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Full Length Research Paper

Effect of maize planting density on the performance of maize/soybean intercropping system in a guinea savannah agroecosystem

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Two field experiments were conducted during the 2004 early and late seasons at the Agricultural Vocational Training Centre, Otobi, Otukpo in the southern guinea savanna agro-ecological zone of Nigeria to evaluate the effects of maize planting density (38,000; 44,440 and 53,330 plants/ha) in intercrop with soybean varieties (TGX 1448-2E and Samsoy-2) on the growth, yield and productivity of the maize/soybean intercropping system. The soybean varieties were maintained at the optimum planting density of 266,660/ha in both sole and intercrops while sole maize (TZR-EW) plots were at the recommended planting density of 53,330 plants/ha. Samsoy -2 soybean plants were taller at the various ages of growth, had more leaves and attained 50% flowering earlier, produced more and heavier nodules than TGX 1448-2E but TGX 1448-2E produced significantly (P < 0.01) more pods and higher seed yield in both seasons. Intercropping reduced the number of soybean pods per plant by 46% in the early season and seed yield by 42 and 46% in the early and late seasons, respectively. Increasing maize planting density reduced soybean seed yield by 21 and 23% at maize planting density of 44,440 and 53,330 plants/ha, respectively, compared with intercropping at 38,000 maize plants/ha. Maize plant height and leaf production were not influenced by intercropping nor by maize planting density but in the late season, maize grain yield was highest with 53,330 maize density/TGX 1448-2E but lowest with 38,000 maize density/Samsoy-2 cropping. The productivity of the intercropping system indicated yield advantage of 2-63% as depicted by the LER 0f 1.02-1.63 showing efficient utilization of land resource by growing the crops together and this increased with maize planting density. The total monetary return was higher for the intercrops than the sole crops with the values highest with 53,330 maize density/TGX 1448-2E in both early (N293,171.80) and late (283,069.70) seasons. The implication of this is that farmers in the study area would earn more income growing the crops together.

Key words: Maize planting density, soybean, intercropping, land equivalent ratio, monetary return.

INTRODUCTION

Soybean (Glycine max L. Merill) is one of the most important food legumes in Nigeria and other parts of the world. In Nigeria, the first successful soybean production in 1937 was in Yandev, Benue State, located in the southern guinea savannah agro-ecological zone of the country with the Malayan cultivar which was suitable for commercial production (Egbe, 1995).

In Africa, soybean is one of the leguminous crops selected for active research, production and utilization (Atungwu and Afolami, 2001). It has potential of fixing atmospheric nitrogen (N) besides meeting its own N requirement and serves as a viable and low cost medium for soil fertility improvement. Recent trends in Nigeria have been mostly in integration of the various mono-bred genotypes and varieties into the traditional cropping systems involving non-legumes. An important component

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crop in soybean system is maize. Soybean has the potential for improving human diet through supplying high quality protein as well as animal feed and serves as a source of raw material base for agro-industries (Atungwu and Afolabi, 2001).

Maize (Zea mays L.), which is one of the most important cereal crops grown in Africa and ranks as the third most cultivated crop in Nigeria (Ayeni, 1987), features prominently in inter-cropping systems involving legume and non-legume crops such as soybean, cowpea, cassava, yam, etc. Maize is used for human food, livestock feed and as a source of industrial raw material for the production of oil, alcohol and starch.

Grain legume/cereal crop mixtures are very popular among small scale farmers in West Africa. The traditional farmers have adopted mixed cropping for various reasons which include increased monetary returns, insurance against crop failure and reduction of pests and diseases due to biological diversity within the system, among others (Muoneke and Asiegbu, 1997).

In recognition of the economic and nutritional importance of soybean as grain legume and maize as important cereal crop, resource poor farmers prefer the cultivation of soybean and maize in mixture as against sole cropping system. In the rainforest agro-ecological zones, small-scale farmers practice among others, maize/yam, maize/cassava and maize/cocoyam mixtures (Akobundu, 1980). In the guinea savannah agro-ecological zones, mixtures involving maize include maize/yam, maize/cowpea, maize/rice and maize/melon systems (Alhasan, 2002).

Mixtures involving soybean had been reported such as soybean/potato (Okonkwo, 1984), soybean/yam (Okigbo and Greenland, 1976), soybean/sorghum (Hiebsch et al., 1995), and soybean/maize (Olufajo, 1992). It is on the bases of the symbolic nature of grain legumes and their nutritional value in the diets of Nigerian that soybean is found in mixtures with other crops in most agro – ecological zones of Nigeria (Wahua, 1985; Mc Namara and Morse, 1996; Kalu and Omojor, 1991).

Hiebsch et al. (1995) stated that collective production from the component crops may be greater in intercropping than in sole cropping from a unit land area.

The beneficial effects of intercropping soybean/maize have not been fully exploited by farmers in the major soybean producing areas of the southern guinea savannah agro-ecological zone (Kalu and Omojor, 1991). Many vegetative and yield variables of crops are potentially influenced by competition of the plant with the second crop in an intercropping system and by competition with other plants of the same species. This influence may be affected by changes in plant population density. One of the major constraints of soybean production has been the dearth of information on the relative plant population densities of the non-legume components where soybean is grown in the intercropping system especially in the southern guinea savannah agro-ecosystem typified by Otukpo area of Benue State, Nigeria. Maize is an important component crop in the inter-cropping systems of the area.

For the Otukpo environment typified by mixed cropping, it is considered necessary to determine the relative maize population density in soybean/maize intercrop for optimal productivity. Farmers in Otukpo area of Benue State, Nigeria have adopted maize/soybean technology, especially with improved soybean varieties such as TGX 1448-2E and Samsoy -2 but no documented information exists on this technology.

The objectives of this study, therefore, were to: Determine the effect of varying plant populations of maize on the growth and yield of soybean varieties and maize and evaluate the productivity of the intercropping system.

MATERIALS AND METHODS

Two field experiments were conducted during the early and late seasons of 2004 at the Agricultural Vocational Training Centre (AVTC) farm, Otobi in Otukpo Local Government Area of Benue State, Nigeria to study the effect of maize planting densities on the productivity of soybean/maize intercropping system. Otobi is located at 07º 13´ N and 08º 11´ E, and elevation 180 m above sea level. The location falls within the southern guinea savannah agro-ecological zone of Nigeria (Kowal and Knabe, 1972) with annual rainfall of 1200 - 1500 m bimodally distributed (Ikeorgu, 2001). The experimental site had a total rainfall of 1735 mm in 2004 (January to December) with 1137 mm occurring during the early season (May - August) and 598 mm during the late season (July - November). Some of the soil physico-chemical characteristics of the site were as follow: soil pH 6.08 and 6.44 (1:2.5 soil: water); organic matter 1.00 and 0.10%; total N 0.042 and 0.28%; available P 34.00 and 30.00 ppm, exchangeable K 0.13 and 0.20 meq/100 g for early and late seasons, respectively. The soil textural class was sandy loam in both seasons.

The experiments were laid out factorially in randomized complete block design (RCBD) with three blocks. Each block consisted of nine treatments, involving two soybean varieties (TGX 1448-2E) and (Samsoy-2), each with three maize (TZR-EW) population densities (38,000; 44,440 and 53,330 plants/ha) (2 x 3) factorial and sole crop of each soybean variety at 266,660 plants/ha and maize at 53,330 plants/ha for determining the productivity of the intercropping systems.

The land was manually cleared and ridged with hoes at 0.75 m apart. Each plot size was 4.5 m x 4 m containing six ridges each of 4 m length. The gross land area (40.5 x 14 m) was 0.057 hectares with one meter between blocks.

The two seasons of cropping were early (May) for experiment 1 and late (July) 2004 for experiment 2. Soybean and maize were planted on the same day (20 May, 2004) early and (21 July, 2004) late seasons in all the plots. Two seeds each were sown for soybean and maize and were thinned to one plant per stand seven days after planting (DAP) and 10 DAP, respectively. The sole soybean at 266,666 plants/ha and sole maize at 53,330 plants/ha were maintained as control for the determination of land equivalent ratio (LER). Soybean was sown on the crest of the ridge at 75 cm (inter-row) by 5 cm (intra-row) spacing. Maize was sown at the base of the ridge at 35, 30, and 25 cm apart (intra-row spacing) to achieve the population densities of 38000, 44440 and 53330 plants/ha, respectively. Soybean was intercropped at 266 666 plants/ha.

Mixed fertilizer NPK was separately applied to soybean by drilling at 21 DAP to supply 10 kg N, 36 kg P_2O_5 and 20 kg K_2O per hectare and this was achieved by mixing 22 kg urea + 200 kg P_2O_5 + 100 kg K_2O per ha. Also 450 kg/ha NPK (20:10:10) compound fertilizer was applied to maize stands by side dressing at the same time with soybean, that is, 21 DAP to supply 90 kg N, 45 kg P_2O_5 45 kg K_2O per ha as recommended by BNARDA (2000). This was achieved by mixing 450 kg NPK 20:10:10 (BNARDA, 2000).

Two manual weedings were done at three and six weeks after planting (WAP). A broad spectrum insecticide (Cypertex 10EC) was sprayed at 500 ml per 400 litres of water per hectare using an 18 L Jacto sprayer. This was to control leaf hoppers and grass hoppers, which are the devastating leaf eating insects in soybean (Onwueme and Sinha, 1991).

Data on plant height, number of leaves in soybean and maize were taken from five plants of each crop from the inner rows 4, 6 and 8 WAP in each plot. Nodulation in soybean was determined by counting the number of nodules per plant, and also recording nodule weight per plant at 8 WAP. Other data taken included days to 50% flowering and podding (soybean) and days to 50% tasseling and silking (maize). From five soybean plants, number of pods per plant was recorded. At physiological maturity, (brown leaf stage in soybean (Salado et al., 1993; Liu et al., 2003) and black layer formation in maize (Jagtap and Abamu, 2003; Earl and Davis, 2003), yield and yield component data were taken from each crop species from net plot area (four inner ridges) of 3 m x 2.1 m (6.3 m^2) on 100 seed weight and seed yield per hectare for soybean at 12 % moisture content (MC) (Zandstra et al., 1981) and 100 grain weight and grain yield per hectare for maize at 13 % MC (Zandstra et al., 1981). Also maize cob length was taken from five plants in each plot and from these plants, the number of grains per cob was determined.

The productivity of the intercropping system in terms of the land equivalent ratio (LER) (Willey, 1979) was used to assess the yield advantage or otherwise of the maize/soybean cropping system over the sole crops. The gross monetary return was determined to ascertain the economic viability of the system.

The data were subjected to analysis of variance for each component crop at 5% level of significance. Standard error of mean was used for treatment comparison.

RESULTS AND DISCUSSION

The early season rainfall was about double that of the late season. The soils of the experimental sites were slightly acidic, having pH of 6.08 and 6.44 and appeared adequate for the production of the crops. The organic matter was higher in the early than the late season. Soil N, available P and exchangeable K were low in both seasons. The soils were generally low in fertility.

Soybean growth and yield

There was no cropping system effect on soybean plant height in both early and late cropping seasons, except at 8 WAP when intercropped plants were taller than the sole crops (Table 1). Samsoy-2 soybean plants were always taller than TGX 1448-2E at all ages of growth in both seasons but at 8 WAP in the early season planting, there was no significant difference ($P > 0.05$) in height between the two cultivars.

Interaction between cropping system and soybean cultivar for plant height was significant only at 4 and 6 WAP in the early season planting. At these periods, intercropped Samsoy-2 was taller than the sole crop whereas sole TGX 1448-2E plants were taller than the intercrops, showing different varietal responses to the cropping systems. There was no effect of maize planting density on soybean plant heights, except at 8 WAP in early season planting when soybean plants were taller with the highest maize density (53,330 plants/ha) than other planting densities, probably because of their struggle for light. There was no soybean variety x maize planting density interaction for soybean plant height at any age of growth or growing season.

There was no effect of cropping system, soybean variety, maize planting density, cropping system x soybean variety and maize planting density x soybean variety interactions on the number of soybean leaves per plant at any age in both cropping seasons, except at 8 WAP in the early planting when Samsoy-2 had significantly ($P < 0.05$) more leaves than TGX 1448-2E (Table 2). Data on days to 50% flowering, podding and nodule production are presented in Table 3. The attainment of 50% flowering was similar whether the crop was intercropped or grown sole in both seasons while podding was earlier in the intercropped plant at early planting season. Samsoy-2 attained flowering and podding earlier than TGX 1448-2E in both seasons. Attainment of reproductive phase is a varietal characteristic as a result of different genetic constitution of the varieties. The cropping season x soybean variety interaction showed that in the late planting season, Samsoy-2 whether sole or intercropped significantly ($P < 0.01$) attained flowering earlier than TGX 1448-2E. Neither maize planting density nor maize planting density x soybean variety interaction influenced time of flowering and podding in the seasons. The cropping system neither influenced nodule production nor nodule size in both seasons (Table 3) but Samsoy-2 variety produced more and larger size nodules per plant than TGX 1448-2E. In fact, Samsoy-2 had about 400 % and 260 % more nodules and about 190 and 130 % heavier nodules per plant than TGX 1448-2E in early and late seasons, respectively. These showed that Samsoy-2 was more compatible with the native Rhizobium in the soil of the experimental area than TGX 1448-2E and hence was more nodulating than TGX 1448-2E. Interaction of cropping system x soybean variety showed that Samsoy-2 irrespective of intercropping or sole planting had more and heavier nodules than TGX 1448-2E. The number of nodules and nodule weight were highest when soybean was intercropped with the lowest maize planting density during the early season. These reduced as maize densities increased, probably because of the depressing effect of high population of maize. In the late season, maize planting density had no effect on nodule production and nodule size, may be because during the late season, characterised by low soil moisture, maize suffered moisture stress and therefore was not vigorous

Table 1. Plant height (cm) of soybean as influenced by cropping system, soybean variety and maize planting density in 2004 early and late cropping seasons.

Treatment	Early			Late		
	Plant height (cm)					
	Weeks after planting			Weeks after planting		
	4	6	8	4	6	8
Cropping system						
Sole	19.20	34.77	46.67	20.92	38.35	46.10
Intercrop	18.93	35.62	54.33	20.30	40.43	50.62
Se	0.281	0.968	1.858	0.435	1.230	1.326
Sig.	ns	ns	*	ns	ns	ns
Soybean varieties						
TGX 1448-2E	18.27	33.45	50.10	18.00	32.23	41.98
Samsoy-2	19.87	36.93	50.90	23.22	46.55	54.73
Se	0.281	0.968	1.858	0.435	1.230	1.326
Sig.	**	*	Ns	**	**	**
Cropping system x Soybean variety						
Sole TGX 1448-2E	19.10	34.80	49.40	18.67	32.50	40.47
Intercrop TGX 1448-2E	17.43	32.10	50.80	17.33	31.97	43.50
Sole Samsoy-2	19.30	34.73	43.93	23.17	44.20	51.73
Intercrop Samsoy-2	20.43	39.13	57.87	23.27	48.90	57.73
Se	0.398	1.369	2.628	0.616	1.739	1.875
Sig.	*	*	Ns	ns	ns	ns
Maize planting density (plants/ha)						
38,000	19.27	36.30	55.77	20.57	39.35	48.82
44,440	17.93	34.63	48.40	19.78	38.33	43.50
53,330	19.70	36.70	58.97	20.57	43.58	54.58
Se	0.787	1.711	1.759	0.542	2.242	2.486
Sig.	ns	ns	**	ns	ns	ns
Maize\planting density x soybean variety						
Se	1.114	2.420	2.488	0.766	3.171	3.515
Sig.	ns	ns	Ns	ns	Ns	ns

*, ** = significant at $P < 0.05$, 0.01, respectively, ns = not significant ($P > 0.05$)

Table 2. Number of leaves/plant of soybean as influenced by cropping system, soybean variety and maize planting density in 2004 early and late seasons.

Treatment	Early			Late		
	Number of leaves per plant					
	Weeks after planting			Weeks after planting		
	4	6	8	4	6	8
Cropping system						
Sole	11.22	18.17	75.25	15.92	35.58	75.75
Intercrop	10.86	17.96	76.24	14.79	35.65	78.03
Se	0.507	0.942	2.700	0.638	2.057	8.114
Sig.	ns	ns	ns	ns	ns	ns
Soybean varieties						
TGX 1448-2E	11.80	18.57	83.88	15.32	35.14	68.51
Samsoy-2	10.28	17.56	67.61	15.39	36.10	85.26
Se	0.507	0.942	2.700	0.638	2.057	8.114
Sig.	ns	ns	**	ns	ns	ns

Table 2 Cont.

Cropping system x Soybean variety						
Sole TGX 1448-2E	12.17	18.57	87.83	16.08	36.17	69.28
Intercrop TGX 1448-2E	11.42	18.39	79.92	14.56	34.11	67.78
Sole Samsoy-2	10.27	17.58	62.67	15.75	35.00	82.25
Intercrop Samsoy-2	10.30	17.53	72.56	15.03	37.19	88.28
Se	0.717	1.332	3.819	0.902	2.910	11.44
Sig.	ns	ns	ns	ns	ns	ns
Maize planting density (plants/ha)						
38,000	10.29	16.79	78.63	15.33	33.33	78.63
44,440	10.54	17.04	86.63	14.75	36.67	86.21
53,330	11.67	20.04	69.33	14.25	36.96	69.33
Se	0.517	1.134	6.853	0.568	2.304	6.480
Sig.	ns	ns	ns	ns	ns	ns
Maize\planting density x soybean variety						
Se	0.732	1.604	9.692	0.803	3.258	9.673
Sig.	ns	ns	ns	ns	Ns	ns

** = significant at P < 0.01, ns = not significant (P> 0.05)

Table 3. Days to flowering, podding, number of nodules per plant and nodule weight per plant as influenced by cropping system, soybean variety and maize planting density in 2004 early and late seasons

	Days to 50% flowering		**Days to 50% podding**		**No. of nodules/plant**		**Nodule wt (g/plant)**	
	Early	Late	Early	Late	Early	Late	Early	Late
Cropping system								
Sole	44.83	45.33	67.17	73.50	32.17	17.83	0.32	0.22
Intercrop	45.17	45.10	66.00	73.05	27.17	19.00	0.35	0.21
Se	0.226	0.071	0.333	0.250	6.861	3.111	0.029	0.034
Sig.	ns	ns	*	ns	ns	ns	Ns	ns
Soybean variety								
TGX 1448-2E	45.83	46.93	68.00	77.77	9.67	8.00	0.17	0.13
Samsoy-2	44.17	43.50	65.18	68.78	49.67	28.83	0.50	0.30
Se	0.226	0.071	0.333	0.25	6.861	3.111	0.029	0.034
Sig.	**	**	**	**	**	**	**	*
Cropping system x Soybean variety								
Sole TGX 1448-2E	45.67	47.33	69.00	78.33	7.00	7.33	0.13	0.13
Intercrop TGX 1448-2E	46.00	46.53	67.00	77.20	12.33	8.67	0.21	0.12
Sole Samsoy-2	44.00	43.33	65.33	68.67	57.33	28.33	0.50	0.31
Intercrop Samsoy-2	44.33	43.67	65.00	68.90	42.00	29.33	0.49	0.29
Se	0.319	0.100	0.471	0.418	9.703	4.40	0.041	0.049
Sig.	ns	**	ns	ns	**	**	**	*
Maize planting density (plants/ha)								
38,000	45.00	45.17	65.33	73.50	39.67	20.50	0.58	0.23
44,440	45.02	45.20	66.33	72.67	27.33	19.67	0.33	0.23
53,330	45.15	45.26	66.17	73.00	14.50	15.42	0.22	0.17
Se	0.197	0.211	0.445	0.232	7.156	2.978	0.076	0.036
Sig.	ns	ns	ns	ns	*	ns	*	ns
Maize planting density x soybean variety								
Sig.	ns	ns	ns	ns	*	*	*	*

Table 4. Interaction of soybean variety and maize planting density on number of nodules per plant and nodule dry weight per plant in 2004 early and late cropping seasons.

Number of nodules per plant						
	Early			Late		
	Maize planting density (plants/ha)			Maize planting density (plants/ha		
	38000	44440	53330	38000	44440	53330
Soybean variety						
TGX 1448-2E	24.00	7.67	5.67	8.33	9.67	6.00
Samsoy-2	55.33	47.00	23.33	32.67	29.67	24.83
Se		10.120			4.212	
Sig.		*			*	
Nodule dry wt (g/plant)						
Soybean variety						
TGX 1448-2E	0.47	0.20	0.13	0.11	0.17	0.09
Samsoy-2	0.70	0.47	0.30	0.34	0.29	0.25
Se		0.107			0.050	
Sig.		*			*	

* = Significant ($P < 0.05$)

enough at any population to affect the below ground attributes such as root weight (data not shown), nodule production and nodule size. However, significant ($P<$ 0.05) maize planting density x soybean variety interaction (Table 4) showed that Samsoy-2 produced higher number of nodules per plant than TGX 1448-2E at 44,440 maize plants per hectare (early season) and at all the maize planting densities (late season) while nodule dry weight per plant was heaviest with Samsoy-2 intercropped with lowest maize planting density and lightest with TGX 1448-2E intercropped with the highest maize density in both seasons.

Soybean variety TGX 1448-2E produced significantly ($P < 0.01$) more pods than Samsoy-2 in both seasons (Table 5). The cropping system x soybean variety interaction showed that in the early season planting, intercropping reduced TGX 1448-2E pods per plant but it had no effect on pods per plant of Samsoy-2. In the late season, there was no effect of intercropping on pod production of the two varieties of soybean. Neither maize planting density nor its interaction with soybean variety influenced pod production in both seasons. Data on 100 seed weight showed that the seeds were heavier for sole crop than intercrop and for TGX 1448-2E thanSamsoy-2 during the late season but there was no effects in the early season. There was no maize planting density, cropping system x soybean variety nor maize planting density x soybean variety effects on soybean 100 seed weight.

Intercropping reduced the number of soybean pods per plant by 46% in the early season and seed yield per hectare by 42 and 46% in early and late seasons, respectively. The reduction in seed yield by intercropping could be due to interspecific competition and depressive effect of maize, a C_4 species on soybean, a C_3 crop. Crops with C_4 photosynthetic pathways such as maize have been known to be dominant when intercropped with C_3 crops like soybean (Hiebsch, et al., 1995). The higher seed yield of sole over intercropped soybean had been reported by other workers (Olufajo, 1992; Muneer et al., (2004). Also, the reduction in intercropped soybean could be due to shading by the taller maize plants. Olufajo (1992) and O' Callaghan et al. (1994) reported that shading by the taller plants in mixture could reduce the photosynthetic rate of the lower growing plants and thereby reduce their yields. There was no significant cropping system x soybean variety interaction for seed yield in both seasons although the trend was for higher seed yield in sole cropping system for the two varieties. Increasing maize population significantly ($P < 0.05$) reduced soybean seed yield, especially for the early season crop; the reduction was 21 and 23% at intercropping with 44,440 and 53,330 maize plants/ha in comparison with intercropping at the lowest (38,000) maize planting density. This reduction could be because of population pressure of maize with its competition on soybean as maize planting density in the mixture increased.

When averaged over cropping system, TGX 1448-2E yielded higher than Samsoy-2, especially in the early season planting. The differences in seed yield between the two varieties in the early season could be attributed to the inherent varietal characteristics as also reported by Udealor (2002) and Ano (2005). According to Udealor (2002), different varieties of a particular crop respond differently to intercropping. Also higher seed yield of TGX 1448-2E could be because of its greater number of pods per plant than Samsoy-2.

The maize planting density x soybean variety interact-

Table 5. Yield and yield components of soybean as influenced by cropping system, soybean variety and maize planting density and interaction of maize plant density and soybean variety on seed yield in 2004 early and late

	No. of pods/plant		Pod length (cm)		100 seed wt (g)		‡Seed yield (kg/ha)	
	Early	Late	Early	Late	Early	Late	Early	Late
Cropping system								
Sole	95.00	49.83	3.77	3.62	12.98	9.05	1626.98	1005.29
Intercrop	51.00	49.67	3.65	3.59	12.05	8.37	944.21	544.98
Se	9.229	2.735	0.077	0.006	0.274	0.165	61.76	75.151
Sig.	*	ns	*	ns	ns	*	ns	**
Soybean variety								
TGX 1448-2E	104.33	59.00	3.28	3.29	12.13	9.98	1252.86	802.47
Samsoy-2	42.17	40.00	4.13	3.92	12.91	8.37	1318.34	747.80
Se	9.229	2.735	0.770	0.006	0.274	0.165	61.76	75.151
Sig.	**	**	**	**	ns	**	*	ns
Cropping system x Soybean variety								
Sole TGX 1448-2E	148.33	58.67	3.33	3.28	12.01	10.07	1772.49	1031.75
Intercrop TGX 1448-2E	60.3	60.33	3.23	3.30	12.25	9.89	733.22	573.19
Sole Samsoy-2	42.67	41.00	4.20	3.96	13.96	8.03	1481.48	978.84
Intercrop Samsoy-2	41.67	39.00	4.07	3.87	11.85	6.84	1155.19	516.76
Se	13.052	3.868	0.109	0.093	0.387	0.233	227.271	106.280
Sig.	*	ns	ns	ns	*	ns	ns	ns
Maize planting density (plants/ha)								
38,000	55.33	46.17	3.65	3.81	11.95	8.27	1097.88	462.97
44,440	45.00	51.00	3.60	3.64	12.17	8.44	873.02	589.94
53,330	53.67	52.17	3.72	3.46	12.04	8.53	846.56	582.76
Se	4.669	4.526	0.073	0.083	0.551	0.295	61.760	82.692
Sig.	ns	ns	ns	*	ns	ns	*	ns
Maize planting density x soybean variety								
Sig.	ns	ns	ns	ns	ns	ns	*	ns

Interaction of soybean variety and maize planting density on seed yield in 2004 early and late cropping seasons

	Seed yield (kg/ha)					
	Early			Late		
	Maize planting density (plants/ha)			Maize planting density (plants/ha		
	38000	44440	53330	38000	44440	53330
Soybean variety						
TGX 1448-2E	687.8	740.7	740.7	449.7	608.5	661.4
Samsoy-2	1507.3	1005.3	952.4	476.2	571.8	502.5
Se		87.34			116.94	
Sig.		*			ns	

‡ Seed yield at 12 % moisture content.
** = significant at P < 0.05, 0.01, respectively, ns = not significant (P> 0.05).

ion in the early season cropping showed that Samsoy-2 always had significantly (*P* < 0.05) higher seed yield than TGX 1448-2E at the maize planting density of 38,000 plants/ha but in the late season, TGX 1448-2E had higher seed yield than Samsoy-2 at maize density of 53,330 plants/ha indicating that Samsoy-2 could be intercropped with 38,000 maize plants/ha in the early season while TGX 1448-2E could be compatible with maize density of 53,330 plants/ha during the late season. Different varietal responses to season and intercropping at varying planting density of component crops have been reported in okra/cassava system (Olasantan, 2003).

Maize growth and yield

In the early season planting, there was no significant (*P* > 0.05) effect of soybean variety in intercrop with maize or maize planting density on maize plant height and leaf production at any age of the maize plants (Table 6). Also tasselling and silking were not influenced by intercropping with soybean variety or maize planting density. Similar results were obtained in late planting, except at 6 and 8 WAP when the plants were tallest at the highest maize planting density and at 8 WAP when maize intercropped with TGX 1448-2E produced slightly more leaves than those intercropped with Samsoy -2. The cob length, number of grains per cob and 100 grain weight were not affected by soybean variety or maize planting density, except in the late season when the number of grains per cob was higher with maize/ TGX 1448-2E intercropping (Table 7). Grain yield was significantly (P < 0.05) higher in TGX 1448-2E intercropped maize than with

Table 6. Growth and development parameters of maize as influenced by soybean variety and maize planting density in 2004 early and late seasons

	Plant height (cm)			Number of leaves (cm)			Days to 50% tasseling	Days to 50% silking	Ear height (cm)
	WAP			WAP					
	4	6	8	4	6	8			
Early									
Soybean variety									
TGX 1448-2E	22.77	65.96	149.93	4.53	5.67	11.33	58.67	64.67	88.38
Samsoy-2	21.23	61.49	133.20	4.33	5.33	10.47	59.56	65.56	87.00
Se	1.218	2.659	7.479	0.162	0.205	0.416	0.402	0.470	2.954
Sig.	ns	ns	ns	ns	ns	ns	ns	ns	ns
Maize plant (plants/ha)									
38000	19.79	57.00	135.03	4.33	5.42	10.58	59.50	65.17	80.73
44,444	22.18	65.07	137.63	4.21	5.33	10.96	58.83	65.33	89.50
53330	24.25	69.10	152.03	4.75	5.75	11.17	59.00	64.33	92.83
Se	1.488	3.257	9.160	0.199	0.251	0.510	0.493	0.576	3.618
Sig.	ns	ns	ns	ns	ns	ns	ns	ns	ns
Maize plant density x soybean variety									
Se	2.104	4.605	12.954	0.281	0.036	0.271	0.697	0.814	5.177
Sig.	ns	ns	ns	ns	ns	ns	ns	ns	ns
Late									
Soybean variety									
TGX 1448-2E	25.23	79.94	174.33	5.11	7.25	11.39	70.56	77.00	96.13
Samsoy-2	25.18	78.60	162.89	4.67	6.83	10.64	70.89	77.89	95.22
Se	0.834	2.242	3.874	0.308	0.167	0.213	0.117	0.332	2.301
Sig.	ns	ns	ns	ns	ns	ns	ns	ns	ns
Maize plant (plants/ha)									
38000	24.27	75.65	160.77	4.71	6.50	10.92	70.83	77.50	92.40
44,444	24.07	25.93	164.80	5.21	7.33	10.88	70.50	77.33	95.30
53330	27.28	86.23	180.33	4.75	7.29	11.25	70.83	77.50	99.33
Se	1.021	2.745	4.745	0.377	0.205	0.261	0.143	0.406	2.818
Sig.	ns.	ns	ns	ns	ns	ns	ns	ns	ns
Maize plant density x soybean variety									
Se	1.444	3.883	6.710	0.533	0.290	0.369	0.202	0.574	3.986
Sig.	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns = Not significant

maize/Samsoy-2 cropping system in the late season but the yields were similar in the early season. The lower yield in maize/Samsoy-2 than maize/TGX 1448-2E system, especially during the stress late season could be due to vigorous growth of Samsoy-2 than TGX 1448-2E as shown in their heights and leaf productions (Tables 1 and 2). This vigorous growth of Samsoy-2 might have depressed maize yield compared with maize yields in TGX 1448-2E plots. The main effect of maize planting density showed that maize grain yield per unit area increased as maize planting density increased in both seasons, probably due to more maize cobs as maize plant population increased. This result agrees with that of Olufajo (1992) who reported that in maize/soybean intercrops, increasing maize plant density increased maize yield significantly. A significant (P < 0.05) maize planting density x soybean variety interaction in the late season indicated that grain yield was highest with the highest maize population (53,330 plants/ha) intercropped with TGX 1448-2E while the lowest maize density (38,000 plants/ha) intercropped with Samsoy-2 (Table 7). In fact, at any maize planting density, grain yield was always higher when intercropped with TGX 1448-2E than with Samsoy-2 indicating that it is better to intercrop maize with TGX 1448-2E.

Table 7. Yield and yield components of maize as influenced by soybean variety and maize planting density in 2004 early and late seasons

	Cob length (cm)		Grains per cob		100 grain wt (g)		‡Grain yield (kg/ha)	
	Early	Late	Early	Late	Early	Late	Early	Late
Soybean variety								
TGX 1448-2E	17.74	16.87	411.56	389.89	27.78	26.79	4330.70	4497.35
Samsoy-2	17.10	15.80	379.44	345.44	26.55	26.47	3835.98	3783.07
Se	0.290	0.364	11.928	7.561	0.397	0.352	226.225	113.788
Sig.	ns	Ns	ns	**	ns	ns	ns	**
Maize planting density (plants/ha)								
38,000	17.53	16.37	382.67	358.33	25.60	27.38	3202.39	3624.33
44,440	16.95	16.33	399.50	380.50	27.25	26.38	3941.80	3941.80
53,330	17.78	16.30	404.33	364.17	28.65	26.13	5105.82	4854.50
Se	0.355	0.446	14.609	9.260	0.487	0.422	277.104	139.361
Sig.	ns	Ns	ns	ns	**	ns	**	**
Maize planting density x soybean variety								
Se	0.502	0.631	20.660	13.631	0.688	0.544	391.885	197.086
Sig.	ns	Ns	ns	ns	ns	ns	ns	*

Interaction of soybean variety and maize planting density on grain yield in 2004 late season

Soybean variety	Maize planting density (plants/ha)		
	38000	44440	53330
TGX 1448-2E	4259.24	4338.62	4894.19
Samsoy-2	2989.42	3544.97	4814.82
Se		197.086	
Sig.		*	

*, ** = significant at P < 0.05, 0.01, respectively.
ns = not significant. ‡ Grain yield at 13% moisture content.

Table 8. Land equivalent ratio in maize planting density/ soybean variety in 2004 early and late seasons.

Maize planting density (plants ha[1])/soybean variety	Early season			Late season		
	Land equivalent ratio					
	Partial		Total	Partial		Total
	Maize	Soybean		Maize	Soybean	
38,000/TGX 1448-2E	0.53	0.39	0.92	0.79	0.44	1.23
38,000/Samsoy-2	0.61	1.02	1.63	0.55	0.49	1.04
44,440/TGX 1448-2E	0.78	0.42	1.20	0.80	0.59	1.39
44,440/Samsoy-2	0.62	0.68	1.30	0.66	0.58	1.24
53,330/TGX 1448-2E	1.01	0.42	1.42	1.91	0.64	1.55
53,330/Samsoy-2	0.81	0.64	1.45	0.89	0.51	1.41

Productivity of the system

The results of the intercropping systems showed that the mean land equivalent ratio (LER) values were above one in all the systems except in the 38,000 maize plants/ha + TGX 1448-2E plots in the early season (Table 8). The values above unity in most systems indicated complementarity in resource utilization by the component crops. The yield advantages in the intercropping systems (2-63%) indicated that land resource was efficiently utilised. Other researchers (Olufajo, 1992; Adeleye, 1999; Agbaje, et al., 2002) had also confirmed higher land productivity in maize/soybean intercropping and other systems. Efficient utilisation of land resource where scarcity of land makes farmers to grow many crops on small piece of land is one of the rationales of intercropping in the traditional farming systems (Willey, 1979; O'Callaghan et al., 1994).

The mean LER values increased with an increase in maize planting density from 38,000 to 53,330 plants/ha. This agreed with the reports of Huxley and Maingu (1978) who stated that LER increased at closer spacing (higher plant population) provided that the pure and intercropped plots were given the same level of management. The

Table 9. Gross monetary return in maize planting density/soybean variety in 2004 early and late seasons

Maize planting density (plants ha^{-1})/soybean variety	Early season			Late season		
	Gross Monetary return (₦/ha)			Gross Monetary return (₦/ha)		
	Partial		Total	Partial		Total
	Maize	Soybean		Maize	Soybean	
38,000/TGX 1448-2E	118625.20	61904.70	180529.90	191665.80	42725.30	234391.10
38,000/Samsoy-2	1375660	135713.70	273279.70	134523.90	45238.05	179762.00
44,440/TGX 1448-2E	174603.20	66666.60	241269.80	195237.90	57802.75	253040.70
44,440/Samsoy-2	140740.80	90476.10	231216.90	159523.70	543210	213844.70
53,330/TGX 1448-2E	226455.20	66666.60	293121.80	220238.60	62831.10	283069.70
53,330/Samsoy-2	182010.80	85984.20	267995.00	216666.90	47751.75	264418.70
Sole TGX 1448-2E	-	159524.10	159524.10	-	98016.25	98016.25
Sole Samsoy-2	-	133333.20	133333.20	-	92989.80	92989.80
Sole Maize (53,330)	204232.80	-	204232.80	218452.50	-	218452.50

LER values of 1.63, 1.30, 1.45, 1.23, 1.39 and 1.55 (Table 8) are indications of efficiency and high productivity. There was yield disadvantage of 8% as depicted by LER of 0.92 for 38,000 maize density/TGX 1448-2Ein the early season but an advantage (LER of 1.23) in the same system in the late season. The total LERs of the mixtures were contributed more by the maize component as depicted by the higher partial LER of maize in all the intercropping systems, probably because maize being a C_4 crop suppressed soybean. However, Samsoy-2 soybean variety had higher contribution than maize in the early season when intercropped with the lowest maize planting density (38,000 plants/ha).

The gross monetary returns of the cropping systems are presented in Table 9. Maize contributed more in monetary return than soybean as depicted by its higher partial monetary return than soybean, probably due to its higher yield values in spite of the higher price per kg for soybean. The total monetary return was always higher for the intercrops than the sole crops in both seasons. It was highest with 53,330 maize density/TGX 1448-2e soybean variety in both early (₦293,121.80) and late (₦283,069.70) seasons than the other cropping systems. This was followed by the 38,000 maize density/Samsoy - 2 (early season, ₦273,779.70) and 53,330 maize density/samsoy-2 (late season,₦264, 418.70). The implication of this is that the farmers in the study area would earn higher income growing maize/soybean than cropping them separately.

Conclusion

Samsoy-2 soybean could be intercropped with 38,000 maize plants/ha in the early season but in late season, TGX 1448-2E could be grown with the highest maize planting density (53,330 plants/ha) as there were highest compatibilities among the systems at the two cropping seasons, respectively. Maize should be grown at lower density in intercrop with soybean in late season with low rainfall to avoid severely depressing soybean yield. The result of the study also showed that farmers would earn more income intercropping the crops than growing them in sole cropping.

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