YIELD AND ECONOMIC RETURNS OF MAIZE/SOYABEAN MIXTURE AS INFLUENCED BY CROP PROPORTION AND GREEN MANURE AT SAMARU, NIGERIA

TUNKU P., ODION E.C., AMANS E.B., SHEBAYAN J.A.Y., ISHAYA D.B., ADEKPE D.I.

Department of Agronomy, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria

Abstract

Field trials were conducted during the 2002 and 2003 wet season, at the Institute for Agricultural Research Farm, Samaru (11°11', 07°38'E) in the northern Guinea savanna of Nigeria to study the effect of component crop proportion and pigeonpea green manure on yield and economic returns of maize/soyabean mixture. The treatments consisted of three intercrops (1 : 1, 1 : 2, 2 : 1 maize : soyabean) and two sole crops of maize and soyabean with or without pigeon green manure. The trial was laid out in a randomized complete block design with three replications. The highest maize grain yield of 1 300 kg/ha and 400 kg/ha in 2002 and 2003 respectively was found in sole maize. However, among the intercrops, the highest maize grain yield (1 000 kg/ha and 400 kg/ha in 2002 and 2003 respectively) was realized in 1 : 2 ratio (one maize row alternated with two soyabean rows). The highest soyabean grain yield of 1 323 kg/ha and 837 kg/ha in 2002 and 2003 respectively was realized in sole soyabean. Among the mixed crop, the highest soyabean grain yield was realized in 1:2 ratio (one maize row alternated with two soyabean rows) with 752 kg/ha in 2002 and 457 kg/ha in 2003. In terms of land use efficiency, 1:2 component crop proportion was the best pattern, with LERs of 1.25 and 1.09 in 2002 and 2003 respectively. The highest cash returns of N 63 555 was realized in 2 : 1 in 2002 and N 32 578 from 1 : 2 in 2003. The highest grain yield of both crops and highest cash return was realized in plots with pigeonpea green manure.

Key words: mixture, green manure, maize, soyabean, yield, economic returns

INTRODUCTION

Sustaining yield and income is a more important objective for farmers with limited resources than maximizing either yield or income. Additionally, the family objectives include maintaining food supply and income through the year, minimizing risk of failure in every season, keeping cash costs at minimum, and meeting other social obligations in the community (Olabanji et al., 2002). The improvements of agricultural sustainability favour the maintenance of the intercropping system. Intercropping is an efficient soil conservation practice due to the increased ground cover that its provides as well as the exploitation of different soil layers due to the different depth of the root systems of the two species (Jarenyama et al., 2000). Inter-cropping, through more effective use of water, nutrient and solar energy, can significantly enhance crop productivity compared with the growth of sole crops (Hussaini et al., 2001). Guvenc and Yildirim (1999) reported that intercropping is a safer and more stable system of agricultural production than sole cropping for small farms, where capital is limited and labour is available. Many studies have indicated that intercropping with different legumes was more productive and profitable than sole cropping because of the complementary effect of intercrops (Odion and Idem, 2005; Peter and Odion, 2008). Furthermore, intercropping has a great potential for pests, and diseases reduction (Baumann et al., 2000). Studies have affirmed the utility of intercropping as one of the crop contingency strategies against any monocultured crop failure. Intercropping has been acclaimed internationally as the most reliable approach to safeguard the sustainability of crop production (Ayoola and Agboola, 2001).

Maize (*Zea mays* L.) is the third most important cereal after wheat and rice in the world. It is one of the important food security crop grown by subsistence farmers of the Guinea and Sudan savanna of West Africa. It provides a staple diet for over 400 million people who live in the tropics of Africa and India (Hussaini et al., 2001). Apart from being a staple food, it has several other industrial uses and a cheap source of livestock feeds. Soyabean (*Glycine max* L.) is grown largely in mixture with other crops, particularly cereal such as maize, millet and sorghum in Nigeria. The crop has been variously described as a "miracle bean" or a "golden bean" because it is a

cheap source of protein. The grains of soyabean contain 40% protein, 20% edible vegetable oil, and a good balance of amino acid (Adetiloye et al., 2005) and has therefore tremendous potential to improve the nutritional status and welfare of the families of resource-poor farmers. Soyabean can also contribute to enhanced sustainability of intensified cropping system by improving soil fertility through nitrogen fixation, permitting a longer duration of ground cover in the cropping sequence to suppress weeds and providing useful crop residue for animal feed (Adetiloye et al., 2005).

In order to achieve self-sufficiency in cereal and legumes production and meet the demand for food by the year 2020 in Nigeria, it is suggested that cereal and legumes production must increase by 6.4 million metric tones of which maize production must increase by 320 000 metric tonnes or by 300% (Anon., 2003).

This study was therefore conducted to evaluate the effect of component crop proportion and pigeon-pea green manure on Yields and economic returns of maize/soyabean mixture at Samaru, Nigeria.

MATERIALS AND METHODS

Site: This study was conducted at the Institute for Agricultural Research Farm, Samaru (11°11'N, 07°38'E) in the northern Guinea savanna ecological zone of Nigeria during the 2002 and 2003 wet seasons. The rainfall pattern in the area is unimodal with its peak usually in the month of August. The top soils (0–15 cm) of the experimental field before the incorporation of pigeon-pea green manure were analysed for physical and chemical properties using standard procedures as described by Black (1965). The textural class was sandy loam. The total N was 0.08 g/kg, available P was 8.75 g/kg, K was 1.21 cmol/kg and organic carbon was 4.02 g/kg. The pH (1 : 2 : 5, soil : water) was 6.10 and CEC was 8.30 cmol/kg.

Experimental design and treatments: The experimental field was ploughed and harrowed twice in order to bury plant residues and to break soil clods before ridging. The treatments consists of five cropping pattern (sole maize, sole soyabean, mixed miaze/soyabean ratios of 2 : 1 i.e. two rows of maize alternated with one row of soyabean; 1 : 1 i.e. one row of maize alternated with one row of soyabean and 1 : 2 i.e. one row of maize alternate with two rows of soyabean) with or without pigeon-pea green manure. Factorial combination of the treatments were laid out in a randomized complete block design and replicated three times. Each gross plot size was 6.0 m × 6.0 m (36.0 m^2) while net plot was 3 m × 6 m (18 m^2). Two seeds of extra early maize (var. TZEE.Y) were planted per hole at a spacings of 25 cm × 75 cm, while two seeds of soyabean (var. Samsoy 2) were planted per hole at a spacing of 5 cm × 75 cm. Blanket fertilizer application at the rate of 90 kg N, 20 kg P and 33 kg K per hectare to maize, while 10 kg N, 26 kg P and 33 kg K per hectare to soyabean. Half of the N dosage together with the entire P and K were applied at planting to maize while entire N, P and K were applied to soyabean at planting. The balance of the N was top dressed to maize at four weeks after planting.

Data collection and analysis

Data on number of grain row per cob, 1000-grain weight, harvest index, shelling percentage and grain yield (kg/ha) was collected for maize while number of pods per plant, weight of pods per plant, 100-grain weight, harvest index, shelling percentage and grain yield (kg/ha) was collected for soyabean.

Land Equivalent Ratio (LER): To determine land use-efficiency LERs were calculated thus:

$$LER = La + L_b = \frac{Ya}{Sa} + \frac{Y_b}{S_b}$$

Where:

La and L_b = partial LERs of crop a (maize) and (soyabean)
Ya and Y_b = individual crop yields in intercropping
Sa and S_b = individual crop yields in sole crop.

Competitive indices

One of the indice used to measure the competitiveness of crops in intercropping was competitive ratio (CR). Competitive ratio (C_R) was calculated using the formular given by Wiley and Rao (1980):

$$CR = \left(\frac{Y_{ab}}{y_{aa}} + \frac{Y_{ba}}{y_{bb}}\right) x \frac{Z_{ba}}{Z_{ab}} = \frac{LER_a}{LER_b} x \frac{Z_{ba}}{Z_{ab}}$$

Where:

Y_{aa} = yield of component "a" (maize) as sole crop
Y_{bb} = yield of component "b" (soyabean) as sole crop
y_{ab} = yield of components "a" as intercrop grown in combination with component "b"
y_{ba} = yield of components "b" as intercrop grown in combination with component "a"
Z_{ab} = sown proportion of component "a" in combination with component "b"
Z_{ba} = sown proportion of component "b" in combination with component "a"

Gross economic returns

The monetary value of the output from each treatment was calculated based on the prevailing market prices

of maize and soyabeans. The prices were ₦ 31/kg and ₦ 18/kg for maize in 2002 and 2003 production year respectively and ₦ 27/kg and ₦ 35/kg for soyabean in 2002 and 2003 production year respectively. The used of gross economic return was based on the assumption that fixed costs of production were negligible (Olabanji et al., 2002) and the costs of inputs (labours, fertilizer, etc) were regarded fairly/approximately the same for the experimental plots.

Data collected were subjected to analysis of variance and means were compared using Duncan's Multiple Range test (DMRT) where F-values were significant (Duncan, 1955).

RESULTS AND DISCUSSION

Yield components and yield

Maize

The performance of maize in both intercrop and sole crops in respect to yield components and yield is given in Table 1. Intercropping significantly affected the yield components of maize, the harvest index were generally lower in intercrop than in pure stand while the shelling percentage and 1 000-grain weight were generally higher in intercrops than in pure stands. Among the mixed crop treatments, the 1 : 1 and 1 : 2 ratio (maize : soyabean) had significantly higher shelling percentage, more number of grain rows per cob and 1000-grain weight, this could be due to relatively low maize population, which accounted for lower inter-specific competition between maize and soyabean. This situation might have resulted in enhanced translocation of assimilates to the ear at relatively low population, consequently bringing about the observed higher shelling percentage, more number of grain rows per cob and 1 000-grain weight in 1 : 1 and 1 : 2 (maize : soya-bean) as compared to 2 : 1 crops proportion. This findings agrees with that of Hussaini et al. (2001) that there is more translocation of assimilate to the ear at relatively low population of maize.

Component crop proportion significantly affected the yield of maize where sole crop out yielded all other crop proportion in intercrops. The high yield of maize in sole crop could be attributed to the higher population of the crop and lack of interspecific competition as a result of the absence of soyabean. This finding agrees with that of (Oyewole and Magaji, 2006) who reported that the mean yield of millet increased significantly in sole plot than in mixture and he attributed this to the higher population of the crop and lack of interspecific competition as a result of the absence of cowpea.

Pigeonpea green manure significantly affected the yield components and yield of maize, harvest index, grain row per cob, 1 000-grain weight and yield of maize were generally higher in plots with pigeonpea green manure than plots without pigeonpea green manure. The significant higher of yield components and yield of maize in plots

Tab. 1: The Performance of maize in a maize/soyabean mixture as influenced by component proportion and pigeonpea green manure at Samaru, Nigeria

Treatment: Proportion (P) (maize : soyabean)	Harvest index		Shelling percentage		Grain row per cob		1000 grain weight (g)		Grain yield (t/ha)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Sole maize	63.8a	37.3a	69.3b	68.6b	14.4b	12.2b	184.5b	142.7b	1.3a	0.40a
1:1	61.2b	28.3b	75.2a	73.7a	14.9b	12.8b	204.8a	150.2a	1.0ab	0.32bc
1:2	61.4b	26.7b	75.7a	75.0a	15.0a	13.2a	208.5a	151.3a	1.0ab	0.40a
2:1	57.1c	25.1b	71.6ab	73.4a	14.5b	12.0b	196.7ab	147.2ab	0.9c	0.3c
SE±	1.61	0.67	0.73	0.92	0.11	0.11	2.23	0.82	17.1	7.2
Pigeonpea green manure (M)										
With pigeonpea green manure	68.9a	35.7a	73.8a	73.7a	14.9	13.0a	208.3a	150.8a	1.1a	0.4a
Without pigeonpea green manure	52.9b	23.0b	72.1b	71.6b	14.5	12.1b	188.9b	144.7b	0.9b	0.3b
SE+	0.81	0.33	0.37	0.46	0.05	0.09	1.11	0.41	8.55	3.59
Interaction										
P × M	**	**	**	*	*	**	**	**	**	**

Means followed by the same letter(s) in a column did not differ significantly at 5% level of significance using DMRT
** = Significant at 1% level of probability; NS = Not significant

with pigeonpea green manure could be due to the improvement of soil fertility brought about by pigeonpea green manure. This findings agrees with that of (Adetiloye et al., 2005) who attributed the higher yield characters of maize grown in rotation with pigeonpea to the ability of the legume (pigeonpea) to build up surface organic matter through litter fall, recovering of nutrients from the suibsoil and made such available to the crops, releasing N into the soil, provide better habitat for fauna, suppress weed because of better canopy, thus reducing leaching and erosion and favour both water infiltration and soil life which in turn favour the growth and better yield of maize plant.

Soyabean

The performance of soyabean in both sole and intercrop crops in respect to yield components and yield is given in Tables 2 and 3. Component crop proportion significantly affected yield components of soyabean. In both years the highest number of pods per plant, pod fresh

Tab. 2: Effect of component crop proportion and pigeonpea green manure on number of pods per plant, pods fresh weight/plant, harvest index and shelling percentage of soyabean in a maize/soyabean mixture at Samaru, Nigeria

Treatment: Proportion (P) (maize : soyabean)	No of pods per plant		Pods fresh weight/plant (g)		Harvest index		Shelling percentage	
	2002	2003	2002	2003	2002	2003	2002	2003
Sole soyabean	34.7a	27.3a	12.8a	10.1a	20.2a	21.0a	61.4c	61.6
1 : 1	31.9b	26.4a	11.5b	9.7a	15.8bc	14.1b	66.1a	65.6
1 : 2	33.2ab	26.8a	12.0ab	10.0a	16.6b	14.0b	64.1ab	64.2
	29.0c	20.8b	9.5c	7.6b	14.4c	13.9b	61.8bc	62.6
SE±	0.26	0.53	0.17	0.17	0.25	0.44	0.34	0.50
Pigeonpea green manure (M)								
With pigeonpea green manure	32.8	28.4a	11.8	9.3	19.3a	17.3a	64.8a	64.2
Without pigeonpea green manure	31.6	22.2b	11.1	9.4	14.1b	14.2b	61.9b	62.8
SE±	0.13	0.27	0.09	0.08	0.13	0.22	0.17	0.25
Interaction								
P × M	NS	NS	NS	NS	**	**	NS	NS

Means followed by the same letter(s) in a column did not differ significantly at 5% level of significance using DMRT
** = Significant at 1% level of probability; NS = Not significant

Tab. 3: Effect of component crop proportion and pigeonpea green manure on 100-grain weight, grain yield of soyabean in a maize/soyabean mixture at Samaru, Nigeria

Treatment: Proportion (P) (maize : soyabean)	100-grain weight (g)		Grain yield (kg/ha)	
	2002	2003	2002	2003
Sole soyabean	12.6	12.1b	1 323a	837a
1:1	13.0	12.8a	701b	431b
1:2	13.4	13.0a	752b	457b
2:1	12.6	12.8a	609c	416b
SE±	0.20	0.08	11.94	6.36
Pigeonpea green manure (M)				
With pigeonpea green manure	13.1	12.6	891a	557a
Without pigeonpea green manure	12.7	12.7	801b	513b
SE±	0.09	0.04	5.97	3.18
Interaction				
P × M	NS	NS	**	**

Means followed by the same letter(s) in a column did not differ significantly at 5% level of significance using DMRT
** = Significant at 1% level of probability; NS = Not significant

weight/plant and harvest index was in pure stand while the lowest was in 2 : 1 (maize: soyabean) ratio. The lowest yield com-ponents of soyabean (numbet of pods/ plant, pod fresh weight/plant, harvest index and shelling percentage) obtained in 2 : 1 could be attributed to the high population of maize in the ratio which may have been more competitive in term of resources utilization than soyabean. In 2002 the highest shelling percentage was in 1 : 1 (66.1%), however, this was not significantly diggerent from those of 1 : 2. In 2003, the lowest 100 grain weight was in pure soyabean stand while the intercrops had significantly heavier soyabean grain. The

T**ab. 4:** Effect of component crop proportion and pigeonpea green manure on total land equivalent ratio (total LER) and competitive ratio of maize (a) and soyabean (b) grown in mixture at Samaru, Nigeria

Treatment: Proportion (P) (maize:soyabean)	Total LER (grain)		Competitive ratio (CR)			
			maize (a)		soyabean (b)	
	2002	2003	2002	2003	2002	2003
Sole maize	1.00d	1.00b	N/A	N/A	N/A	N/A
Sole soyabean	1.00d	1.00b	N/A	N/A	N/A	N/A
1:1	1.29b	1.01a	1.49	0.70	1.07	0.99
1:2	1.35a	1.09a	1.39	0.78	1.06	0.98
2:1	1.10c	0.95c	1.49	0.71	0.80	1.09
SE±	0.004	0.004	0.06	0.03	0.05	0.05
Pigeonpea green manure (M)						
With pigeonpea green manure	1.49a	1.33a	1.42	0.72	1.40	0.94
Without pigeonpea green manure	1.38b	1.20b	1.43	0.69	0.95	1.10
SE±	0.002	0.002	0.03	0.02	0.03	0.03
Interaction						
P × M	**	**	NS	NS	NS	NS

Means followed by the same letter(s) in a column did not differ significantly at 5% level of significance using DMRT
** = Significant at 1% level of probability; NS = Not significant; N/A = Not applicable

Tab. 5: Gross economic return (N/ha) from maize/soyabean mixture as affected by crop proportion and pigeonpea green manure at Samaru, Nigeria

Treatment: Proportion (P) (maize : soyabean)	Gross economic returns (N/ha)	
	2002	2003
Sole maize	39 421c	7 712e
Sole soyabean	34 268c	29 307b
1 : 1	50 196b	20 877c
1 : 2	52 530b	32 578a
2 : 1	63 555a	19 521d
SE±	2 358.7	1 178.5
Pigeonpea green manure (M)		
With pigeonpea green manure	65 974a	32 204a
Without pigeonpea green manure	54 011b	22 792b
SE+	1 179.4	589.3
Interaction		
P × M	NS	NS

Means followed by the same letter(s) in a column did not differ significantly at 5% level of significance using DMRT
** = Significant at 1% level of probability; NS = Not significant
Source: Agricultural Economics and Rural Sociology Department, Ahmadu Bello University, Zaria, Nigeria

highest grain yield of soyabean was realized in pure stand of soyabean (1 323 kg/ha and 837 kg/ha) in 2002 and 2003 respectively. Proportionately, yields declined with declining proportion of soyabean in the mixture. The high yield of soyabean in pure stand could be attributed to the higher population of the crop (soyabean) and lack of interspecific competition as a result of the absence of maize. This finding agrees with that of (Adeniyi and Omotunde, 2001) who reported a decrease in cowpea yield as a result of intercropping with maize.
Pigeonpea green manure significantly affected the yield component (number of pods/plant, harvest index and shelling percentage) and yield of soyabean, which were generally higher in plots with pigeonpea green manure than those without pigeonpea green manure.
The significant higher yield component and yield of soyabean in plots with pigeonpea green manure could be attributed to the initial improvement of soil fertility brought about by pigeonpea green manure which in turn improved the performance of the crop.

B. Measuring intercropping productivity

Total land equivalent ratio

The values of LERs indicated better land use in all intercrop treatments except 2 : 1 in 2003 (Table 4). The highest yield advantage of 1.35 and 1.09 in 2002 and 2003 respectively was realized in 1 : 2 ratio, reflecting a clear superiority of this mixture to other mixture and sole cropping of the components in this study. The 1 : 1 ratio in both years produced significantly higher yield advantage compared to the sole cropping. The higher yield advantages realized in intercropping in this study were possibly because the vegetative and reproductive phases of the component crops did not coincide. Maize (var. extra early maize) matured earlier than soyabean (var. samsoy –2). The land equivalent ratio (LER) showed that intercropping was more productive per unit of land than growing maize and soyabean separately. The tendency to obtain high yield advantage appeared most frequent at crop proportion of 1 : 2 which contradicts the findings of Olabanji et al. (2002) who suggests 1 : 1 as the most appropriate crop proportion in millet/cowpea mixture.
The high yield advantage realized in plots with pigeonpea green manure could be attributed to the improvement in soil fertility.

Competitive ratios

Competitive ratio is an important indice used to show the behaviour and degree at which any crop competes with another when intercropped. The results presented in Table 4 show that maize had higher competitive values in both years of experimentation except in 2003 at 2 : 1 proportion and in plots without pigeonpea green manure where soyabean has higher competitive value than maize. The higher competitive values of maize clearly showed that maize is a strong competitor when intercropped with soyabean, though the effect of component crop proportion and pigeonpea green manure on competitive ratio was not significant in both years of experimentation.

Economic analysis

Monetary returns for the various cropping system and pigeonpea green manure treatments are presented in Table 5. The gross margin of yield of maize and soyabean in mixture was estimated as a measure of profitability. All intercrop combination were more profitable than sole crops. The highest monetary returns was from 2 : 1 treatments (₦ 63 555) and treatment 1 : 2 (₦ 32 578) in 2002 and 2003 respectively.
Treatments with pigeonpea green manure produced the highest gross returns of ₦ 65 974 compared with gross returns of ₦ 54 011 realized from treatments without pigeonpea green manure in 2002 and ₦ 32 204 realized from treatment with pigeonpea green manure compared with gross returns of ₦ 22 792 realized from treatment without pigeonpea green manure in 2003. Results of gross returns have consistently shown that maize/soyabean mixture could fetch higher returns than sole crop. Similarly, application of pigeonea green manure appears more promising in terms of total yield and profitability than treatments without pigeonpea green manure. This confirms why farmers in the Guinea savanna of Nigeria are often advised to plough in pigeonpea into the soil to serve as sources of organic matter.

CONCLUSION

Based on the results obtained from this study, intercropping maize and soyabean at 1 : 2 ratios is highly recommended as these treatments recorded the highest total LER and yield of maize and soyabean. Similarly, growing maize and soyabean in intercrop enhances land use efficiency and increases monetary return. The study further shows that application of pigeonpea green manure appears more promising in terms of total yield and profitability.

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Corresponding author:

Dr. Peter Tunku
Department of Agronomy
Faculty of Agriculture
Ahmadu Bello University
Zaria, Kaduna State, Nigeria
e-mail: petertunku2000@yahoo.com