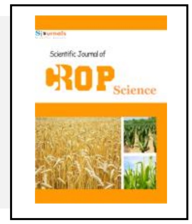
Sjournals
Scientific Journal of Crop Science (2012) 1(2) 39-47
ISSN 2322-1690

Contents lists available at Sjournals
Scientific Journal of CROP Science
Journal homepage: www.Sjournals.com



Original article

Effects of different cropping pattern on performance of maize-soybean mixture in Makurdi, Nigeria

M.O. Ijoyah[a,*], **F.T. Fanen**[b]

[a]*Department of Crop Production, University of Agriculture, P.M.B 2373, Makurdi, Nigeria.*
[b]*Department of Crop Production Technology, Akperan Orshi College of Agriculture, Yandev, Benue State, Nigeria.*

[*]Corresponding author; Department of Crop Production, University of Agriculture, P.M.B. 2373, Makurdi, Nigeria. Tel:+2348052368419.

ARTICLE INFO

Article history:
Received 15 September 2012
Accepted 25 September 2012
Available online 30 September 2012

Keywords:
Intercropping
Cropping pattern
Maize
Soybean
Nigeria

ABSTRACT

Field experiments were conducted from July to November during the 2009 and 2010 cropping seasons, at the Research Farm, University of Agriculture, Makurdi, Nigeria, to evaluate the effects of different cropping pattern on performance of maize-soybean mixture and to assess the advantage of the intercropping system. The treatments consisted of four cropping patterns, which consisted of alternating one stand of maize with one stand of soybean (1sM:1sS); one stand of maize alternated with two stands of soybean (1sM:2sS); one row of maize alternated with one row of soybean (1rM:1rS); and one row of maize alternated with two rows of soybean (1rM:2rS), while the sole crops of maize and soybean constituted the fifth and sixth treatments, which also serve as controls. The six treatments were replicated four times in a randomized complete block design. The results obtained showed that alternating 1sM:1sS gave the greatest intercrop yields of maize and soybean and highest land equivalent ratio (LER) values of 1.87 and 1.86 respectively, in years 2009 and 2010, indicating that the greatest productivity per unit area was achieved by growing the two crops together alternating 1sM:1sS, than by growing them separately. With these LER values, 46.5 % and 46.2 % of land were respectively saved in 2009 and 2010, which could be used for other agricultural purposes. This study showed that in a maize-soybean intercropping system, the appropriate cropping pattern would be alternating 1sM:1sS. This should therefore be recommended for Makurdi location, Nigeria.

1. Introduction

Soybean (*Glycine max* L. Merill) is one of the most important food legumes in Nigeria and other parts of the world. In Nigeria, it has assumed a wider scope as a result of its nutritive and economic importance and the diverse domestic usage (Atungwu and Afolabi, 2001). Also, it has been found agronomically compatible with other common arable crops. Since the introduction of soybean to Nigerian farmers, various attempts have been made to include it in various crop types like cereals and tubers. It has the 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 (Root *et al.,* 1987). It 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 agroindustries (Atungwu and Afolabi, 2001).

Maize (*Zea mays* L.) which is one of the most important cereal crops grown in Africa ranks as the third most cultivated crop in Nigeria (Ayeni, 1987), It features prominently in intercropping systems involving legumes and non-legume crops such as soybean, okra, cassava, yam, cowpea, etc (Ijoyah *et al*., 2012a). Maize is used for human food, livestock feed and a source of industrial raw material for the production of oil, alcohol and starch (Kling and Edmeades, 1997).

Grain legume-cereal crop mixtures are very popular among small scale farmers in West Africa. In the Guinea savannah agro-ecological zone, mixtures involving maize include maize-okra, maize-melon, maize-yam and maize-cassava systems (Ijoyah *et al*., 2012b). A number of studies have been conducted on monocultured maize and soybean as influenced by cropping pattern, however, those studies did not reveal the appropriate cropping pattern particularly in a maize-soybean mixture. The experiment, therefore aimed at evaluating the effects of different cropping pattern on intercropped yields of maize and soybean with the objective of identifying the appropriate cropping pattern that will maximize yields of both crops in mixture and to assess the advantage of the intercropping system.

2. Materials and methods

2.1. Site description and variety of crops

The experiments were conducted from July to November, 2009 and 2010 cropping seasons at the Research Farm of the University of Agriculture, Makurdi, Nigeria, to evaluate the effects of different cropping pattern on the performance of maize-soybean mixture. The study location (7^0 $45^/$N, 8^0 $36^/$E) and at an altitude of 228 m above sea level, falls within the Southern Guinea savannah agroecological zone of Nigeria. The meteorological information of the area over the trial period is provided in Table 1. The average monthly temperature over the years ranged from 21.2 ^{0}C to 32.4 ^{0}C, while the average relative humidity ranged from 75.2 % to 79.8 %. Mean daily radiation was low throughout the growth period while the month of July recorded the highest amount of rainfall and highest number of rainy days. The variety of soybean used was 'TGX 1448-2E' (medium maturing variety), while that of maize was 'Oba 98' (an open pollinated variety). The varieties of crops are popularly grown by farmers and shows good adaptation to the local environment.

2.2. Experimental area, design, treatments and planting

The experimental area (201.3 m^2) which consisted of sandy-loam soil was ploughed, harrowed, ridged and divided into 24 plots. Each plot had an area of 6.0 m^2. The plots consisted of four ridges in which 5 maize stands per ridge were sown at a spacing of 1m x 30 cm, giving a total plant population of 20 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 120 plants per plot (200,000 plants per hectare equivalent). The trial area consisted of six treatments, replicated four times in a randomized complete block design. Four of the treatments consisted of alternating 1 stand of maize with 1 stand of soybean (1sM:1sS); one stand of maize alternated with two stands of soybean (1sM: 2sS); one row of maize alternated with one row of soybean (1rM:1rS); and one row of maize alternated with 2 rows of soybean (1rM:2rS). Sole soybean and sole maize respectively sown at their recommended intra-row spacing of 5 cm and 30 cm (Dugje *et al.,* 2009; Ijoyah and Dzer, 2012) constituted the fifth and sixth treatments, which also served as control plots. In the intercrop, maize and soybean were sown 2-3 cm deep at the different cropping pattern.

2.3. Cultural practices

NPK 15-15-15 fertilizer was applied to maize at 200 kg ha^{-1} while 100 kg ha^{-1} of single superphosphate was applied to soybean. Both fertilizers were applied at one week after planting. At tasselling, 100 kg ha^{-1} of urea was again applied to maize (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 WAP, 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 % silking, 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. 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 competitive ratio (CR) as described by Willey and Rao (1980) was determined using the formula: CR= Lm/Ls , where Lm: Partial LER for maize; Ls: Partial LER for soybean.

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

$$\%\ \text{Land saved} = 100 - 1/\text{LER} \times 100$$

These calculations were used to assess the advantage of the intercropping system.

3. Results and discussion

3.1. Yield and yield components of soybean

Intercropping soybean and maize at the different cropping pattern took greater number of days to attain 50 % flowering compared to that recorded for sole cropping of soybean (Table 2). The intense overcrowding of the intercrops could have prompted competitive demands on available nutrients and moisture, thus prolonging days to attain 50 % flowering for soybean. Alternating 1sM:1sS recorded the greatest number of days to attain 50 % flowering.

Generally, soybean height was taller when intercropped at the different cropping pattern compared to that obtained from sole soybean (Table 2). Competition for light under intercropping could have induced taller plants at the different cropping pattern compared to sole cropping of soybean.

Table 1
Meteorological Information for Makurdi (July-November) 2009, 2010.

Year/Month	Average monthly rainfall (mm)	Average monthly temperature (°C)		Mean daily radiation (Cal cm^{-2} day^{-1})	Average relative humidity (%)
2009		Max	Min		
July	230.2(18)+	30.0	22.4	175.3	75.2
August	221.5(16)	30.1	23.2	165.0	79.8
September	196.0(12)	29.7	22.5	163.7	79.6
October	98.5(8)	31.5	22.4	160.6	78.6
November	20.0(2)	29.8	22.5	160.7	78.8
2010					
July	235.2 (20)+	30.7	22.7	164.5	76.8
August	225.0(15)	30.5	23.1	168.3	77.4
September	210.0(12)	31.4	21.2	164.0	77.8
October	110.3(7)	32.4	23.3	163.7	75.2
November	22.2(2)	32.5	23.5	164.2	75.4

+Values in parenthesis indicate number of rainy days. Source: Air Force Base, Makurdi Meteorological Station.

Table 2
Yield and Yield Components of Soybean as Affected by Different Cropping Pattern at Makurdi, Nigeria in 2009 and 2010 Cropping Seasons.

	Days to 50% flowering		Plant height (cm) at 8WAP		Number of leaves per plant at 8WAP		Number of pods per plant		Number of nodules per plant		Nodule dry weight per plant (g)		Seed yield (tha^{-1})	
Treatments	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**
Sole soybean	44.3	43.5	46.6	50.1	84.6	86.2	49.8	50.3	20.5	19.3	0.49	0.53	1.28	1.15
1sM:1sS	46.2	45.2	57.8	59.3	76.8	75.0	48.6	48.2	19.0	18.0	0.38	0.43	1.21	1.10
1sM:2sS	45.8	44.3	56.2	56.0	75.3	74.0	43.2	46.3	18.0	17.5	0.30	0.35	0.98	0.92
1rM:1rS	45.2	44.2	53.1	51.2	74.2	73.1	42.1	45.2	16.0	16.2	0.25	0.25	0.85	0.87
1rM:2rS	45.1	44.0	50.6	51.0	70.1	72.0	42.0	44.3	15.4	15.1	0.20	0,22	0.80	0.76
Means	45.3	44.2	52.9	53.5	76.2	76.1	45.1	46.9	17.8	17.2	0.32	0.36	1.02	0.96
LSD ($P \leq 0.05$)	Ns	Ns	3.5	5.6	6.5	5.3	0.8	0.6	1.2	1.0	0.08	0.06	0.10	0.08
Cv (%)	15.3	10.2	8.6	9.2	12.2	15.3	10.3	6.8	9.8	12.2	16.3	12.5	18.2	12.0

1sM:1sS = 1 stand of maize alternated with 1 stand of soybean
1sM:2sS = 1 stand of maize alternated with 2 stands of soybean
1rM:1rS = 1 row of maize alternated with 1 row of soybean
1rM:2rS = 1 row of maize alternated with 2 rows of soybean
Ns = Not significant
WAP = Weeks after Planting

Table 3

Yield and Yield Components of Maize as Affected by Different Cropping Pattern at Makurdi, Nigeria in 2009 and 2010 Cropping Seasons.

	Maize plant height at 50% flowering		Days to 50% silking		Number of cobs per plant		Cob length (cm)		Cob diameter (cm)		Cob weight (g)		Seed yield (tha^{-1})	
Treatments	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**
Sole maize	134.0	140.5	57.2	56.0	1.6	1.9	27.5	26.4	15.2	15.2	240.2	245.3	5.2	5.0
1sM:1sS	142.3	146.2	56.8	56.2	1.5	1.6	25.3	25.0	14.5	14.8	238.0	234.2	4.8	4.5
1sM:2sS	140.1	145.0	57.3	56.5	1.4	1.5	24.2	24.6	14.0	13.9	235.2	230.0	4.3	4.0
1rM:1rS	137.3	140.1	56.3	57.2	1.3	1.4	22.1	24.3	13.8	13.5	230.1	224.5	4.1	3.8
1rM:2rS	135.0	133.0	56.0	56.0	1.2	1.0	22.0	23.2	13.4	13.0	225.2	220.0	3.8	3.6
Means	137.7	141.0	56.7	56.4	1.4	1.5	24.2	24.7	14.3	14.1	233.7	230.8	4.4	4.2
LSD ($P \leq 0.05$)	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
Cv (%)	10.2	4.5	6.5	8.0	9.2	9.2	5.7	6.8	8.4	12.2	10.6	12.1	15.3	13.2

1sM:1sS = 1 stand of maize alternated with 1 stand of soybean
1sM:2sS = 1 stand of maize alternated with 2 stands of soybean
1rM:1rS = 1 row of maize alternated with 1 row of soybean
1rM:2rS = 1 row of maize alternated with 2 rows of soybean
Ns = Not significant

Table 4
Yield of Soybean and Maize, Intercrop Yields, Total Intercrop Yield, Partial Land Equivalent Ratio, Land Equivalent Ratio (LER), Competitive Ratio (CR) and Percentage (%) Land Saved as Affected by Different Cropping Pattern at Makurdi, Nigeria in 2009 and 2010 Cropping Seasons.

	Sole crop yield				Intercrop yield (t ha^{-1})															
Cropping pattern	Sole soybean		Sole maize		Soybean		Maize		Total intercrop yield (t ha^{-1})		Ls		Lm		LER		CR		% Land saved	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Soles	1.28	1.15	5.2	5.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1sM:1sS	-	-	-	-	1.21	1.10	4.8	4.5	6.0	5.6	0.95	0.96	0.92	0.90	1.87	1.86	1.03	1.07	46.5	46.2
1sM:2sS	-	-	-	-	0.98	0.92	4.3	4.0	5.3	4.9	0.77	0.80	0.83	0.80	1.60	1.60	0.93	1.00	37.5	37.5
1rM:1rS	-	-	-	-	0.85	0.87	4.1	3.8	5.0	4.7	0.66	0.76	0.79	0.76	1.45	1.52	0.84	1.00	31.0	34.2
1rM:2rS	-	-	-	-	0.80	0.76	3.8	3.6	4.6	4.4	0.63	0.66	0.73	0.72	1.36	1.38	0.86	0.92	26.5	27.5

Ls: Partial land equivalent ratio of soybean; Lm: Partial land equivalent ratio of maize
1sM:1sS = 1 stand of maize alternated with 1 stand of soybean
1sM:2sS = 1 stand of maize alternated with 2 stands of soybean
1rM:1rS = 1 row of maize alternated with 1 row of soybean
1rM:2rS = 1 row of maize alternated with 2 rows of soybean

Monocropped soybean gave the highest number of leaves per plant at 8 WAP, significantly (P≤0.05) greater than that produced from intercropped soybean at different cropping pattern. This view agreed with Silwana and Lucas (2002) who reported that intercropping reduced vegetative growth of component crops.

Planting soybean and maize at the different cropping pattern significantly (P≤0.05) reduced number of pods compared to that obtained from monocropped soybean. Under intercropping, the greatest number of pods was obtained alternating 1sM:1sS. The reduction in number of pods under the different cropping pattern as compared to sole could be due to the interspecific competition and depressive effect of maize on soybean.. 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).

Under the different cropping pattern, alternating 1sM: 1sS produced the greatest nodule number per plant, nodule weight and yield. Shading by taller maize plant under the rest cropping pattern could have contributed in the reduction of nodule number per plant, nodule weight and yield. Higher yield in sole cropping over intercropping had also been reported by Olufajo (1992) and Muneer *et al*., (2004).

3.2. Yield and yield components of maize

Maize plant height at 50 % flowering, number of days to 50 % silking, number of cobs per plant, cob length, cob diameter, cob weight and maize yield were not significantly (P≤0.05) affected by the different cropping pattern employed (Table 3). The yield of monocultured maize was greater than that produced from intercropped maize under the different cropping pattern. Under intercropping, alternating 1sM: 1sS produced the greatest maize yield of 4.8 t ha $^{-1}$ and 4.5 t ha $^{-1}$ respectively, for years 2009 and 2010. This could be due to the greater number of cobs and cob weight obtained. This view agreed with Ijoyah *et al*., (2012a) who reported that the greatest grain yield obtained when intercropped maize was sown at the maximum density of 50,000 plants ha $^{-1}$, might be due to the greatest number of cobs produced. In the year 2009, yield of intercropped maize produced from alternating 1sM:1sS was greater by 10.4 %, 14.6 % and 20.8 % respectively, compared to that produced from alternating 1sM:2sS; 1rM:1rS and 1rM:2rS, while in 2010, it was greater by 11.1 %, 15.6 and 20.0 % respectively, compared to that obtained alternating 1sM:2sS; 1rM:1rS and 1rM:2rS.

3.3. Assessing intercropping advantages

The land equivalent ratio (LER) values were all above 1.00, signifying that it is advantageous to have both crops in intercropping at the different cropping pattern. This could be due to greater efficiency of resource utilization in intercropping. Mohta and De (1980) reported that LER increased to maximum of about 48.0 % by intercropping compared with the cereal sole crops. Intercropping maize with soybean using the cropping pattern of 1sM:1sS gave the highest LER values of 1.87 and 1.86 respectively, in years 2009 and 2010, indicating that the greatest productivity per unit area was achieved by growing the two crops together alternating 1sM:1sS than by growing them separately. With these LER values, 46.5 % and 46.2 % of land were respectively saved in 2009 and 2010, which could be used for other agricultural purposes. The average of both years, indicate that the lowest competitive pressure was recorded when planting was done alternating 1rM:2rS.

4. Conclusion

From the results obtained, it can be concluded that alternating 1sM:1sS gave the greatest intercrop yields of maize and soybean, highest land equivalent ratio value and greatest percentage of land saved. It is however, recommended that further investigation be done to evaluate a wider range of maize and soybean varieties and across different locations within the Guinea savannah agroecological zone of Nigeria.

Acknowledgement

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

References

Atungwu, J.J., Afolami, S.O., 2001. Field assessment of resistance of some (*Glycine max* (L.) Merril) lines and varieties to *Meloidogyne spp*. Using a combination of gall-index and grain yield. Trop. oil seeds J. 6, 41-49.

Ayeni, A.O., 1987. Maize production in Nigeria: Problems and Prospects, J. of Agri., 2, 123-129.

Dugje, I.Y., Omoigui, L.O., Ekeleme, F., Bandyopadhyay, R., Kumar, P.L., Kamara, A.Y., 2009. Farmers guide to soybean production in Northern Nigeria, pp16.

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.

Hiebsch, C., Tetio-Kegho, F., Chirembo, F.P., 1995. Plant density and soybean maturity in a soybean-maize intercrop. Agron. J. 87, 965-970.

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, 7pages, doi: 10.5402/2012/485810.

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. of Biodiv. Env. Sci. 2(2), 38-44.

Ijoyah, M.O., Adagba, E.O., Iorlamen, T., 2012a. Productivity of okra-maize intercropping system as influenced by varying maize plant densities in Makurdi, Nigeria. Int. J. Curr. Res. 4(4), 59-63.

Ijoyah, M.O., Amos, A., Fanen, F.T., 2012b. Effect of varying maize intra-row spacing on intercropped yields of egusi melon (*Citrullus lunatus* Thunb.) and maize (*Zea mays* L.) at Makurdi, Nigeria. Int. J. Agron. Agri. Res. 2(1), 22-29.

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.

Mohta, N.K., De, R., 1980. Intercropping maize and sorghum with soybean. Agric. Sci. 95, 112-122.

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. App. Sci. 4(2), 201-205.

Olufajo, O.O., 1992. Response of soybean to intercropping with maize in a subhumid 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.

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.