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Implications of Associating Sweetpotato [*Ipomoea batatas* (L.) Lam.] with Different Groundnut (*Arachis hypogaea* L.) Populations on Tuber Yield and Soil and Tuber Chemical Properties

[1]*E.M. Ossom and* [2]*R.L. Rhykerd*

[1]Department of Crop Production, Faculty of Agriculture,
University of Swaziland, Private Bag Luyengo, Luyengo M205, Swaziland
[2]Department of Agriculture, Illinois State University, Normal, IL 61790-5020, USA

Abstract: Sweetpotato [*Ipomoea batatas* (L.) Lam.] is a storage root crop commonly cultivated in Southern Africa; groundnut (*Arachis hypogaea* L.) is a popular grain legume that is also commonly grown in the same region. An experiment was carried out in 2006-2007 cropping season, to determine the effects that intercropping a fixed plant population of sweetpotato with varying groundnut (peanut) populations, could have on the chemical properties of the soil and sweetpotato tubers. Results showed no significant differences among soil chemical properties (except total nitrogen, with a range of 0.091-0.106%); macronutrient concentrations in tubers showed no significant differences. Among the micronutrients, only boron concentrations were significantly ($P < 0.05$) higher in monocropped sweetpotato (7.333 mg kg^{-1}) and lower (6.006 mg kg^{-1}) when sweetpotato (33,000 plants ha^{-1}) was intercropped with 100,000 plants ha^{-1} of groundnut. Tuber yields showed 54% increase under a groundnut population density of 66,667 plants ha^{-1}. Small-scale farmers are encouraged to intercrop sweetpotato with 66,667 plants ha^{-1} of groundnut.

Key words: Sweetpotato · Grain legumes · Groundnut · Peanut · Intercropping · Soil chemical properties · Tuber chemical properties · Storage root

INTRODUCTION

Most small-scale farmers in the tropics practice mixed cropping [1], which is differentiated from intercropping [2, 3] where farmers plant a mixture of crops at any convenient spacing and do not use any line arrangement. Different types of crops are involved in intercropping. Usually, small-scale farmers plant any combination of crops in their gardens, depending on their individual fancy, previous experiences in farming, farm size and soil characteristics, among other reasons. Farmers are encouraged to plant grain legumes (pulses) as part of the cropping system in order to gain some benefits that include improved soil characteristics, harvesting both grain legumes and the companion crops for family use, or for sale. There are about 40 species of grain legumes, belonging to about 20 genera [4]. Grain legumes are cultivated for their seeds that are mainly used for human consumption, but they can also be grown for animal feed, or they may be used to produce oils for industrial uses.

Groundnut (*Arachis hypogaea* L.) is a very important food and cash crop, especially in sub-Saharan Africa that accounts for 25% of the world's production of groundnut and 38% of farmland under groundnut worldwide [5]. Very few investigations have been done in Swaziland to determine the mineral nutrient concentrations of soils and plant tissue under intercropping. It would be beneficial to know how legume populations could affect crop yields under intercropping. Pointing out some of the reasons for intercropping, [6] noted that having longer periods of crops covering the soil improved soil conservation; besides, mixtures of legumes and non-legumes might help to maintain soil fertility. It was reported [7, 8] that tropical farmers, including modern farmers, use mixed cropping as a pest-control measure.

Sweetpotato [*Ipomoea batatas* (L.) Lam.] is the most important storage root crop or root tuber crop that is grown in every agro-ecological zone of Swaziland. It is a drought-tolerant crop and performs better than maize (*Zea mays* L.), the staple food of Swaziland, in low-rainfall

Corresponding Author: Prof. Dr. E.M. Ossom, Agronomist, Department of Crop Production, Faculty of Agriculture, University of Swaziland, Private Bag Luyengo, Luyengo M205, Swaziland

areas of the country. A previous study [9] on the growth and performance of different grain legumes under intercropping with sweetpotato in Swaziland, did not investigate the soil and tuber concentrations of mineral nutrients. Therefore, the objective of this experiment was to determine the concentrations of nutrient elements in the soils that were planted to sweetpotato under varying populations of groundnut and to assess the concentrations of mineral nutrients in the tubers of sweetpotato.

MATERIALS AND METHODS

Site and experimental design: The investigation was carried out in the University of Swaziland, Crop Production Department Experimental Farm in Luyengo (26°34'S, 31°12'E; 750 m above sea level; mean annual temperature, 18°C; annual rainfall, 800 mm) from September 2006 to February 2007. The soil type was an Oxisol (M-set) of the Malkerns series [10]. The experimental design was a randomized complete block. There were 5 groundnut population treatments and one population of sweetpotato. There were 6 replications of each treatment.

The treatments (T) and their respective plant populations were: T_1, monocropped sweetpotato at 33,333 plants ha^{-1} (30 cm within rows x 100 cm between rows); T_2, monocropped groundnut at 100,000 plants ha^{-1} (10 cm within rows x 100 cm between rows); T_3, sweetpotato (33,333 plants ha^{-1}) interplanted with groundnut at 100,000 plants ha^{-1} (10 cm within rows x 100 cm between rows, high groundnut population); T_4, sweetpotato (33,333 plants ha^{-1}) interplanted with groundnut at 66,667 plants ha^{-1} (15 cm within rows x 100 cm between rows, medium groundnut population); and T_5, sweetpotato (33,333 plants ha^{-1}) interplanted with groundnut at 33,333 plants ha^{-1} (30 cm within rows x 100 cm between rows, low groundnut population).

There were 7 ridges (each 4.2 m in length) in each plot measuring 4.2 m x 6.0 m. Ridges were 1.0 m apart. Each plot was separated from the contiguous one on all sides by a space of 1.0 m; a 1.0-m perimeter enclosed the entire experiment.

Lime and fertilizer application: Dolomitic lime (30.4% CaO; 21.7% MgO) was broadcast on the ridges at the rate of 2 t ha^{-1}, worked into the ridges [11] and the ridges re-constructed, using spades and garden forks, on planting day. For a soil having a pH of 5.9, it was believed that liming might be beneficial. A soil pH range of 5.2-6.7 was reported [12] to lead to good sweetpotato growth and yield.

After the lime application, a compound fertilizer [N:P:K, 2:3:2 (22)] that also contained 0.5% Zn, was applied at the rate of 350 kg ha^{-1} [11] to all plots, using the banding and incorporation method, 10 cm away from the planting rows. Because sweetpotato is a storage root crop that has a high requirement for phosphorus, an additional 50 kg ha^{-1} of single superphosphate (10.5% P) was applied to all plots of monocropped sweetpotato or intercropped sweetpotato, but no superphosphate was applied to sole groundnut plots. As recommended [11], a side dressing of 10 parts urea (46% N) and 50 parts KCl (50% K) was applied at the rate of 120 kg ha^{-1} to pure sweetpotato or intercropped sweetpotato at 6 weeks after planting (WAP), but no urea or KCl was applied to pure groundnut [11].

Planting: The experiment was planted on 25 September 2006. Groundnut seeds were dusted with an insecticide powder (active ingredients, Mercaptothion, 10 g kg^{-1}; Permethrin, 1.5 g kg^{-1}) at the rate of 1.0 kg of insecticide per 1,000 kg of groundnut, one day before planting. Both sweetpotato and groundnut were planted at the top of the ridges, as recommended [11] for the main crop, sweetpotato. The variety of sweetpotato planted was 'Kenya' and that of groundnut was 'ICG 10478'; both varieties were obtained from Malkerns Research Station, Malkerns. The terminal parts of vines, with mature leaves removed and measuring 30 cm in length, were the planting materials used for establishing sweetpotato; shelled seeds of groundnut were planted.

Crop management, data collection and data analysis: The experiment was routinely managed as recommended [11], with weeding carried out at 4 WAP and at 8 WAP. Pesticides were not applied, as there was no pest infestation that required using pesticides as control measures. Harvesting was done at 20 WAP; garden forks were used to dig up the tubers and pods. Five tuber samples were randomly obtained from each plot; the samples were washed and air-dried for 2 hours on a laboratory bench. Thereafter, the unpeeled tubers were sliced using a sharp knife and 500 g per plot were weighed and dried in a hot-air oven at 80°C for 5 days. The dried samples were ground, sifted and shipped in labeled, plastic bags, for chemical analyses by standard analytical procedures [13] in a reputable laboratory in the United States. The tuber samples were analyzed for concentrations of N, S, P, K, Mg, Ca and Na, in addition to the micronutrients.

Also, after harvest, soil samples (10 from each plot) were collected (15 cm depth), using a soil auger. The 10 samples from each plot were thoroughly mixed in a plastic bucket to obtain one composite sample for each plot. The composite samples were dried on a laboratory bench for 5 days, after which they were sifted, put into labeled plastic bags and shipped for chemical analysis [13] in the same laboratory that analyzed the tuber samples. The soil samples were analyzed for organic matter, N, P, K, Mg, Ca, pH, cation exchange capacity (CEC), nitrate N, total N, base saturation, S, Zn, Mn, Fe, Cu, B and Al concentrations.

Crop yields were determined at harvest (20 WAP). Marketable sweetpotato tubers were whole tubers, weighing between 100 g and 1.4 kg and having no harvest wounds. In Swaziland, tubers outside this mass range are not usually favored or bought by consumers. Data were analyzed using MSTAT-C statistical package, version 1.3 [14]. Mean separation tests were done using least significant difference tests at a probability level of 0.05 [15].

RESULTS AND DISCUSSION

Organic matter concentration: As shown in Table 1, organic matter concentration in the soil was not significantly ($P < 0.05$) higher (3.083%) when sweetpotato was intercropped with 100,000 plants ha^{-1} of peanut than when sweetpotato was associated with a lower population of peanut (2.950%) at 33,333 plants ha^{-1} of peanut.Assuming soil organic matter is 5% N and 2% becomes available through mineralization per year (17), the soil organic matter supplied 59.3-63.7 kg N ha^{-1} yr^{-1}.

Soil acidity: Soil acidity (Table 1) was non-significantly improved when sweetpotato was interplanted with 33,333 plants ha^{-1} of peanut (pH, 5.817), whereas sweetpotato interplanted through 100,000 plants ha^{-1} of peanut had the lowest soil pH (5.800).

Soil macronutrients, CEC and N concentrations: As shown in Table 1, macronutrients and CEC concentrations did not significantly vary among the treatments. Higher Ca concentrations were found in monocropped sweetpotato soil, but lower Ca concentrations were observed in sole groundnut and groundnut-associated soils. Though CEC did not show significant differences among the cropping systems, it ranged from a high of 5.683 me 100 g^{-1} (soil with 66,667 plants ha^{-1} of groundnut interplanted through sweetpotato) to a low of 4.950 me 100 g^{-1} in soil planted to sole groundnut. However, total N was significantly ($P < 0.05$) higher in soil planted to sole sweetpotato (0.106%) and lower in soil where groundnut was planted (0.091%), indicating that more N was unused in the soil planted to sole sweetpotato. Among the intercropped sweetpotato soils, there were no significant differences in total N. The soil in which sweetpotato was associated with 66,667 plants ha^{-1} of groundnut had the highest total N concentration (0.102%), whereas the soil with 100,000 plants ha^{-1} of groundnut interplanted through sweetpotato had the lowest N concentration (0.097%).

Mineral nutrient concentrations and availability in soils could be influenced by various factors. The depressed soil Ca concentration in groundnut association suggests that there was increased Ca utilization by groundnut, especially during peg formation. This was consistent with an earlier observation [17] that in

Table 1: Effects of intercropping sweetpotato (*Ipomoea batatas* L.) with different groundnut (*Arachis hypogaea* L.) populations on some soil chemical properties

Cropping system	Organic matter (%)	Parts per million: P	K	Mg	Ca	pH	Cation exchange capacity (me 100 g^{-1})	Nitrate N (mg kg^{-1})	Total N (%)
Pure sweetpotato (33,000 plants ha^{-1})	3.317	34.167	122.667	178.333	441.667	5.850	5.217	6.667	0.106
Pure groundnut (100,000 plants ha^{-1})	3.083	43.500	134.833	169.167	400.000	5.833	4.950	7.000	0.091
Sweetpotato (33,000 plants ha^{-1}) + groundnut (100,000 plants ha^{-1})	3.083	43.000	148.167	171.667	383.333	5.800	5.133	7.167	0.097
Sweetpotato (33,000 plants ha^{-1}) + groundnut (66,667 plants ha^{-1})	3.000	30.667	141.333	180.833	483.333	5.883	5.683	7.833	0.102
Sweetpotato (33,000 plants ha^{-1}) + groundnut (33,333 plants ha^{-1})	2.950	37.333	148.500	175.833	433.333	5.817	5.417	7.167	0.099
Means	3.087	37.733	139.100	175.167	428.333	5.837	5.280	7.167	0.099
[1]LSD $_{(0.05)}$	0.394	18.109	34.021	44.328	147.418	0.328	1.195	2.516	0.015
Significance	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	*

[1]Least significant difference; *, significant at $P < 0.05$; Ns, not significant at $P > 0.05$.

Table 2: Influence of groundnut (*Arachis hypogaea* L.) population on base saturation and other chemical properties of soil grown to *Ipomoea batatas* L.

Cropping system	Base saturation (%)				Concentrations (mg kg^{-1})						
	K	Mg	Ca	H	S	Zn	Mn	Fe	Cu	B	Al
Pure sweetpotato (33,000 plants ha^{-1})	6.100	28.567	41.833	23.500	16.167	4.417	28.333	1.833	1.017	0.283	3.167
Pure groundnut (100,000 plants ha^{-1})	7.067	27.850	39.967	25.100	15.667	5.283	27.667	2.500	1.017	0.283	5.333
Sweetpotato (33,000 plants ha^{-1}) + groundnut (100,000 plants ha^{-1})	7.450	27.633	37.133	27.783	15.667	4.800	27.833	2.000	1.017	0.283	4.833
Sweetpotato (33,000 plants ha^{-1}) + groundnut (66,667 plants ha^{-1})	6.533	27.050	42.117	24.250	16.333	4.300	28.500	1.000	1.017	0.267	2.667
Sweetpotato (33,000 plants ha^{-1}) + groundnut (33,333 plants ha^{-1})	7.250	27.400	39.550	25.750	17.000	4.417	28.667	2.333	1.050	0.283	3.000
Means	6.880	27.000	40.120	25.277	16.167	4.643	28.200	1.933	1.023	0.280	3.800
[1]LSD $_{(0.05)}$	1.898	4.970	5.973	7.977	2.670	1.692	3.022	2.663	0.091	0.070	3.363
Significance	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

[1]Least significant difference; Ns, not significant at $P > 0.05$.

Table 3: Effects of groundnut (*Arachis hypogaea* L.) population on mineral concentration in sweetpotato (*Ipomoea batatas* L.) tubers

Cropping system	Mineral nutrient concentration (%)						
	N	S	P	K	Mg	Ca	Na
Pure sweetpotato (33,000 plants ha^{-1})	0.800	0.072	0.165	1.075	0.130	0.110	0.082
Sweetpotato (33,000 plants ha^{-1}) + groundnut (100,000 plants ha^{-1})	0.655	0.062	0.150	1.102	0.117	0.105	0.073
Sweetpotato (33,000 plants ha^{-1}) + groundnut (66,667 plants ha^{-1})	0.683	0.065	0.142	1.128	0.123	0.132	0.078
Sweetpotato (33,000 plants ha^{-1}) + groundnut (33,333 plants ha^{-1})	0.605	0.058	0.145	1.112	0.102	0.092	0.072
Means	0.686	0.064	0.150	1.104	0.118	0.110	0.076
[1]LSD $_{(0.05)}$	0.254	0.015	0.045	0.241	0.038	0.053	0.043
Significance	Ns	Ns	Ns	Ns	Ns	Ns	Ns

[1]Least significant difference; Ns, not significant at $P > 0.05$.

groundnut, Ca might limit pod formation, though plant analysis did not detect Ca shortages in storage organs such as groundnut pods. The data on lower Ca concentrations in groundnut-associations also agreed with previous findings [18] who also reported lower soil Ca concentrations when groundnut was interplanted through sweetpotato. It was stressed [19] that adequate supply of Ca in the soil was very essential for the production of groundnut pods with whole, healthy and mature kernels. It had also been reported that Ca requirement of groundnut plants could be quite high, especially during the pod-filling stage [20]. An indication was made [21] that Ca is essential in groundnut for high yields and disease resistance.

Base saturation and micronutrients in soil: Base saturation of K, Mg, Ca and H, as well as micronutrients in the soil (Table 2) did not show any significant differences among the cropping systems. In a previous investigation involving intercropping of sweetpotato with different grain legumes [18], no significant differences were also found among the base saturation of the same chemical elements reported here.

Mineral nutrient concentrations in storage tubers: There were no significant differences in the concentrations of macronutrients in the storage roots of sweetpotato (Table 3). Micronutrients (Table 4) also showed no significant differences, except for boron concentrations, which were significantly ($P < 0.05$) higher in monocropped sweetpotato (7.333 mg kg^{-1}) and lower (6.006 mg kg^{-1}) when sweetpotato (33,000 plants ha^{-1}) was intercropped with 100,000 plants ha^{-1} of groundnut. Among the intercrops, the highest boron concentration (6.833 mg kg^{-1}) was attained when sweetpotato was associated with 66,667 plants ha^{-1} of groundnut.

Table 4: Effects of groundnut (*Arachis hypogaea* L.) population on micronutrient and aluminium concentrations in sweetpotato (*Ipomoea batatas* L.) tubers

Cropping system	Mineral nutrient concentrations (mg kg^{-1})						Total sweetpotato tuber yield (t ha^{-1})	Marketable sweetpotato tuber yield (t ha^{-1})
	B	Zn	Mn	Fe	Cu	Al		
Pure sweetpotato (33,000 plants ha^{-1})	7.333	11.500	10.500	179.333	4.833	221.000	14.42	11.23
Sweetpotato (33,000 plants ha^{-1})+groundnut (100,000 plants ha^{-1})	6.006	10.500	9.833	153.333	4.500	180.333	8.05	6.67
Sweetpotato (33,000 plants ha^{-1})+groundnut (66,667 plants ha^{-1})	6.833	12.000	11.667	201.000	4.833	237.333	8.77	7.42
Sweetpotato (33,000 plants ha^{-1})+groundnut (33,333 plants ha^{-1})	6.167	11.667	9.167	239.000	4.500	280.833	8.13	6.27
Means	6.583	11.417	10.292	193.167	4.667	229.875	9.84	7.90
[1]LSD $_{(0.05)}$	1.131	3.524	3.682	100.346	1.224	112.892	6.82	5.74
Significance	*	Ns	Ns	Ns	Ns	Ns	Ns	Ns

[1]Least significant difference; *, significant at $P < 0.05$; Ns, not significant at $P > 0.05$.

Table 5: Effects of sweetpotato-groundnut association on some crop characteristics and land equivalent ratios

Cropping system	Groundnut		Sweetpotato		
	Seed yield (kg ha^{-1})	No. of pods per plant	No. of tubers per plant	Dry mass (g) of tubers per plant	[1]LER
Pure groundnut at 100,000 plants ha^{-1}	953.2	15.8	NA	NA	NA
Pure sweetpotato at 33,333 plants ha^{-1}	NA	NA	1.0	0.3	NA
Sweetpotato + groundnut at 100,000 plants ha^{-1}	850.8	17.2	0.8	0.2	1.49
Sweetpotato + groundnut at 66,667 plants ha^{-1}	830.9	21.3	0.8	0.2	1.54
Sweetpotato + groundnut at 33,333 plants ha^{-1}	595.6	23.5	0.9	0.2	1.19
Mean	807.6	19.5	0.9	0.2	1.41
[2]LSD $_{(0.05)}$	222.47	7.05	0.41	0.14	-
Significance	*	*	NS	NS	-

[1]Land equivalent ratio; [2]Least significant difference; NA, not applicable; *, significant at $P < 0.05$; NS, not significant at $P > 0.05$.

Sweetpotato storage root yield: Table 4 shows the marketable and total sweetpotato storage root yields. There was no significant difference ($P < 0.05$) in sweetpotato marketable tuber yields under monocropping, compared to intercropping sweetpotato with the three population densities of groundnut. The highest marketable tuber yield (11.23 tonnes ha^{-1}) was obtained from monocropped sweetpotato culture. The lowest marketable tuber yield (6.27 t ha^{-1}) was attained when sweetpotato was associated with the lowest groundnut population (33,333 plants ha^{-1}). Among the intercrops, the sweetpotato associated with 66,667 plants ha^{-1} of groundnut had the highest marketable tuber yield (7.42 t ha^{-1}) and the sweetpotato associated with groundnut planted at a population density of 33,333 plants ha^{-1} had the lowest marketable tuber yield (6.27 t ha^{-1}). Correlation coefficient data showed that there was a positive (but not significant) relationship between the marketable tuber yield and the number of marketable tubers per plant ($r = 0.232$; $r^2 = 0.0538$; N, 24). Thus, 5.38% of the variation in marketable tuber yield could be ascribed to the number of marketable tubers per plant.

Though total tuber yields (Table 4) did not significantly vary among the cropping systems, pure sweetpotato yielded the highest (14.43 t ha^{-1}). Among the intercrops, the highest total tuber yield was from the sweetpotato intercropped with 66,667 plants ha^{-1} of groundnut; the lowest total tuber yield (8.05 t ha^{-1}) was from the sweetpotato associated with groundnut planted at a plant population of 100,000 plants ha^{-1}. The total tuber yield and the number of marketable tubers per plant was also positively but not significantly correlated ($r = 0.299$; $r^2 = 0.089$; N, 24) to the yield of marketable tubers, indicating that 8.94% of the variation in total tuber yield could be ascribed to the number of marketable tubers per plant.

Groundnut seed yields: Groundnut yields (Table 5) were significantly influenced ($P < 0.05$) by groundnut population density and intercropping with sweetpotato. Monocropped groundnut yielded the highest (953.0 kg ha^{-1} of seeds); which was significantly ($P < 0.05$) higher than the seed yield (595.6 kg ha^{-1}) of intercropped groundnut at 33,333 plant ha^{-1}. Groundnut seed yields were not significantly reduced by intercropping with sweetpotato at a groundnut population density of 66,667 or 100,000 plants ha^{-1}. It appeared that 33,333 plants ha^{-1} of groundnut plant density was not sufficient when intercropped with sweetpotato, to produce a groundnut yield comparable to that of pure groundnut. The number of groundnut pods per plant was lowest (15.8) in monocropped groundnut. Among the intercrops, the lowest number of pods per plant (17.2) was attained when groundnut was intercropped at 100,000 plants ha^{-1}; the highest number of pods per plant (23.5) was attained when 33,333 plants ha^{-1} of groundnut was interplanted through sweetpotato. Thus, there appeared to be an increased number of groundnut pods per plant associated with a decreasing number of groundnut plants per ha under intercropping. Both sweetpotato and groundnut yields were low compared to yields of previous research [9, 22, 23], probably on account of the low and unpredictable rainfall that was experienced during the period of the investigation.

Land equivalent ratios: Land equivalent ratio, LER (Table 5), for intercropped sweetpotato and groundnut ranged from a low of 1.19 for sweetpotato intercropped with a groundnut plant density of 33,333 plants ha^{-1}, to a high of 1.59 for intercropped sweetpotato at the groundnut plant density of 66,667 plants ha^{-1}. LER at 66,667 groundnut plants ha^{-1} was 1.54, implying that a yield increase of 54% was obtained by intercropping sweetpotato and groundnut at a planting density of 66,667 plants ha^{-1}. The LER results reported here were similar to data from a previous investigation [24] in which an LER of 1.79 was obtained in sweetpotato-groundnut intercropping and 1.48 in sweetpotato-field bean (*Phaseolus vulgaris* L.) association, both results confirming the advantages of sweetpotato intercropping.

CONCLUSIONS AND RECOMMENDATIONS

This study has shown that improved soil chemical properties were associated with intercropping sweetpotato with 66,667 plants ha^{-1} of groundnut. Although a monoculture of sweetpotato produced the highest sweetpotato tuber yields, the intercropping of sweetpotato with groundnut populations of 33,333, 66,667 and 100,000 plants ha^{-1} resulted in a yield increase of 19-54% as determined by LERs. The 54% increase was obtained by intercropping sweetpotato with a groundnut population density of 66,667 plants ha^{-1}. A groundnut population density of 33,333 plants ha^{-1} appeared insufficient for high yield, as this population density resulted in the lowest LER of 1.19. It is recommended that small-scale farmers plant sweetpotato with 66,667 plants ha^{-1} of groundnut in order to obtain the advantages of improved soil fertility, more nutritious tubers and better land productivity.

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REFERENCES

1. Sullivan, P., 2000. Intercropping principles and production practices – Agronomy systems guide. Appropriate technology transfer for rural areas. http://www.attra.ncat.org/attra-pub/intercrop.html. 09/06/03.
2. Ruthernberg, H., 1980. Farming systems in the tropics. 3rd Edn. Clarendon Press, Oxford, UK.
3. Vandermeer, J.H., 1992. The ecology of intercropping. Cambridge University Press, Cambridge, U.K.
4. Smartt, J., 1990. Grain Legumes: Evolution and Genetic Resources. J. Veg. Sci., 1(5): 714-715.
5. Anonymous, 2007. Improving tropical legume productivity for marginal environments in sub-Saharan Africa (Tropical legumes I). http://www.generationcp.org/tli.php?da=0789315. 11/24/07.
6. Gomez, A.A. and K.A. Gomez, 1983. Multiple cropping in the humid tropics of Asia. International Development Research Center (IDRC), Ottawa, Canada.
7. Karel, A.K., 1993. Effects of intercropping with maize on the incident and damage caused by pod borers of common bean. Env. Ent., 22: 1076-1083.
8. Altieri, M.A., C.I., Nicholls, L. Ponti and A. York, 2005. Designing biodiverse, pest-resilient vineyards through habitat management. Pract. Winery and Vineyard, 27: 16-30.
9. Ossom, E.M., M.H. Nxumalo and R.L. Rhykerd, 2005. Comparison of land equivalent ratio, yield and income from intercropping *Ipomoea batatas* (L.) Lam. with pulses in Swaziland. UNISWA Res. J. Agric., Sci. & Tech., 8(2): 108-112.
10. Murdoch, G., 1968. Soils and land capability of Swaziland. Swaziland Ministry of Agriculture, Mbabane, Swaziland.

11. Anonymous, 1991. Field crops production. p. 41-43. *In*: Pitts, C. W. (Ed.) Farmer's Handbook. Ministry of Agriculture and Cooperatives, Mbabane, Swaziland.
12. Motes, J.E. and J.T. Criswell, 2007. Sweet potato production. http://pods.dasnr.okstate.edu/docushare/dsweb/ApplySimpleSearch. 02/19/ 2007.
13. Association of Official Analytical Chemists, AOAC, 1990. Official Methods of Analysis, 15th ed. Arlington, Virginia, U.S.A.
14. Nissen, O., 1983. MSTAT-C: A microcomputer program for the design, management and analysis of agronomic research experiments. Michigan State University, East Lansing, U.S.A.
15. Steel, R.G.D., J.H. Torrie and D.A. Dickey, 1997. Principles and procedures of statistics: A biometrical approach, 3rd ed. McGraw-Hill, New York, U.S.A.
16. Havlin, J.L., J.D. Beaton, S.L. Tisdale and W.L. Nelson, 2005. Nitrogen. pp. 97-159. *In:* Soil fertility and fertilizers, 7th edition. Prentice Hall, Upper Saddle River, NJ, U.S.A.
17. Putnam, D.H., E.S. Oplinger, T.M. Teynor, E.A. Oelke, K.A. Kelling and J.D. Doll, 1991. Peanut: Alternative field crops manual. http://www.hort.purdue.edu/newcrop/afcm/peanut.html. 11/24/07.
18. Ossom, E.M., M.H. Nxumalo and R.L. Rhykerd, 2006. Contributions of grain legume companion crops to sweetpotato [*Ipomoea batatas* (L.) Lam.] ecological properties and yields in Swaziland. UNISWA Res. J. Agric., Sci. & Tech., 9(2): 149-158.
19. Anonymous, 2003a. Groundnut. http://www.ikisan.com/links/ap_groundnutSoils%20And%20Climate.shtml 7/12/03.
20. Anonymous, 2003b. Importance of sulphur and calcium in groundnut. http://www.ikisan.com/links/ap_groundnutNutrient%20Management.shtml# 7/12/03.
21. Onwueme, I.C. and T.D. Sinha, 1991. Field crop production in tropical Africa. The Technical Centre for Agricultural and Rural Co-operation (CTA), Ede, The Netherlands.
22. Ayaz, S., D.L. McNeil, B.A. McKenzie and G.D. Hill, 2001. Population and sowing depth effects on yield components of grain legumes. http://www.regional.org.au/au/asa/2001/5/c/mcneil.htm. 05/02/05.
23. Ossom, E.M. and R.L. Rhykerd, 2007. *Phaseolus vulgaris* L. population density affects intercropped *Ipomoea batatas* (L.) Lam. Trans. Illinois State Acad. Sci., 100(1): 13-23.
24. Ossom, E.M. and M. Nxumalo, 2003. Influence of sweetpotato and grain legume crops grown in monoculture and in association on crop growth and yield in Swaziland. Final report submitted to UNISWA Research Board, September 2003.