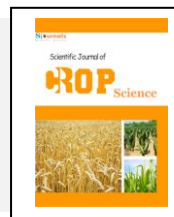


Contents lists available at Sjournals

Scientific Journal of
CROP ScienceJournal homepage: www.Sjournals.com**Original article****Soybean-maize intercropping on yield and system productivity in Makurdi, Central Nigeria****M.O. Ijoyah*, A.O. Ogar, G.O.S. Ojo***Department of Crop Production, University of Agriculture, P.M.B. 2373, Makurdi, Nigeria.*

*Corresponding author; Department of Crop Production, University of Agriculture, P.M.B. 2373, Makurdi, Nigeria.

ARTICLE INFO

ABSTRACT

Article history:

Received 23 March 2013

Accepted 18 April 2013

Available online 29 April 2013

Keywords:

Soybean

Maize

Intercropping

System productivity

Central Nigeria

Field experiments were conducted from July to November, during 2011 and 2012 cropping seasons at the Research Farm, University of Agriculture, Makurdi, Nigeria, to evaluate soybean-maize intercropping on yield and system productivity. Sole soybean, sole maize and the intercrop of soybean and maize constituted the treatments, which were laid out in a randomized complete block design with four replications. Results of study showed that intercropping soybean with maize significantly ($P \leq 0.05$) reduced soybean yield by 43.8 % and 55.6 % respectively, in 2011 and 2012. However, maize yield was not significantly ($P \leq 0.05$) affected when intercropped with soybean. Total intercrop yield was greater than the sole crop yields. Intercropping soybean and maize gave land equivalent ratio (LER) values of 1.40 and 1.29 respectively, in years 2011 and 2012, indicating that higher productivity per unit area was achieved by growing the two crops together than by growing them separately. With these LER values, 28.6 % and 22.5% of lands were saved respectively, in 2011 and 2012, which could be used for other agricultural purposes. In addition, land equivalent coefficient values exceeded 0.25, indicating yield advantage of the intercropping system. Competitive pressure of component crops was low, indicating that both crops are complementary and suitable in mixture.

© 2013 Sjournals. All rights reserved.

1. Introduction

Soybean (*Glycine max* L. Merrill) belongs to the legume family and is a native to East Asia (Dugje et al., 2009). It grows on a variety of soil and a wide range of climates (Ijoyah and Fanen, 2012).

Soybean is an important crop in Nigeria. The country is the largest producer in West and Central Africa (Root et al., 1987). It has a high protein content of 40 % by weight, 32 % carbohydrate, 20 % fat, 5 % minerals and 3 % fibre and other trace substances. It is used as sources of protein in human food and animal feed. It is also used in industries as a source of edible oil and the by-product of the oil extraction is the soybean cake used as animal feed (Atungu and Afolabi, 2001).

Maize (*Zea mays* L.) is an annual cereal plant of the gramineae family and native of Mexico (Hugar and Palled, 2008). Maize is Nigeria's third most important cereal crop following sorghum and millet (Uozie, 2001). It is grown for its grain which contains 65 % carbohydrate, 10-12 % protein and 4-8 % fat (Iken and Amusa, 2004). The crop also contains the vitamins A, B, C and E, including mineral salts and essential trace elements such as carotene, thiamine, ascorbic acid and tocopherol (Groote, 2002). Maize is used mainly for human food and livestock feed, while in the industry, it is used in the production of starch, oil and alcohol (Kling and Edmeades, 1997).

Since the introduction of soybean to farmers in Makurdi, a location in Central Nigeria, various attempts have been made to include it in various crop types like tubers and cereals, however, there is a dearth of scientific information on the performance of soybean under intercropping with cereals, particularly maize. This study was therefore designed to augment the currently available information.

2. Materials and methods

2.1. Site description and variety of crops

The experiments were conducted from July to November, 2011 and 2012 cropping seasons at the Research Farm of the University of Agriculture, Makurdi, Nigeria, to evaluate soybean-maize intercropping on yield and system productivity. The study location ($7^{\circ} 48'N$, $8^{\circ} 39'E$) and at an altitude of 228 m above sea level, falls within the Southern Guinea savannah agroecological zone of Nigeria. The variety of soybean used was 'TGX 1448-2E' (medium maturing variety), while that of maize was 'Downy mildew streak resistance-yellow' (DMSR-Y). The varieties of crops are popularly grown by farmers within the locality.

2.2. Experimental area, design, treatments and planting

The experimental area (135.0 m²) which consisted of sandy-loam soil was ploughed, harrowed, ridged and divided into 12 plots. Each plot had an area of 9.0 m². Each plot consisted of three ridges in which 10 maize stands per ridge were sown at a spacing of 1 m x 30 cm, giving a total plant population of 30 maize plants per plot (33,333 maize plants per hectare equivalent). Soybean was spaced at an intra-row spacing of 5 cm to give a plant population of 180 plants per plot (200,000 plants per hectare equivalent). The trial area consisted of three treatments (Sole soybean, sole maize and the intercrop of soybean and maize), replicated four times in a randomized complete block design. Sole soybean and sole maize were respectively sown at their recommended intra-row spacing of 5 cm and 30 cm (Dugje et al., 2009; Ijoyah and Dzer, 2012). In soles and in intercrop, maize and soybean were sown at a depth of 2-3 cm.

2.3. Cultural practices

Mixed fertilizer NPK 15-15-15 was applied to sole maize at the rate of 200 kg ha⁻¹ while 100 kg ha⁻¹ of single superphosphate was applied to sole soybean and for soybean-maize mixture, 100 kg N ha⁻¹, 100 kg P ha⁻¹ and 100 kg K ha⁻¹ was applied (Enwezor et al., 1989). Weeding was done as the need arose.

Soybean was harvested when the pods have turned brown and seeds are at the hard-dough stage with moisture content between 14 and 16 % (Dugje et al., 2009).

Maize was harvested at 12 weeks after planting (WAP) when the leaves turned yellowish and fallen off which were signs of senescence and cob maturity (Ijoyah and Jimba, 2012).

2.4. Data collection

Data taken on soybean include days to 50 % flowering, plant height (cm) at 8 weeks after planting (WAP), number of branches per plant, number of leaves per plant at 8 WAP, number of pods per plant, number of nodules per plant (determined by counting), nodule dry weight per plant, and seed yield (t ha^{-1}).

Data taken for maize include maize plant height at 50 % flowering (measured as the distance in cm from the soil surface to the collar of the top most leaf), days to 50 % flowering, number of cobs per plant, cob length (cm), cob diameter (the diameters at the head, centre and tail ends of the cobs were measured in cm and averaged) and cob weight (g). The cobs were later shelled manually and the total grains for each plot weighed to obtain the yield (t ha^{-1}).

2.5. Statistical analysis

All data were statistically treated using the Analysis of variance (ANOVA) for randomized complete block design and the Least Significant Difference (LSD) was used for mean separation ($P \leq 0.05$) following the procedure of Steel and Torrie (1980). The land equivalent ratio (LER) was determined as described by Willey (1985) using the formula:

$$\text{LER} = \frac{\text{Intercrop yield of crop A}}{\text{Sole crop yield of A}} + \frac{\text{Intercrop yield of crop B}}{\text{Sole crop yield of B}}$$

The land equivalent coefficient (LEC) as described by Adetiloye *et al.*, (1983) was determined using the formula:

$$\text{LEC} = L_a \times L_b$$
 where L_a : LER of main crop; L_b : LER of intercrop.

The competitive ratio (CR) as described by Willey and Rao (1980) was determined using the formula: $\text{CR} = L_m/L_s$, where L_m : Partial LER for maize; L_s : Partial LER for soybean.

The percentage (%) land saved as described by Willey (1985) using the formula:

$$\% \text{ Land saved} = 100 - \frac{1}{\text{LER}} \times 100$$
. These calculations were used to assess the advantage of the intercropping system.

3. Results and discussion

3.1 Soybean yield

Yield of soybean as sole and in intercrop with maize at Makurdi, Nigeria in 2011 and 2012 cropping seasons is given in Table 1. Although, days to 50 % flowering for soybean was not significantly ($P \leq 0.05$) affected when intercropped with maize, however, intercropping took longer days to attain 50 % flowering compared to that recorded for soybean planted as a sole crop. The intense overcrowding of the intercrops could have prompted competitive demands on available nutrients and moisture, thus prolonging days to attain 50 % flowering (Ijoyah and Fanen, 2012).

Intercropping produced taller soybean plants than that obtained from monocropped soybean (Table 1). The competition for light from the greater population of plants in intercropping might have induced taller soybean plants.

Greater number of branches and leaves per plant were produced from monocropped soybean compared to those from intercropped soybean. This view agreed with Silwana and Lucas (2002) who reported that intercropping reduced vegetative growth of component crops.

The number of pods per plant was significantly ($P \leq 0.05$) greater for soybean planted as a sole crop compared to when sown in intercrop with maize (Table 1). The greater number of pods produced from monocropped soybean could have been influenced by its greater number of branches and leaves. This view supports Ijoyah *et al.*, (2010), who reported that number of okra pods would depend on the intensity of plant growth. The number of pods produced from monocropped soybean was significantly ($P \leq 0.05$) greater by 42.3 % and 38.6 % respectively, in years 2011 and 2012 compared to that obtained from intercropped soybean.

Intercropping significantly ($P \leq 0.05$) reduced number of nodules per plant, nodule dry weight and seed yield compared to those produced from soybean planted as a sole crop (Table 1). Shading by taller maize plants could have contributed in the reduction of soybean yield. Higher yield in sole cropping over intercropping had also been reported by Olufajo (1992) and Muneer *et al.*, (2004). Intercropping significantly ($P \leq 0.05$) reduced soybean yield by 43.8 % and 55.6 % respectively, in years 2011 and 2012.

3.2. Yield of maize

Yield of maize as sole and in intercrop with soybean at Makurdi, Nigeria in years 2011 and 2012 cropping seasons is given in Table 2.

Intercropping prolonged days to 50 % flowering for maize. Competition for growth resources such as soil nutrients and moisture could have been responsible.

Intercropping did not significantly ($P \leq 0.05$) affect maize plant height at 50 % flowering, number of cobs per plant, cob length, cob diameter, cob weight and grain yield ($t\ ha^{-1}$). The yield obtained from monocropped maize was however greater than that produced from intercropped maize (Table 2). This could be due to the greater number of cobs and cob weight obtained. The yield produced from monocropped maize was greater by 16.3 % and 15.0 % respectively, in years 2011 and 2012 compared to that obtained from intercropped maize.

3.3. System productivity

The total intercrop yield was greater than the component crop yields (Table 3). Intercropping soybean and maize gave land equivalent ratio (LER) values of 1.40 and 1.29 respectively, in years 2011 and 2012, indicating that higher productivity per unit area was achieved by growing the two crops together than by growing them separately (Table 3). With these LER values, 28.6 % and 22.5 % of lands were saved respectively, in 2011 and 2012, which could be used for other agricultural purposes. In addition, land equivalent coefficient (LEC) values for years 2011 and 2012 exceeded 0.25, indicating yield advantage of the system. Maize was about three-fifth (3/5) as competitive as soybean. The competitive pressure of component crops was low, thus, indicating that both crops were found complementary and suitable in mixture.

4. Conclusion

From the results obtained, it can be concluded that it is advantageous intercropping soybean and maize. This is associated with a greater total intercrop yield, higher land equivalent ratios greater than 1.0, indicating greater productivity per unit area and greater percentage of land saved, which could be used for other agricultural purposes. In addition, land equivalent coefficient values exceeded 0.25, indicating yield advantage of the intercropping system. Competitive pressures were low, signifying that the crops were found to be complementary and suitable in mixture. It is, however, recommended that further investigation be evaluated across different locations within the Southern Guinea savanna agroecological zone of Nigeria.

Acknowledgement

The authors are grateful to the research technicians of the University of Agriculture Research Farm in Makurdi, for their assistance in the field operations.

Table 1

Yield of soybean as sole and in intercrop with maize at Makurdi, Nigeria in years 2011 and 2012 cropping seasons.

Treatments	Days to 50% flowering		Plant height at 8WAP		Number of branches per plant		Number of leaves per plant at 8 WAP		Number of pods per plant		Number of nodules per plant		Nodule dry weight per plant (g)		Seed yield (tha ⁻¹)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Sole soybean	54.3	54.5	64.0	73.6	7.8	8.9	65.6	70.4	50.3	52.8	15.6	17.7	0.43	0.56	1.6	1.8
Soybean-maize intercrop	55.2	54.7	76.6	81.6	6.4	8.7	48.2	51.5	29.0	32.4	14.2	15.6	0.21	0.32	0.9	0.8
Means	54.8	54.6	70.3	77.6	7.1	8.8	56.9	61.0	39.7	42.6	14.9	16.7	0.32	0.44	1.3	1.3
LSD (P ≤ 0.05)	Ns	Ns	15.2	18.7	Ns	Ns	10.2	13.9	8.6	10.2	0.8	1.5	0.08	0.05	0.4	0.7
Cv (%)	3.2	1.1	11.4	15.4	10.9	14.7	18.6	13.2	16.1	14.7	4.3	6.0	15.0	12.8	14.3	18.2

WAP: Weeks after planting.

Ns: Not significant.

Table 2

Yield of maize as sole and in intercrop with soybean at Makurdi, Nigeria in years 2011 and 2012 cropping seasons.

Treatments	Maize plant height (cm) at 50% flowering		Days to 50% flowering		Number of cobs per plant		Cob length (cm)		Cob diameter (cm)		Cob weight (g)		Grain yield (t ha ⁻¹)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Sole soybean	160.2	157.4	47.0	47.2	1.3	1.4	15.9	16.7	10.5	11.2	225.4	235.3	4.3	4.0
Soybean-maize intercrop	154.5	152.3	48.3	48.0	1.1	1.2	15.4	16.2	9.8	10.6	221.3	230.0	3.6	3.4
Means	157.4	154.9	47.7	47.6	1.2	1.3	15.7	16.5	10.2	10.9	223.4	232.7	4.0	3.7
LSD (P ≤ 0.05)	Ns	Ns	0.4	0.6	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
Cv (%)	8.2	6.0	0.8	0.7	15.4	20.9	8.0	3.6	6.4	3.8	12.2	15.0	10.7	16.8

Ns: Not significant.

Table 3

Yields of soybean and maize, intercrop yields, total intercrop yields, land equivalent ratio (LER), land equivalent coefficient (LEC), competitive ratio (CR) and percentage (%) land saved.

Treatments	Sole crop yield (t ha ⁻¹)				Intercrop yield (t ha ⁻¹)				Total intercrop yield (t ha ⁻¹)		Ls		Lm		LER		LEC		CR		% Land saved	
	Sole soybean		Sole maize		Soybean		Maize		2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
	2011	2012	2011	2012	2011	2012	2011	2012														
Soles	1.6	1.8	4.3	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Intercrop	-	-	-	-	0.9	0.8	3.6	3.4	4.5	4.2	0.56	0.44	0.84	0.85	1.40	1.29	0.47	0.37	0.67 (3/5)	0.62 (3/5)	28.6	22.5

LER= Intercrop yield of crop A + Intercrop yield of Crop B.

Sole crop yield of crop A Sole crop yield of crop B.

% Land saved= 100- 1/LER X 100.

Ls, Lm= Partial LER of soybean and maize.

CR= Ls/Lm (Division of the partial LER of the component crops).

LEC= La x Lb (LER of main and intercrop).

References

- Adetiloye, P.O., Ezedinma, F.O.C., Okigbo, B.N., 1983. A land equivalent coefficient concept for the evaluation of competitive and productive interactions on simple complex mixtures. *Ecol. Modelling*. 19, 27-39.
- Atungu, J.J., Afolabi, S.O., 2001. Field assessment of resistance of some (*Glycine max* (L) Merril) lines and varieties to *Meloidogyne spp*, using combination of gall index and grain yield. *Trop. Oil Seeds J.* 6, 41-49.
- Dugje, I.Y., Omoigui, L.O., Ekelem, F., Bandyopadhyay, R., Kumar, P.L., Kamara, A.Y., 2009. Farmers guide to soybean production in Northern Nigeria, pp. 16.
- Enwezor, W.O.E., Udo, J., Ajotade, K.A., 1989. Fertilizer procurement and distribution. Fertilizer use and management practice for crops in Nigeria. Savenda Publishers, Nsukka, Nigeria. Pp. 25-28.
- Groote, H.M., 2002. Identifying farmers preference for new maize varieties in Eastern Africa. 1st edition, CIMMYT Publishers, Nairobi, Pp. 102.
- Hugar, H.Y., Palled, Y.B., 2008. Studies on maize-vegetable intercropping systems. *Karnataka J. Agric. Sci.* 21, 162-164.
- Ijoyah, M.O., Dzer, D.M., 2012. Yield performance of okra (*Abelmoschus esculentus* L. Moench) and Maize (*Zea mays* L.) as affected by time of planting maize in Makurdi, Nigeria. *International Scholarly Research Network (ISRN Agronomy)*, Volume 2012, Article ID 485810, 7 pages, doi: 10.5402/2012/485810.
- Ijoyah, M.O., Fanen, F.T., 2012. Effects of different cropping pattern on performance of maize-soybean mixture in Makurdi, Nigeria. *Scient. J. Crop Sci.* 1(2), 39-47.
- Ijoyah, M.O., Jimba, J., 2012. Evaluation of yield and yield components of maize (*Zea mays* L.) and okra (*Abelmoschus esculentus* L. Moench) intercropping system at Makurdi, Nigeria. *J. Biodiv. and Environ. Sci.* 2(2), 38-44.
- Ijoyah, M.O., Atanu, S.O., Ojo, S., 2010. Productivity of okra (*Abelmoschus esculentus* L. Moench) at varying sowing dates in Makurdi, Nigeria. *J. Appl. Biosci.* 32, 2015-2019.
- Iken, J.E., Amusa, N.A., 2004. Maize research and production in Nigeria. *African J. Biotech.* 3, 302-307.
- Kling, J.G., Edmeades, G., 1997. Morphology and growth of maize. Research guide No 9 Training Programme. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, pp. 3-6.
- Muneer, A.P., Fida, H.M., Mumtaz, A.K., Muhammad, I.S., 2004. Performance of maize in intercropping system with soybean under different patterns and nitrogen levels. *J. Appl. Sci.* 4(2), 201-205.
- Olufajo, O.O., 1992. Response of soybean to intercropping with maize in a sub-humid tropical environment. *Trop. Oil Seeds J.* 1, 27-33.
- Root, W.R., Oyekan, P.O., Dashiell, K.E., 1987. West and Central Africa, Nigeria sets example for expansion of soybean. In *soybeans for the Tropics Research Production and Utilization*. P. 230.
- Silwana, T.T., Lucas, E.O., 2002. The effect of planting combinations and weeding and yield of component crops of maize-bean and maize-pumpkin intercrops. *J. Agric. Sci.* 138, 193-200.
- Steel, R.G.D., Torrie, J.H., 1980. Principles and procedures of statistics. A Biometrical Approach. 2nd edition, McGraw Hill, New York, 633pp.
- Uzozie, P.R., 2001. Effect of time of interplanting maize on the performance of cassava-maize intercrop. *J. Agric. Sci.* 12, 18-21.
- Willey, R.W., 1985. Evaluation and presentation of intercropping advantages. *Expl. Agric.* 21, 119-133.
- Willey, R.W., Rao, M.R., 1980. A competitive ratio for quantifying competition between intercrops. *Expl. Agric.* 16, 117-125.