Legume-maize association influences crop characteristics and yields

M.G. Thwala and **E.M. Ossom**[1]

Faculty of Agriculture, University of Swaziland, P.O. Luyengo, Luyengo, Swaziland M 205.
[1] Corresponding author: Email emossom@agric.uniswa.sz.

Abstract

Intercropping involves growing two or more crops on the same land, and in the same season. In Swaziland, peasant farmers commonly intercrop maize (*Zea mays* L.) with sugar bean (*Phaseolus vulgaris* L.), but do not intercrop groundnut (*Arachis hypogaea* L.) with maize because there is a lack of knowledge regarding which crop combinations are most beneficial. Maize was grown as a monocrop and in association with sugar bean and groundnut, to determine the effects of crop combination on the agronomic characteristics of the associated crops. Pure maize gave the highest yield (6298 kg/ha); the maize-groundnut combination yielded 6146 kg/ha of maize, and the maize-sugar bean mixture gave 5806 kg/ha of maize. Pure groundnut yielded significantly ($P<0.05$) higher (840 kg/ha) than intercropped groundnut (419 kg/ha). Crop competition was probably responsible for observed reduced yields. The maize-groundnut mixture provided the best weed control. To simultaneously obtain the three benefits of higher maize yields, higher total crop yields/ha and effective weed suppression, the maize-groundnut intercrop is recommended.

Media summary

Growing a mixture of maize and groundnut is recommended in small-scale farming because this combination gives the highest total crop yields/ha and lowest weed infestation.

Key Words

Intercropping, maize, yield, groundnut, field beans, grain legumes.

Introduction

Intercropping is a popular cropping system among small-scale farmers in the tropics (Vandermeer 1992; Gomez and Gomez c1983; Ruthenberg 1980). Peasant farmers practise intercropping because they see some advantages in the practice. Some measure of disease control can be effected through intercropping (Messiaen 1994). There is the possibility that competition between crops could offer some solutions to weed control (Schoonhoven and Voysest 1993). There is great need to increase food production in Swaziland to alleviate poverty and hunger. Maize is the staple food crop in Swaziland. Groundnut is the most important grain legume in Swazi cuisine. Field bean is called sugar bean in Swaziland, and is the second most important pulse. The objective of this study was to determine the effects of crop mixtures on the agronomic characteristics of crops in the cereal-legume association.

Materials and methods

This field study was conducted at the Crop Production Department Experimental Farm at Luyengo Campus (26?41'S, 31?12'E; 732.5 m above sea level; mean temperature, 18?C) of the University of Swaziland during the 2003/2004 cropping season. The soil, an oxisol of the Mdutshane series (Murdock 1968), had pH, 5.0; potassium, 0.4%; phosphorus, 1.2%; nitrogen, 0.1%; exchangeable acidity, 0.5% and organic matter, 2.6%. The experimental design was a randomized complete block having five treatments, replicated four times. The treatments (T) were: T1, Pure maize spaced at 90 cm x 25 cm; T2, Pure sugar bean at 90 cm x 10 cm spacing; T3, Pure groundnut at 90 cm x 10 cm spacing; T4, Maize at 90 cm x 25 cm + sugar bean at 90 cm x 10 cm; T5, Maize at 90 cm x 25 cm + groundnut at 90 cm x 10 cm. Crop mixtures were planted along the same row. Plots were 5.5 m long and 5.0 m wide.

Sowing was done after ploughing and harrowing. Maize (variety 'SC 405') was sown at an initial plant population of 96,000 plants/ha. Sugar bean ('PAN 159') and groundnut ('HARTS') were planted at 120,000 plants/ha. All crops were planted on the flat, and on the same day. Thinning was done at four weeks after planting (WAP), resulting in the following plant populations: maize, 48,000 plants/ha; sugar bean or groundnut, 120,000 plants/ha. Weeding was done by hoeing at four and 12 WAP. Weed infestation was scored at eight and 12 WAP using a scale of 1-6 where 1 represented minimum weed density within a 90-cm quadrat, and 6 represented the maximum weed density (Daisley *et al*. 1988; Orluchukwu and Ossom 1988; Ossom *et al*. 2001). All plots were fertilized (banding method) with the recommended basal dressing of 300 kg/ha (Anon. 1991) of a compound fertilizer, 2:3:2 (22) + 0.5% Zinc, one day before planting. A side dressing with nitrogen was made at five WAP using 200 kg/ha of Limestone Ammonium Nitrate (LAN), containing 280 g of nitrogen/kg (Anon. 1991). Destructive sampling was done at 4, 7, 10 and 13 WAP to collect the data, using four plants/plot in each crop. Maize was harvested at 18 WAP. Yield and yield component data were collected for each crop. Leaf area (LA) of maize was taken by means of linear measurements. Calculations of LA were made using recommended methods and derived formulae as follows: maize or groundnut, Edje and Osiru (1988), and sugar bean, Sesay and Zungu (2000). Data were analyzed using MSTAT-C statistical package (Nissen 1983). Mean comparisons were made using the F-protected LSD (Steel and Torrie 1980).

Results and discussion

Agronomic characteristics of maize

Table 1 indicates the effects of maize-legume association on the number of leaves/plant of maize. There were no significant differences in the number of leaves/plant of maize, whether grown alone or in association with sugar beans or groundnut. The number of leaves/plant would affect the ability of a crop to trap solar radiation and so manufacture carbohydrates by photosynthesis. Slafer and Rawson (1997) found no significant differences between wheat cultivars in their final number of leaves and in the duration of different phasic development. There was no significant difference in plant height of maize. However, height provided to maize the advantage of intercepting more solar radiation (than the legumes), which is a crucial factor in the growth and development of crops. There was no advantage of pure maize over the associated maize in terms of canopy height and width. Canopy structure was reported to cause variation in leaf productivity in *Erythrina poeppigiana* (Nygren 1994) but a similar variation was not observed in this investigation. Leaf area continued to generally increase throughout the experiment without any significant decreases, in agreement with the observations of Tsuno and Fujise (1965). When associated with groundnut, leaf area development in maize was enhanced whereas when associated with sugar bean, maize leaf area was depressed. Crop yields are often associated with leaf area development. LA trends showed that groundnut was better than sugar bean in improving the size of maize leaves.

Table 1. Effects of crop association on the number of leaves/plant of maize

Cropping system	Weeks after planting				Mean
	4	7	10	13	
Pure maize	7.0a	10.8a	13.1a	13.9a	11.2
Maize and sugar beans	6.6a	9.9bc	13.3a	14.3a	11.00
Maize and groundnut	6.7a	10.3ac	13.2a	14.1a	11.2

Grand mean	6.7	10.3	13.4	14.1	11.1
$LSD^{1}_{(0.05)}$	0.8	0.6	1.0	0.7	-
CV^{2} (%)	6.8	3.1	4.2	3.0	-

[1]Least significant difference test; [2]Coefficient of variation

Means in the same column followed by the same letter are not significantly different at P<0.05, according to LSD.

Grain yield and cob characteristics

There was no significant difference in grain yield and other yield components of maize, whether maize was monocropped, or intercropped with sugar bean or with groundnut (Table 2). There was a highly significant (P<0.01) and positive correlation (r = 0.75) between cob length and seed yield, but a negative, non-significant correlation (r = -0.18) was observed between the number of kernels/rows and seed yield.

Crop association had no influence on the number of kernel rows/cob and number of grains/kernel row of maize cob. Groundnut-associated maize yielded higher than sugar bean-associated maize, and supported the view that groundnut is more efficient than other legumes in nitrogen fixation ability (Yamada 1974; Lindemann and Glover 2003). The increased yield of maize when associated with groundnut as observed in this investigation, showed that groundnut probably fixed more nitrogen for use by maize than sugar bean did. This was in agreement with beneficial effects of nitrogen as reported by Yamada (1974), Lindemann and Glover (2003), Bliss and Hardarson (1993), and Gomez and Gomez (1983).

Table 2. Effects of intercropping on yield and yield components of maize.

Cropping system	Maize yield components and yield						
	Cob length (cm)	Cob diameter (cm)	Number of kernel rows/cob	Number of grains/kernel row	Mass of 100 grains (g)	Cob yield (kg/ha)	Grain yield (kg/ha)
Pure maize	20.9a	4.7a	12.5a	44.0a	48.8a	8863.6a	6298.0a
Maize + Sugar bean	19.9a	4.4a	12.5a	42.0a	51.7a	8684.4a	5805.6a
Maize + Groundnut	20.4a	4.4a	13.0a	42.8a	54.6a	8974.8a	6146.4a
Mean	20.4	4.5	12.7	42.9	51.7	8840.9	6083.3

$LSD^{1}_{(0.05)}$	4.1	0.8	1.0	6.6	13.3	2746.8	2657.8
CV^{2} (%)	11.6	10.9	4.6	8.9	14.9	18.0	25.3

[1]Least significant difference test; [2]Coefficient of variation;
Means in the same column followed by the same letter are not significantly different at P<0.05, according to LSD.

Agronomic characteristics of grain legumes

This investigation showed that the number of leaves/plant in both legume crops was adversely affected by intercropping. Pure groundnut developed a significantly (P<0.05) greater number of leaves than the mixed crop. Monocropped sugar bean developed a higher number of leaves/plant than intercropped sugar bean. This was consistent with the observations of Ossom and Nxumalo (2003) who also found pure sugar bean to develop a larger number of leaves/plant than the associated crop. Intercropping was disadvantageous to groundnut in leaf area development. Maize provided shade to the legumes, and sunlight was limiting to the legume crops; therefore, leaf formation in legumes was impaired. Intercropped legume crops grew taller than their sole counterparts. The taller groundnut plants observed in the groundnut-maize association were probably a consequence of light and space competition with the maize. Competition and a shady habitat had been shown to trigger the development of longer plant parts (Anon. 2004). The canopy of pure sugar bean was wider than that of intercropped sugar bean. At 10 and 13 WAP, pure sugar bean developed a significantly wider (P<0.05) canopy than associated sugar bean. Intercropping had an adverse effect on the development of groundnut canopy width probably because of inter-species competition. Shading results in increased length of anatomical structures (Anon. 2004); an increased plant height, therefore, would result in a higher plant canopy when there is shading. The leaf area of pure groundnut was significantly larger (P<0.05) than that of the intercrops at 10 and 13 WAP. The pod yield of pure sugar bean (1203.4 kg/ha) was significantly higher (P<0.05) than that of the intercropped sugar bean (945.2 kg/ha). The significantly higher (P<0.05) number of pods/plant, pod yield and seed yield/ha in groundnut when monocropped, were consistent with the findings of Ossom and Nxumalo (2003). Seed yield of monocropped groundnut (840.2 kg/ha) was significantly higher than that of intercropped groundnut (419.0 kg/ha).

Conclusion and recommendation

Planting maize with sugar bean or groundnut was a disadvantage to the grain legumes, but beneficial to maize. Groundnut proved to be superior to sugar bean as a companion crop to maize. Intercropping groundnut with maize would be advantageous to the small-scale farmer in terms of increased maize yields, higher combined crop yields/ha, and increased weed suppression. To achieve the combined benefits of higher maize yields, higher combined crop yields/ha, increased weed suppression, and possibly, improved soil enrichment and more nutritious family diet, small-scale farmers are encouraged to sow maize with groundnut in preference to the sugar bean-maize mixture.

References

Anonymous (1991). Field crops production. p.1-60. *In* Pitts, C.W. (ed.) Farmers' handbook. Ministry of Agriculture and Cooperatives, Mbabane, Swaziland.

Anonymous (2004). The influence of shading on flowering and morphology in the lesser Celandine, *Ranunculus ficaria*. http://www.ex.ac.uk/~sawatlin/graduation/celandine_project.htm.

Bliss FA and Hardarson G (eds.) (1993). Enhancement of biological nitrogen fixation of common bean in Latin America. Result from an FAO/IAEA-coordinated research programme, 1985-1991. http://www.neutrino.co.jp/abi_dpss/0-7923-2451-X.PDF 04/05/04.

Daisley LEA, Chong SK, Olsen FJ, Singh L, and George C (1988). Effects of surface-applied grass mulch on soil water content and yields of cowpea and eggplant in Antigua, Tropical Agriculture (Trinidad) 65 (4): 300-304.

Edje OT and Osiru DSO (1988). Methods for determining leaf area in some crop plants. Cassava-based cropping systems research I. Contributions from the First annual meeting of the collaborative group in cassava-based cropping systems research. International Institute of Tropical Agriculture, Ibadan, Nigeria. 16-19 November 1987.

Gomez AA and Gomez KA (c1983). Multiple Cropping in the humid tropics of Asia. International Development Research Centre (IDRC), Ottawa, Canada. http://www.ceci.ca/w/i/n/m007144.htm.

Lindemann WC and Glover CR (2003). Nitrogen fixation by legumes. Guide A-129. Cooperative Extension Service, College of Agriculture and Home Economics. http://www.cahe.nmsu.edu/pubs/_a/a-129.pdf.

Messiaen CM (1994). The tropical vegetable garden. Principles for improvement and increased production, with applications to the main vegetable types. British Library. London and Basingstoke.

Murdock G (1968). Soils and land capability classification in Swaziland. Ministry of Agriculture and Cooperatives, Mbabane, Swaziland.

Nissen O (1983). MSTAT-C: A microcomputer program for the design, management, and analysis of agronomic research experiments. Michigan State University, East Lansing, Michigan.

Nygren P (1994). Carbon and nitrogen dynamics in *Erythrina poeppigiana* (Leguminosae:Phaseoleae) trees managed by periodic prunings. Doctoral dissertation. University of Helsinki, Finland. http://honeybee.Helsinki.fi/tropic/CNdynpru.html.

Orluchukwu JA and Ossom EM (1988). Effect of management practice on weed infestation, yield and nutrient concentration of the fluted pumpkin, *Telfairia occidentalis* Hook. Tropical Agriculture (Trinidad) 65 (4): 317-320.

Ossom EM and Nxumalo M (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 the University of Swaziland Research Board. September 2003. 83pp.

Ossom EM, Pace PF, Rhykerd RL, and Rhykerd CL (2001). Effect of mulch on weed infestation, soil temperature, nutrient concentration, and tuber yield in *Ipomoea batatas* (L.) Lam. in Papua New Guinea. Tropical Agriculture (Trinidad) 78 (3): 144-151.

Ruthenberg H (1980). Farming systems in the tropics. 3rd edn. Oxford Clarendon Press. England, United Kingdom.

Schoonhoven A van and Voysest O (1993). Common beans research for crop improvement. Library cataloguing in publication data, Great Britain.

Sesay A and Zungu H (2000). Estimating leaf area per plant in bambara groundnut (*Vigna subterranea*) using leaf number and leaf dry weight. UNISWA Research Journal of Agriculture, Science and Technology 3 (2) 63-65.

Slafer GA and Rawson HM (1997). CO_2 effects on phasic development, leaf number and the rate of leaf appearance in wheat. Annals of Botany 79:75-81.

Steel RGD and Torrie JH (1980). Principles and procedures of statistics: A biometrical approach, 2nd ed. McGraw-Hill, New York.

Tsuno Y and Fujise K (1965). Studies on the dry matter production of sweet potato. Bulletin of the National Institute of Agricultural Science. (Japan), Series D: Plant physiology, genetics and crops in general. No. 13, 131 p.

Vandermeer JH (1992). The ecology of intercropping. Cambridge University Press, Cambridge, U.K.

Yamada N (1974). Biological nitrogen fixation – limitless resource supporting agriculture. (In Japanese) *Nettai Noken Shuho* 25:20-28.