general disease coverage/presence; 5, severe disease coverage/presence and 6, complete disease coverage/presence.

Tubers (storage roots) were harvested at 20 WAP, using garden forks. Using samples of five plants $plot^{-1}$, the number of leaves, number of marketable tubers, mass of above- and belowground and total tuber yield were determined. Marketable tubers were whole tubers weighing between 100 g and 1.4 kg and having no harvest wounds, pest or disease damage. Air temperatures and rainfall amounts were obtained from the meteorological station at Malkerns Research Station. Data were analyzed using the MSTAT-C statistical package, version 1.3 (Nissen, 1983). Mean comparisons were made using the least significant ($P < 0.05$) difference (Steel *et al*., 1996).

RESULTS AND DISCUSSION

Diversity of weed species and weed density. Under no lime applied, there were seven weed species spread over five families; at 1.0 kg ha^{-1} of lime, there were 12 species spread over nine families; 2.0 t ha^{-1} and 2.5 t ha^{-1} gave rise to 9 weed species each, whereas 1.5 t ha^{-1} resulted in eight weed species spread over seven families (Table I). Weed density was negatively correlated ($r = -0.307$; $n = 20$) with total tuber yields; the coefficient of determination (R^2, 0.0942) indicated that 9.4% of the reduction in tuber yield could be associated with weed density. The most ubiquitous weed species were *Bidens pilosa* L., *Cyperus esculentus* L., *Oxalis latifolia* H.B.K., *Cynodon dactylon* L. and *Richardia brasiliensis* (Moq.) Gomez. *Oxalis latifolia* (red garden sorrel) is an edible weed species, commonly found on acid soils in Swaziland and its presence is often indicative of the acid nature of a soil (M.M. Shongwe, University of Swaziland, personal communication). It is known as 'Simunyamunyane' in siSwati and 'Simunyuzane' in Zulu, both names alluding to the sour taste of this weed that is also regarded as a good survival plant in a Swaziland forest. Mngometulu and Ossom (2007) had earlier identified *C. rotundus* and *O. latifolia* as the two most prevalent weeds, among 22 weed species, in a crop garden in the Luyengo area. Hance and Holly (1990), Zimdahl (1999) and Acquaah (2005) observed that weeds are able to compete with crops for growth factors e.g., water, light and nutrients with the resultant reduction in crop yields, which is a reason for weed control in crop production. Duval (1997) reported that weed density was often directly related to soil nitrogen levels, an increased nitrogen level having the ability to increase weed density.

Storage root yields. Marketable tuber yields were not significantly different among the treatments (Table II). Increased lime application thus reduced tuber yield, an indication that liming was not desirable in this soil, because the initial acidity level (pH, 5.96) was within the acceptable pH range for sweetpotato. Motes and Criswell (2007) recommended the optimum soil pH for high sweetpotato yields to be 5.8 - 6.0, whereas Lerner (2001) suggested a pH of 5.6 to 6.5. It is likely that a factor, which could adversely affect marketable tuber yield is the care at harvest. Careless harvesting could result in

Table I. Effects of lime levels on relative abundance (%) and diversity of weed species in sweetpotato at 12 weeks after planting

Weed species			Lime levels and weed relative abundance[1]				
Weed family	**Scientific name**	**Common name**	**No lime**	**1.0 t ha^{-1}**	**1.5 t ha^{-1}**	**2.0 t ha^{-1}**	**2.5 t ha^{-1}**
Amaranthaceae	*Amaranthus hybridus* (L.)	Common pigweed	0.0	1.7	0.0	0.8	0.0
Asteraceae	*Acanthospermum hispidum* DC.	Upright starbur	0.0	0.4	0.0	0.0	0.0
Asteraceae	*Bidens pilosa* (L.)	Common blackjack	14.3	8.5	3.8	18.4	8.7
Commelinaceae	*Commelina benghalensis* (L.)	Wandering Jew	0.0	11.7	0.0	0.0	7.3
Convulvulaceae	*Convolvulus arvensis* (L.)	Field Bindweed	0.0	2.1	0.4	0.0	0.0
Cyperaceae	*Cyperus rotundus* (L.)	Purple nut grass	34.0	25.7	21.3	4.1	36.8
Euphorbiaceae	*Euphorbia heterophylla* (L.)	Milk weed	0.0	0.8	0.0	0.0	0.0
Oxalidaceae	*Oxalis latifolia* H. B. K.	Red garden sorrel	17.6	38.0	35.8	38.1	25.8
Oxalidaceae	*Oxalis pes-caprae* (L.) var. pes-caprae.	Yellow sorrel	13.8	0.0	14.6	1.6	1.8
Poaceae	*Brachiaria eruciformis* (Sibth. & Smith) Griseb.	Sweet signal-grass	2.3	0.8	0.0	10.7	0.9
Poaceae	*Cynodon dactylon* (L.) Pers.	Bermuda grass	5.8	3.3	1.3	5.3	10.0
Poaceae	*Digitaria senquinalis* (L.)	Crab finger grass	0.0	6.7	1.3	0.8	0.9
Rubiaceae	*Richardia brasiliensis* (Moq.) Gomez.	Mexican Richardia	12.1	0.2	21.7	20.1	7.8
Weed score	NA	NA	1.7	1.9	1.6	1.7	1.6
LSD[2] $_{(0.05)}$	NA	NA			0.60		

[1]Because of rounding up of figures, totals of relative abundance may not equal 100.0 %.
[2]Least significant difference (P < 0.05) = 0.60;
Weed score mean = 1.7; NA, not applicable

Table II. Effects of lime levels on tuber yield and other parameters in sweetpotato at harvest

Parameter	**Lime levels (tonnes ha^{-1})**					**Mean**	**[1]LSD$_{(0.05)}$**
	0	**1.0**	**1.5**	**2.0**	**2.5**		
Marketable tuber yield (t ha^{-1})	24.6	20.1	22.5	19.5	20.8	21.5	5.41
Total tuber yield ((t ha^{-1}))	29.3	23.6	27.3	23.7	25.1	28.8	6.41
Shoot:root ratio	18.4	20.8	25.0	22.9	17.6	20.9	4.61
Disease score	1.02	1.03	1.02	1.04	1.01	1.02	0.05
Weed density	1.7	1.9	1.5	1.7	1.6	1.7	0.60
Number of leaves per plant	255.1	182.9	292.9	240.6	252.2	244.7	73.38
Length (cm) of vines per plant	109.6	93.9	109.7	94.6	96.1	100.8	14.23
Dry matter (g) of aboveground parts	78.4	61.7	85.1	78.9	86.9	78.2	12.68
Dry matter (g) of underground parts	10.2	6.6	8.7	8.6	11.0	9.0	1.26
Number of storage roots per plant	2.5	1.8	2.4	2.4	2.1	2.2	0.91

[1]Least significant difference

wounds on the tubers and such could reduce the amount of marketable tubers. Sweetpotato consumers in Swaziland do not usually buy tubers that are too small (< 100 g) or too large (> 1.4 kg), for such tubers are considered too small or too large for convenient handling and cooking of whole tubers in Swazi cuisine.

Shoot:root ratio and vine length per plant. Shoot:root ratio increased as the amount of applied lime increased and was weak and negatively correlated ($r = -0.123$; $n = 20$) with total tuber yields. This showed that a 1.5% reduction in tuber yield could be attributed to increased shoot:root ratio. A low and negative correlation ($r = -0.183$; $n = 20$) was found between shoot:root ratio and weed density, indicating that increased shoot:root ratio decreased weed density. There was no consistent trend in the vine length per plant; however, a low and negative correlation ($r = -0.417$; $n = 20$) was observed between vine length per plant and weed density, implying that 17.4% in reduced weed density could be ascribed to the influence of vine length per plant.

Number of leaves per plant. Similarly, the number of leaves per plant did not show a discernable trend; however, correlation studies showed that the number of leaves per plant was low, but positively correlated ($r = 0.196$; $n = 20$) with total tuber yields. The resulting coefficient of determination ($R^2 = 0.0384$) showed that the number of leaves per plant probably contributed 3.8% to increased total tuber yields. However, the number of leaves per plant was negatively correlated ($r = -0.205$; $n = 20$) with weed density, an indication that 4.2% of weed suppression could be ascribed to increased number of leaves per plant. It was reported (Colomb *et al*., 2000) that leaf senescence could be induced by different factors including stress and lack of soil nutrients. Gutiérrez-Boem *et al*. (2004) suggested that increasing soil nitrogen availability during the seed-filling period was not an effective way to delay leaf senescence or to increase seed growth and yield of soya bean.

Dry matter per plant. As shown in Table II, the dry matter of underground sweetpotato parts (absorptive & storage roots) showed significant differences ($P < 0.05$) among treatments with the 1.0 t ha^{-1} of lime resulting in the lowest amount of dry matter per plant (6.6 g) and 2.5 t ha^{-1} of lime giving the highest dry matter per plant (11.0 g).

The dry matter per plant of underground parts of sweetpotato was low and positively correlated (0.170; n = 20) with total tuber yields, indicating that 2.9% of increased tuber yields could be associated with dry matter per plant. On the contrary, the dry matter of aboveground sweetpotato parts was low and negatively correlated (r = - 0.115; n = 20), with total tuber yields and thus could be associated with 1.3% (R^2 = 0.0132) contribution towards reduced total tuber yields.

Number of tubers per plant. The number of tubers per plant was not significantly different among lime levels; it was highest (2.5) when no lime applied and lowest (1.8) when an insufficient quantity of 1.0 t ha^{-1} of lime was applied. The number of tubers per plant was low, but positively correlated (r = 0.171; n = 20) with total tuber yields; the R^2 implied that 2.9% in increased total tuber yields could be ascribed to the number of tubers per plant. Ossom *et al.* (2005) observed no significant difference in the number of sweetpotato tubers in an investigation that involved pure and intercropped sweetpotato. Lowe and Wilson (1975) found a significant negative regression and correlation coefficients of tuber number and mean tuber weight, indicative of the compensatory relationship between these two yield components. They observed that an increase of one tuber per plant could reduce mean tuber weight by almost 50 g and concluded that there was a general tendency for marketable sweetpotato yields to decrease with increasing tuber number.

CONCLUSION

Applying increased levels of dolomitic lime could result in diverse weed species composition and adversely affect sweetpotato growth and yield. However, total tuber yields were reduced with increasing lime levels; applying 1.0 t ha^{-1} of lime appeared to have done more harm. It is apparent that the initial pH of the soil was adequate to give a fairly good yield of sweetpotato and applying lime to this soil was not beneficial. In view of variable effects of lime on growth and yield of this crop, it is recommended that soil tests should always be done before lime is applied.

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