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# Maize-sweetpotato intercropping influences on agronomic characteristics and soil chemical properties in Swaziland

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## ABSTRACT

Intercropping is a common cropping system in the humid tropics, and involves growing two or more crops simultaneously on the same farm. The aims of the study were to assess the effects of intercropping maize (*Zea mays* L.) and sweetpotato [*Ipomoea batatas* (L.) Lam.] on agronomic characteristics and soil chemical properties in Swaziland. Five plant population treatments [$T_1$, maize alone at 40,000 plants/ha; $T_2$, sweetpotato alone at 33,333 plants/ha; $T_3$, maize at 40,000 plants/ha, intercropped with sweetpotato at 33,333 plants/ha; $T_4$, maize at 40,000 plants/ha, intercropped with sweetpotato at 16,666 plants/ha; and $T_5$, sweetpotato alone at 16,666 plants/ha were arranged in a randomized complete block design that was replicated four times. Data were analyzed using the MSTAT-C statistical package. Results showed no significant differences in leaf area, and number of leaves/plant in both maize and sweetpotato. Sole maize yielded significantly ($p < 0.05$) higher (mean cob yield, 4,287.5 kg/ha) than intercropped maize (mean, 1,780.2 kg/ha). Sweetpotato tuber diameter was significantly greater (14.3 cm) under monocropping at 16,667 plants/ha at 16 weeks after planting (WAP), than intercropped sweetpotato (mean, 5.9 cm). Soil pH was significantly improved from 5.3 to 6.3 under maize-sweetpotato, when 50% of the recommended sweetpotato population was used. It is recommended that sweetpotato farmers sow sweetpotato as a monocrop, but should they wish to intercrop with maize, they should plant maize at 40,000 plants/ha and mix-crop it with sweetpotato at 33,333 plants/ha.

**Key words:** Agronomic characteristics, intercropping, potential income, soil chemical properties, and sweetpotato

## INTRODUCTION

Growing two or more crops simultaneously on the same farm is called intercropping (Sullivan, 2000); it is the most common cropping system among small-scale farmers in the humid tropics. Frequent drought has become a common feature of Swaziland agriculture for many years now and had led to reduced crop yields. The high cost of inorganic fertilizers and the limited irrigation facilities in Swaziland make sweetpotato [*Ipomoea batatas* (L.) Lam.] a crop of choice for Swazi farmers. Nsibande (1999) reported that Swazi farmers had grown sweetpotato for many years, usually, for human food; such sweetpotato was predominantly planted as a monocrop. With increased emphasis to produce more food from a limited piece of farmland, current research efforts involve intercropping. Extension activities are now focused on encouraging the introduction of new sweetpotato varieties into Swaziland.

Between 1990 and 1992, Swaziland had about 10% undernourished population, but between 1997 and 1999, this figure rose to

12% (FAO, 2002b). It might have been over 15% by 2007. Swaziland needs to address this bleak scenario. In agreement with two of the seven 2002 World Food Summit commitments (FAO, 2002a), the country should implement policies aimed at "eradicating poverty and inequality and improving physical and economic access by all, at all times, to sufficient, nutritionally adequate and safe food and its effective utilization."

Tropical root and tuber crops [sweetpotato, cassava (*Manihot esculenta* Crantz), yam (*Dioscorea* species) and taro – *Colocassia* species and *Xanthosoma* species] are both important domestic food security and national income-generating crops in many developing countries. Concerted efforts are being made at national and international levels to improve storability, marketing, the nutritional value and processing of these crops. Sweetpotato is not only a source of energy; it supplies important nutrients and is a natural source of dietary fibre. The average sweetpotato tuber is low in cholesterol and sodium, virtually fat-free, and loaded with fibre; many athletes regard sweetpotato as one of the top high-energy foods. Sweetpotato is also an excellent source of carotene, which the body converts into vitamin A. Buoyed by current reports and ongoing research concerning beta-carotene, fibre and vitamins A, C and E, sweetpotato may become the anti-cancer food of the future (Thompson, 2002).

Maize (*Zea mays* L.) is the staple food in Swaziland. However, it is not drought tolerant, but is prone to crop failure, if rains are not timely and regular during the cropping season. Most of Swaziland's shortfall in maize results from drought. One way of mitigating the drought effects is to grow a relatively drought-tolerant crop such as sweetpotato. It would be useful to know the influence of intercropping maize and sweetpotato so that farmers can make informed decisions on which crop combinations to make on their farms. Therefore the objectives of the investigation were to determine the effects of intercropping maize and sweetpotato on agronomic characteristics and soil chemical properties in Luyengo, Swaziland.

## MATERIALS AND METHODS

### Sites of experiment

The investigation lasted approximately nine months, from November 2008 to July 2009. The experiment was conducted in two locations. One location was on the property of a farmer, and located about 2.0 km from Malkerns Research Station. The second site was Malkerns Research Station (26.57°S, 31.17°E; altitude, 740 m above sea level; rainfall range, 800-1460 mm; mean temperature range, 7.3°C-26.6°C during the growing season). Both locations are in the Middleveld agro-ecological zone of Swaziland.

### Treatments, experimental design and plot size

The investigation was a field experiment consisting of 5 crop population combinations, arranged in a randomized complete block design. The treatments were: maize alone at 25 cm x 100 cm (1 grain/stand – 40,000 plants/ha); sweetpotato alone at 30 cm x 100 cm (1 cutting/stand – 33,333 plants/ha); maize at 40,000 plants/ha + sweetpotato at 33,333 plants/ha; maize (40,000 plants/ha) + 50% sweetpotato population spaced at 60 cm x 100 cm – 16,667 plants/ha; and sweetpotato alone at 16,667 plants/ha. Each treatment was replicated four times. Plots measured 8.0 m long and x 6.0 m wide. There were 9 (gross) ridges per plot, each measuring 8.0 m in length; the net plots consisted of 4 ridges each. There was a 100 cm distance between treatments and between blocks. There were 5 discard ridges, 2 at each end of the plot. Inter-row spacing was 100 cm.

**Soil analysis and liming**

Soil chemical analysis was carried out at the start and end of the experiment, to determine the chemical properties of the soil. The pH of the farmer's field was 4.7 and below 5.3 (the lower pH limit requiring lime application when sweetpotato is grown in Swaziland); agricultural lime was applied at the rate of 1,000 kg/ha. The lime was broadcast on the ridges, and worked into the ridges using garden forks and spades. At Malkerns Research Station plots, no liming was done because the soil pH was 5.3.

**Planting and gap filling**

Following ploughing, disking and ridging and liming, the crops were planted on the same day. In the farmer's field or farm, planting was done in the second week of November 2008; at the Research Station, planting was done in the first week of January 2009. Terminal vines of sweetpotato (variety, 'Kenya') that were 30 cm in length were planted on top of the ridges. Maize (variety, SC 603), one grain per station, was planted, also on top of ridges, giving a plant population of 40,000 plants/ha. Gaps were filled within one week of planting.

**Fertilizer application and weeding**

Fertilizer application was made as recommended. At planting, maize alone or maize interplanted through sweetpotato received 200 kg/ha of N: P: K [2:3:2 (38)]; 350 kg/ha of N: P: K [2:3:2 (38)], that also contained 0.5% Zn, was applied to plots that had sweetpotato; 100 kg/ha of superphosphate (10.3% P), was applied to plots with sweetpotato; 100 kg/ha of KCl (60% K) was also applied only to plots of monocropped sweetpotato. At 4 weeks after planting (WAP), 100 kg/ha of limestone ammonium nitrate, LAN (28% N) was applied to plots of monocropped maize. At 6 WAP, 100 kg/ha of LAN was applied as a side dressing to any plots that had sweetpotato. Fertilizers were applied by the banding and incorporation method, 15 cm away from the planting rows. Weeding was done at 5 WAP, using hand hoes. Other routine management practices for maize and sweetpotato were done.

**Data collection and analysis**

Destructive plant sampling (4 plants/plot) was used to collect data at 4-20 WAP; final harvest was at 20 WAP. No plant samples were taken from the farmer's site but yield data were recorded. No data were taken from the farmer's plots because previous experience showed that farmers sometimes feel exploited because plants, which would have formed part of their harvest at the end of the season, get removed from the plots and taken away for procedures that the farmers do not benefit from. Farmers also get the misconception that removing plants from their farms contribute to lower yields from the farms. Linear measurements were made using a tape measure; tuber diameter was measured by the use of a pair of calipers.The leaf area of maize was measured using the relationship, Leaf length x Leaf width x 0.75. The leaf area of sweetpotato was measured using the cork-borer method, recommended by Lutaladio (1986) and adopted by Edje and Osiru (1988). A total of 30 leaf discs/plot/plant was used, and thereafter, applying the formula based on the following relationship:

$$\frac{\text{Leaf area of all discs}}{\text{Dry mass of all discs}} = \frac{\text{Leaf area of all leaves including discs}}{\text{Dry mass of all leaves including discs.}}$$

Data were analyzed using MSTAT-C statistical package, version 1.3 (Nissen, 1983). Data from the two sites were analyzed independently, and not pooled. Mean separation was done by the least significant difference (LSD) test (Steel *et al.*, 1997).

Table 1: Influence of sweetpotato-maize association on maize leaf area per plant ($cm^2$) in Swaziland

| Cropping system | Weeks after planting | | | | |
|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 20 |
| Sole maize 40,000 plants/ha | 410.7 | 404.5 | 175.6 | 333.9 | 256.6 |
| Maize at 40,000 plants/ha + sweetpotato at 33,333 plants/ha | 320.4 | 400.7 | 211.5 | 285.6 | 222.3 |
| Maize at 40,000 plants/ha + sweetpotato at 16,667 plants/ha | 358.6 | 415.4 | 183.6 | 315.8 | 249.2 |
| Means | 363.2 | 406.8 | 190.2 | 311.7 | 242.7 |
| LSD | 127.83 | 118.21 | 107.13 | 73.25 | 43.09 |
| Significance | NS | NS | NS | NS | NS |

NS Not significant; Means separated using the Least Significant Difference (LSD) at P = 0.05.

Table 2: Influence of sweetpotato-maize association on the number of open leaves in maize in Swaziland

| Cropping system | Weeks after planting | | | | |
|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 20 |
| ole maize 40,000 plants/ha | 5.9 | 8.9 | 7.4 | 7.4 | 5.7 |
| Maize at 40,000 plants/ha + sweetpotato at 33,333 plants/ha | 6.0 | 8.5 | 7.3 | 6.3 | 5.4 |
| Maize at 40,000 plants/ha + sweetpotato at 16,667 plants/ha | 5.9 | 8.1 | 6.8 | 7.2 | 5.9 |
| Means | 5.9 | 8.5 | 7.2 | 7.0 | 5.7 |
| LSD | 1.05 | 1.82 | 1.54 | 1.18 | 2.00 |
| Significance | NS | NS | NS | NS | NS |

NS Not significant; Means separated using the Least Significant Difference (LSD) at P = 0.05.

# RESULTS AND DISCUSSION

## Agronomic characteristics of maize

### Leaf area

There were no significant differences (p>0.05) among the leaf areas of maize at all sampling dates. Table 1 shows the leaf area of maize at 4-20 WAP. Sole maize had the highest mean leaf area (316.3 $cm^2$). Of the two maize intercrops, maize interplanted through 50% sweetpotato population developed the higher mean leaf area (304.5 $cm^2$); maize combined with the recommended sweetpotato population (33,333 plants/ha) had the lowest mean leaf area (288.1 $cm^2$).

### Number of open leaves

There were no significant differences among the treatments at any time during the investigation. Table 2 shows that sole maize had a higher mean number (7.0) of open leaves, whereas maize sown with a higher population of sweetpotato had the lowest number (6.7). Maize associated with 50% sweetpotato population had a higher number (6.8) of open leaves.

### Maize yield and yield components

Table 3 shows the yield and yield components of maize from the Research Station at 20 WAP. Though sole maize was superior in yield and yield components than intercropped maize, the differences were not significant. Correlation data showed that cob yield was positively, but not significantly correlated to the 100-grain mass (r = 0.508; $R^2$ = 0.2581; N, 12); the resultant correlation of determination showed that 25.8% in the variation in cob yield could be ascribed to 100-grain mass. Table 4 shows the maize yield data and potential maize income from the farmer's plots. Sole maize yielded significantly ($p < 0.05$) higher (4,287.5 kg/ha) than maize in the other two maize cropping systems. Maize interplanted through the recommended sweetpotato population yielded 1,818.4 kg/ha, which was not significantly higher than the yield of maize (1,741.9 kg/ha) associated with 50% of the recommended sweetpotato population. The 100-grain yield was not significantly different among the three cropping systems.

Table 3: Maize yield components and yield under sweetpotato-maize intercropping in Swaziland

| Cropping system | Mass of shelled grains (g) | Fresh cob mass (kg) from 2 lines/plot | Fresh 100-seed mass (g) | Dry 100-seed mass (g) | Fresh mass of rachis (g) | Shelled grain yield (kg/ha) |
|---|---|---|---|---|---|---|
| Sole maize 40,000 plants/ha | 1,991.8a | 2.5a | 25.3a | 22.0a | 426.2a | 1,659.8a |
| Maize at 40,000 plants/ha + sweetpotato at 33,333 plants/ha | 1,074.3a | 1.6a | 23.8a | 20.9a | 427.5a | 895.2b |
| Maize at 40,000 plants/ha + sweetpotato at 16,667 plants/ha | 1,560.6a | 2.0a | 22.2a | 19.4a | 382.1a | 1,300.4ab |
| Means | 1,542.2 | 2.1 | 23.8 | 20.8 | 411.9 | 1285.1 |
| LSD | 865.27 | 1.07 | 6.85 | 5.32 | 389.07 | 643.0 |
| Significance | NS | NS | NS | NS | NS | * |

NS Not significant;
*, significant at P = 0.05
Means separated using the Least Significant Difference (LSD) at P = 0.05.

Table 4: Maize yields and potential income from the farmer's plots in Swaziland

| Cropping system | Cob yield (kg/ha) | 100-grain dry mass (g) | Potential income from sale of cobs/ha (E)† |
|---|---|---|---|
| Maize at 40,000 plants/ha | 4,287.5b | 31.7a | 4,930.6b |
| Maize at 40,000 plants/ha + sweetpotato at 33,333 plants/ha | 1,818.4ac | 29.9a | 2,091.2ac |
| Maize at 40,000 plants/ha + sweetpotato at 16,667 plants/ha | 1,741.9a | 28.9a | 2,003.2a |
| Means | 2615.92 | 30.15 | 3,008.3 |
| Least significant difference (0.05) | 860.81 | 6.05 | 989.96 |
| Significance at P < 0.05 | * | NS | * |

NS Not significant;
*, significant at P = 0.05
Means separated using the Least Significant Difference (LSD) at P = 0.05.
†, selling price of maize from the project was E1.15 per 1.0 kg of maize-on-the-cob.

## Agronomic characteristics of sweetpotato

### Leaf area per plant

Table 5 shows the leaf area per plant in sweetpotato at 4-20 WAP. Sole sweetpotato at 50% of the recommended plant population had the highest mean leaf area per plant (295.9 $cm^2$), whereas sweetpotato at 50% population and intercropped with maize had the lowest. All cropping systems developed maximum leaf areas/plant at 8 WAP, from when decreases in leaf areas occurred. There were no significant differences among the cropping systems except at 16 and 20 WAP. Kuhlase (2009) reported greater leaf areas in pure sweetpotato than in intercrops; conversely, Enyi (1973) observed soya bean (*Glycine max* L.) to develop increased leaf area as plant population increased.

### Number of leaves per plant

There were no significant differences among the treatments except at 20 WAP. Table 6 shows that all cropping systems reached maximum development of the number of leaves/plant at 8 WAP, after which time the leaf numbers declined, probably because of physiological ageing or senescence. Sole sweetpotato at the recommended population (33,333 plants/ha) had the greatest mean number (120) of leaves/plant, whereas sweetpotato at the recommended population but interplanted with maize, had the lowest number (53.2) of leaves/plant.

It was reported that reduced number of leaves in tuber crops could result from a number of factors that include nutrient deficiency (Trehan *et al.*, 2001) and leaf shedding as an effective drought-avoidance mechanism (Okogbenin *et al.*, 1999).

Table 5: Leaf area ($cm^2$) per plant in sweetpotato under maize-sweetpotato association in Swaziland

| Cropping system | Weeks after planting | | | | |
|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 20 |
| Sweetpotato at 30 cm x 100 cm | 143.5a | 636.0a | 428.3a | 84.8c | 100.4ab |
| Maize at 40,000 plants/ha + Sweetpotato at 33,333 plants/ha | 112.9a | 460.2a | 394.1a | 81.1c | 77.7b |
| Maize (25 cm x 100 cm) + 50% sweetpotato population spaced 60 cm x 100 cm | 151.6a | 458.5a | 410.5a | 79.1bc | 97.0ab |
| Sweetpotato alone at 60 cm x 100 cm | 162.1a | 586.6a | 493.9a | 111.1a | 125.6a |
| Means | 142.5 | 535.3 | 431.7 | 89.0 | 100.2 |
| LSD | 67.03 | 321.51 | 281.66 | 20.51 | 31.77 |
| Significance | NS | NS | NS | * | * |

NS, Not significant;
*, significant at P = 0.05
Means separated using the Least Significant Difference (LSD) at P = 0.05.

Table 6: Influence of sweetpotato-maize association on sweetpotato number of leaves per plant at 4-21 weeks after planting in Swaziland.

| Cropping system | Weeks after planting | | | | |
|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 20 |
| Sweetpotato at 30 cm x 100 cm | 50.7a | 359.5a | 100.7a | 52.3a | 39.2b |
| Maize at 40,000 plants/ha + sweetpotato at 30 cm x 100 cm | 36.6a | 63.6a | 77.5a | 51.1a | 37.4b |
| Maize (25 cm x 100 cm) + 50% sweetpotato population spaced 60 cm x 100 cm | 44.7a | 124.5a | 80.5a | 43.3a | 50.0bc |
| Sweetpotato alone at 60 cm | 53.4a | 130.0a | 124.7a | 67.9a | 78.8a |
| Means | 46.3 | 169.4 | 95.8 | 53.7 | 51.4 |
| LSD | 27.28 | 387.31 | 47.92 | 25.20 | 19.68 |
| Significance | NS | NS | NS | NS | * |

NS, Not significant;
*, significant at P = 0.05
Means separated using the Least Significant Difference (LSD) at P = 0.05.

Table 7: Number of sweetpotato tubers/plant at 8-20 weeks after planting at Malkerns Research Station, Swaziland

| Cropping system | Weeks after planting | | | |
|---|---|---|---|---|
| | 8 | 12 | 16 | 20 |
| Sweetpotato at 33,333 plants/ha | 2.4a | 1.8b | 2.3a | 2.1a |
| Maize at 40,000 plants/ha + sweetpotato at 33,333 plants/ha | 0.9b | 1.5b | 1.4b | 1.8a |
| Maize at 40,000 plants/ha + sweetpotato at 16,667 plants/ha | 1.9a | 1.5b | 1.7b | 1.7a |
| Sweetpotato alone at 16,667 plants/ha | 1.4a | 1.6b | 3.0a | 2.5a |
| Means | 1.6 | 1.6 | 2.1 | 2.0 |
| LSD | 0.86 | 0.70 | 1.08 | 1.16 |
| Significance | * | NS | * | NS |

NS, Not significant;
*, significant at P = 0.05
Means separated using the Least Significant Difference (LSD) at P = 0.05.

**Number of sweetpotato tubers per plant**

Table 7 shows the influence of plant populations on the number of sweetpotato tubers per plant at 8-20. Tuberization did not start before 8 WAP.

Monocropped sweetpotato at the recommended plant population (33,333 plants/ha) had the greatest mean number of tubers (2.2), whereas sweetpotato at the recommended plant population but intercropped with maize had the lowest mean number of tuber (1.4). Significant differences were only found at 8 and 16 WAP. Thus, monocropping resulted in a greater number of tubers/plant. Increased plant population of the component crop resulted in decreased number of tubers per plant, as was also reported by Mayisela (2009). Lowe and Wilson (1975) reported significant negative correlations between tuber number and mean tuber mass in 5 of the 6 cultivars studied, and positive correlations between these yield components and total yield, suggesting that cultivars might be grouped into 'tuber number-tuber mass' and 'tuber mass' types, as well as a 'random type' in which yield was related to neither component. Marketable yield tended to be directly related to both components, and cultivars with lower tuber numbers usually produced a higher percentage of marketable yields.

### Diameter of sweetpotato tubers per plant

Table 8 shows the diameter of marketable sweetpotato tubers at 12-20 WAP. Sweetpotato planted alone at 60 cm x 100 cm (50% the recommended plant population) gave the widest tubers (mean diameter, 10.9 cm), whereas sweetpotato interplanted through the recommended population of sweetpotato had the lowest diameter (mean, 5.9 cm). Significant differences were found only at 16 and 20 WAP, when sole sweetpotato at 50% of the recommended population had greater tuber diameters than found in other cropping systems. Olasantan *et al.* (1995) reported that associating cassava with maize delayed bulking of storage roots and decreased nutrient uptake in cassava.

### Sweetpotato yield

Table 9 shows sweetpotato harvest data at 20 WAP in Malkerns' plots. The fresh mass of tubers/plant was not significantly greater in sole sweetpotato (310.5 g) at the recommended spacing than in the other plant populations (308.6-320.0 g). Similarly, the dry mass of tubers/plant was not significantly different among the plant populations.

Table 8: Diameter (cm) of marketable sweetpotato tubers/plant at 8-20 weeks after planting in Swaziland

| Cropping system | Weeks after planting | | |
|---|---|---|---|
| | 12 | 16 | 20 |
| Sweetpotato at 33,333 plants/ha | 6.5 | 9.4b | 9.2a |
| Maize at 40,000 plants/ha + sweetpotato at 33,333 plants/ha | 4.1 | 5.9bc | 7.6ba |
| Maize at 40,000 plants/ha + sweetpotato at 16,667 plants/ha | 4.7 | 6.2bc | 7.9b |
| Sweetpotato at 16,667 plants/ha | 5.4 | 14.3a | 13.0a |
| Means | 5.2 | 9.0 | 9.5 |
| LSD | 3.56 | 3.67 | 4.50 |
| Significance | NS | * | * |

NS. Not significant;
*, significant at P = 0.05
Means separated using the Least Significant Difference (LSD) at P = 0.05

Tuber yields were significantly ($p < 0.05$) higher in the sole sweetpotato (14,700.5 kg/ha) at the recommended spacing and lowest (6,064.4 kg/ha) when maize was associated with 50% of the recommended sweetpotato plant population.

As shown in Table 10, sweetpotato at the recommended plant population yielded higher (16,708 kg/ha) in Mr. Sipho's plots than at Malkerns Research Station plots (14,701 kg/ha). The differences were significant ($p < 0.05$). The higher yields in the farmer's farm might be associated with the beneficial effects of lime on improved soil nutrient availability, compared with no lime application at the Research Station site. Using sweetpotato yields as the basis for comparison, sole cropping at the recommended population gave greater yield. However, among the intercrops, planting sweetpotato into maize (both at recommended plant populations) seemed more beneficial than planting maize into 50% sweetpotato population. Based on the potential total income, it appears growers might be more readily convinced to grow sweetpotato as a sole crop instead of maize, or a combination of both crops.

Table 9: Sweetpotato harvest data at 20 weeks after planting in Malkerns' plots in Swaziland

| Cropping system | FM tubers (g) | DM tubers (g) | DM as % of tuber mass | Tuber yield (kg/ha) |
|---|---|---|---|---|
| Sweetpotato at 33,333 plants/ha | 310.5a | 178.3 | 57.4 | 14,700.5a |
| Maize at 40,000 plants/ha + sweetpotato at 33,333 plants/ha | 308.6a | 177.6b | 57.6 | 7,354.9bc |
| Maize 40,000 plants/ha + sweetpotato at 16,667 plants/ha | 320.0a | 186.9b | 58.4 | 6,064.4b |
| Sweetpotato at 16,667 plants/ha | 310.4a | 183.1b | 59.0 | 13,960.9 |
| Means | 309.9 | 181.5 | - | 10,520.2 |
| LSD | 13.5 | 18.16 | - | 3,061.2 |
| Significance | NS | NS | - | * |

NS. Not significant; *, significant at P = 0.05
Means separated using the Least Significant Difference (LSD) at P = 0.05.

Table 10: Comparison of sweetpotato marketable yields (kg/ha) and potential incomes per hectare in farmer's farm and the Research Station plots in Swaziland

| Cropping system | Marketable tuber yield (kg/ha) | | Potential income/ha (E)† from farmer's farm |
|---|---|---|---|
| | Research Station | Farmer's plots | |
| Sweetpotato alone at 30 cm x 100 cm | 14,700.5a | 16,707.7a | 62,653.9a |
| Maize at 25 cm x 100 cm + Sweetpotato at 33,333 plants ha$^{-1}$ | 7,354.9bc | 5,866.5b | 21,999.4b |
| Maize (25 cm x 100 cm) + 50% sweetpotato population spaced at 60 cm x 100 cm | 6,064.4b | 3,659.2b | 13,722.0b |
| Sweetpotato alone at 60 cm x 100 cm | 13,960.9 | 10,949.6c | 41,061.0c |
| Means | 10,520.2 | 9,295.72 | 34859.0 |
| LSD | 3,061.2 | 2,782.93 | 10436.0 |
| Significance | * | * | * |

NS. Not significant;
*, significant at P = 0.05
Means separated using the Least Significant Difference (LSD) at P = 0.05.
†, selling price of sweetpotato tubers from the experiment was E3.75/kg; US $1.00 = E7.50

## Soil chemical properties

As shown in Table 11, significant differences were only found among the concentrations of Mg, Ca, CEC, nitrate N, and soil pH. Regarding pH, the initial pH of the Malkerns soil was 5.3. Thus, the best cropping system in improving soil acidity at Malkerns was maize interplanted with 50% sweetpotato population; soil pH significantly increased from 5.3 to 6.3. Sole maize soil was significantly ($p < 0.05$) poorer in reducing soil acidity (pH increased from 5.3 to 5.8). Among the micronutrient and base concentrations (Table 12), significant differences were recorded only among sulphur and copper concentrations. Base saturation of Ca and H were also significantly ($p < 0.05$) different among the soils of the different cropping systems. Ila'ava *et al.* (2000) reported that sweetpotato could be fairly tolerant of low Ca supply, whereas in contrast, soluble Al markedly decreased sweetpotato growth. Their results indicated that Al rather than low Ca supply might be more important in limiting sweetpotato growth in acid soils. Furthermore, tolerance to low Ca and soluble Al appeared to be linked in sweetpotato. These results highlighted the importance of selecting sweetpotato cultivars for specific soil conditions such as soil acidity.

Table 11: Chemical properties of soil under maize-sweetpotato association in Swaziland

| Cropping system | —— (%) —— | | —————— Cmole/kg —————— | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Organic matter | Total N | P | K | Mg | Ca | CEC† | Nitrate N | Exch. Al | pH |
| Maize at 40,000 plants/ha | 2.6a | 0.10a | 14.8a | 62.5a | 206.3bc | 500.0a | 6a.2b | 18.5a | 3.5a | 5.8bc |
| Sweetpotato at 33,333 plants/ha | 2.8a | 0.14a | 18.8a | 55.3a | 203.bd | 487.5ab | 5.5c | 5.3b | 3.8a | 6.0ac |
| Maize at 40,000 plants/ha + sweetpotato at 33,333 plants/ha | 2.6a | 0.12a | 10.0a | 41.8a | 196.3adc | 437.5b | 5.1bc | 5.3b | 3.5a | 5.9bc |
| Maize at 40,000 plants/ha + sweetpotato at 16,667 plants/ha | 3.0a | 0.11a | 23.0a | 48.8a | 267.5b | 612.5a | 6.6a | 9.3bd | 3.5a | 6.3a |
| Sweetpotato at 16,667 plants/ha | 2.8a | 0.11a | 42.0a | 65.3a | 225.0a | 587.5a | 6.2a | 8.5bc | 3.5a | 6.1a |
| Means | 2.8 | 0.1 | 21.7 | 54.7 | 219.8 | 525.0 | 5.9 | 9.4 | 3.6 | 6.0 |
| LSD | 0.47 | 0.95 | 38.63 | 32.82 | 66.80 | 139.94 | 1.09 | 5.32 | 0.60 | 0.31 |
| Significance | NS | NS | NS | NS | * | * | * | * | NS | * |

NS Not significant;
*, significant at P = 0.05
Means separated using the Least Significant Difference (LSD) at P = 0.05.
†, cation exchange capacity

Table 12: Micronutrient concentration and base saturation in soil under maize-sweetpotato association in Swaziland

| Cropping system | —— Cmole/kg —— | | | | | | —— Base saturation (%) —— | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | S | Zn | Mn | Fe | Cu | B | K | Mg | Ca | H |
| Maize at 40,000 plants/ha. | 13.8ac | 3.4a | 11.5a | 7.3a | 1.4a | 0.4a | 2.7a | 28.0a | 40.1b | 29.3a |
| Sweetpotato at 33,333 plants/ha | 15.3a | 3.6a | 12.0a | 5.8a | 1.3a | 0.4a | 2.6a | 30.7a | 44.1ab | 22.7c |
| Maize at 40,000 plants/ha + sweetpotato at 33,333 plants/ha | 12.3bc | 3.2a | 6.5a | 5.3a | 1.2b | 0.5a | 2.2a | 31.8a | 42.4abc | 23.6c |
| Maize at 40,000 plants/ha + sweetpotato at 16,667 plants/ha | 12.3bc | 3.8a | 7.3a | 6.8a | 1.3a | 0.4a | 1.9a | 33.3a | 46.5a | 18.3b |
| Sweetpotato at 16,667 plants/ha | 19.8a | 4.0a | 9.3a | 8.0a | 1.2b | 0.4a | 2.7a | 30.6a | 47.2a | 19.5b |
| Means | 14.7 | 3.6 | 9.3 | 6.6 | 1.3 | 0.4 | 2.4 | 30.9 | 44.1 | 22.7 |
| LSD | 6.59 | 1.05 | 8.16 | 3.83 | 0.19 | 0.12 | 1.41 | 5.82 | 5.69 | 8.22 |
| Significance | * | NS | NS | NS | * | NS | NS | NS | * | * |

NS Not significant;
*, significant at P = 0.05;
Means separated using the Least Significant Difference (LSD) at P = 0.05.

## CONCLUSION AND RECOMMENDATION

Intercropping significantly reduced both maize and sweetpotato yields. However, combined crop yields in intercropping were higher than yields under monocropping. Soil pH was significantly improved from 5.3 to 6.3 under maize-sweetpotato mixture when 50% of the recommended sweetpotato population was used. Farmers should plant sweet potato as a monocrop, but should they wish to intercrop, they should plant maize at 40,000 plants/ha and mix-crop maize with sweetpotato at 33,333 plants/ha.

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