International Letters of Natural Sciences *Online: 2014-08-19*
ISSN: 2300-9675, Vol. 23, pp 36-46
doi:10.56431/p-01e1p5

Yield Evaluation of Three Sesame (*Sesamum indicum* L.) Varieties Intercropped with Maize (*Zea mays* L.) in a Southern Guinea Savannah Location, Nigeria

M. O. Ijoyah[1,*], T. Iorlamen[1], F. T. Fanen[2]

[1]Department of Crop Production, University of Agriculture, P.M.B. 2373, Makurdi, Nigeria

[2]Department of Crop Production Technology, Akperan Orshi College of Agriculture, Yandev, Nigeria
*Phone: +2348052368419

*E-mail address: mikejoy2005@yahoo.com

ABSTRACT

Field experiments were conducted from July to November during the 2012 and 2013 cropping seasons, at the Research Farm, University of Agriculture, Makurdi, Nigeria, to evaluate the yields of two newly introduced sesame varieties (Ex Sudan and SN 603) against the commonly grown variety "E-8" under intercropping with maize variety 'Oba 98'. The trial area consisted of a total of seven treatments, replicated three times in a randomized complete block design. The results showed that, though maize yield was not significantly ($P \leq 0.05$) affected by intercropping with sesame varieties, however, intercropped yield of sesame variety 'Ex Sudan' was significantly ($P \leq 0.05$) greater by 26.8 % and 25.6 % respectively, in years 2012 and 2013, compared to that obtained from intercropped sesame variety 'SN 603', and by 19.5 % and 20.9 % respectively, in years 2012 and 2013, compared to that produced from intercropped popular sesame variety 'E-8'. Intercropping maize variety 'Oba 98' with sesame variety 'Ex Sudan' gave the highest total intercrop yield, greatest biological efficiency with a relative yield total values of 0.87 and 0.91 respectively, in 2012 and 2013. The combination also recorded the highest land equivalent ratio (LER), highest land equivalent coefficient, highest area x time equivalent ratio (ATER), highest total monetary returns (₦584,200 and ₦588,600 respectively, in years 2012 and 2013) and highest monetary equivalent ratio (MER). The implication of study showed that sesame variety 'Ex Sudan' performed best and could therefore be recommended as a potential replacement for the popular variety 'E-8' under intercropping with maize variety 'Oba 98' in Makurdi, Nigeria.

***Keywords*:** intercropping; sesame; maize; crop varieties; Nigeria

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is cultivated in almost all tropical and subtropical African countries for its highly nutritious and edible seeds (Kafiriti and Deckers, 2001). In Nigeria, it is cultivated in the northern, southern guinea, sudan and sahel savannah zones (Dudley *et al*., 2000). The country is the second largest producer after Sudan (Alam *et al*., 2007). Sesame oil is of good quality, and according to Kafiriti and Deckers (2001), the oil is used for cooking, baking, candy making, soaps and alternative medicine (in the control of blood pressure, stress and tension). Leaves are used in vegetable soup, while seeds are

consumed when fried and mixed with sugar. Stems are used as wood and source of potash after burning. The sesame oil cake is a very good cattle feed, since it contains protein of high biological value (Alam *et al*., 2007).

Maize (*Zea mays* L.) is the country's third most important cereal crop following sorghum and millet (Uzozie, 2001). Maize is used mainly for human food and livestock feed. In the industry, it is important in the production of starch, oil and alcohol (Kling and Edmeades, 1997). Intercropping has been associated with such advantages as better utilization of environmental factors, greater yield stability, soil protection, variability of food supply, increasing the return per unit area and insurance against crop failure (Beets, 1982).

In Makurdi, a location in the Southern Guinea savannah, sesame variety 'E-8' is popularly grown by farmers in intercrop with maize, both for home use and source of income. It is the only variety available currently with an average yield of 0.3 t ha^{-1}. The yield is low, compared to that of other varieties grown elsewhere and in intercrop (Alam *et al*., 2007; Jakusko *et al*., 2013). This study was therefore carried out to evaluate the yields of two newly introduced sesame varieties (Ex Sudan and SN 603), against that of the commonly grown variety 'E-8', with the objective of identifying the variety with a higher yield that could displace the low yielding popular variety under intercropping with maize.

2. MATERIALS AND METHODS

2. 1. Location of study and crop varieties

The experiments were conducted from July to November, 2012 and 2013 cropping seasons at the Research Farm of the University of Agriculture, Makurdi, Nigeria, to evaluate the yield of three sesame varieties in intercrop with maize. The varieties of sesame were: 'Ex Sudan', 'SN 603' and 'E-8' (a popular variety), while that of maize was 'Oba 98'.

2. 2. Experimental area, design, treatments and cropping pattern

The experimental area (175.5 m^2), which consisted of sandy-loam soil, was ploughed, harrowed, ridged and divided into 21 plots. Each plot consisted of 3 ridges with an area of 6.0 m^2. The trial area consisted of seven treatments, replicated three times in a randomized complete block design. The intercrop treatments consisted of the three sesame varieties, each sown in mixture with maize. The three varieties of sesame sown as soles and that of sole maize constituted the fourth, fifth, sixth and seventh treatments, which also served as control plots. In the intercrop, maize was sown in a single row on top of the ridge, while sesame was sown by the side of the ridge. In the sole maize and sole sesame plots, seeds were sown about 2 cm deep, in a single row on top of ridge.

2. 3. Cultural practices

Weeding was done as the need arose. The recommended rate of compound fertilizer NPK (15:15:15) for sole maize: 100 Kg N ha^{-1}, 40 Kg P ha^{-1} and 60 Kg K ha^{-1}; for sole sesame: 30 Kg N ha^{-1}, 30 Kg P ha^{-1} and 30 Kg K ha^{-1} and for maize-sesame mixture: 100 Kg N ha^{-1}, 100 Kg P ha^{-1} and 100 Kg K ha^{-1} were applied (Enwezor *et al*., 1989). The fertilizer was applied twice to each plot at 3 and 6 weeks after planting (WAP) for the sole crops and the intercrops. Maize was harvested at 12 WAP, when the leaves turned yellowish and fallen off, which were signs of senescence and cob maturity (Ijoyah and Jimba, 2012). Sesame was harvested when capsule turned yellowish with shedding of leaves.

2. 4. Data collection

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

Data taken for sesame include days to 50 % flowering, plant height (cm) taken at maturity, number of capsules per plant, length of capsule, number of seeds per capsule and seed yield (t ha^{-1}). Other data calculated include total intercrop yield, relative yield total (RYT) as described by Subbian *et al*., (2006), land equivalent ratio (LER) and percentage (%) land saved (Willey, 1985), competitive ratio (CR) as described by Willey and Rao (1980), aggresivity (McGilchrist and Trenbath, 1971), land equivalent coefficient (LEC) as described by Adetiloye *et al*., (1983), area x time equivalent ratio (ATER) as described by Hiebsch and McCollum (1987), crop monetary returns for soles and intercrops and monetary equivalent ratio (MER) as described by Adetiloye (1988).

2. 5. Statistical analysis

All data were statistically treated using the Analysis of variance (ANOVA) and the Least Significant Difference (LSD) was used for mean separation ($P \leq 0.05$) following the procedure of Steel and Torrie (1980).

3. RESULTS AND DISCUSSION

3. 1. Yield and yield parameters of maize variety ‘Oba 98’ as affected by intercropping with varieties of sesame

The yield and yield parameters of maize variety ‘Oba 98’ as affected by intercropping with sesame varieties in a maize-sesame mixture at Makurdi, Nigeria, during 2012 and 2013 cropping seasons is given in Table 1. Greater number of days to flowering was recorded for intercropped maize compared to that recorded for sole maize (Table 1). The intense overcrowding of the intercrops could have prompted competitive demands on available nutrients, thus prolonging days to flowering. Maize plant height was taller under intercropping with sesame varieties compared to when sown as a sole crop (Table 1). Competition for light under intercropping could have been responsible for the taller plants produced. Sole maize produced higher number of leaves per plant compared to that obtained from maize in intercrop with the sesame varieties. This view agreed with that of Silwana and Lucas (2002) who reported that intercropping reduced vegetative growth of component crops. Planting maize with the sesame varieties reduced number of cobs compared to planting maize as a sole crop (Table 1). The reduction in number of cobs under intercropping could be due to the inter-specific competition of the component crops in mixture.

Table 1. Yield and yield parameters of maize variety 'Oba 98' as affected by intercropping with sesame varieties in a maize-sesame mixture at Makurdi, Nigeria, during 2012 and 2013 cropping seasons.

Varieties	Days to flowering		Maize plant height (cm) at flowering		Number of leaves per plant		Number of cobs per plant_		Cob length (cm)		Cob diameter (cm)		Cob weight (g)		Yield (t ha^{-1})	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
Sole Maize (Oba98)	48.4	49.3	93.5	94.9	10.6	10.8	1.90	1.83	15.8	15.1	12.7	12.1	140.2	139.2	4.4	4.2
Oba98+ExSudan	48.9	49.5	99.3	100.7	10.3	10.5	1.73	1.67	14.5	14.7	12.2	11.4	129.0	127.5	3.8	3.8
Oba98+SN 603	49.2	49.6	103.2	104.3	10.0	10.3	1.79	1.75	14.2	14.0	12.6	12.0	122.2	124.6	3.6	3.4
Oba 98 + E-8	49.5	49.4	100.0	99.9	10.0	10.5	1.76	1.78	14.8	14.6	12.7	12.1	120.0	124.6	3.4	3.4
LSD ($P \leq 0.05$)	0.2	0.4	3.2	4.0	0.2	0.4	0.12	0.15	4.6	6.3	5.7	3.5	7.4	5.2	0.8	0.6
Cv (%)	10.8	15.2	12.5	9.6	5.4	8.2	10.4	15.0	8.4	5.2	10.0	12.1	15.0	18.4	7.4	10.2

Though cob length, cob diameter, cob weight and maize yield were not significantly ($P \leq 0.05$) affected by intercropping with sesame varieties (Table 1), however, greater cob weight and higher maize yield were produced from sole maize compared to that obtained from intercropped maize. Higher yield in sole cropping over intercropping had also been reported by Olufajo (1992) and Muneer *et al*., (2004). Under intercropping, maize variety 'Oba 98' sown with sesame variety 'Ex Sudan' produced the highest cob weight and highest maize yield of 3.8 t ha^{-1} in years 2012 and 2013.

3. 2. Yield and yield parameters of sesame varieties planted as soles and in intercrop With maize variety 'Oba 98'

The yield and yield parameters of sesame varieties planted as soles and in intercrop with maize variety 'Oba 98' at Makurdi, Nigeria, during 2012 and 2013 cropping seasons is given in Table 2. Sesame variety 'SN 603' was the earliest to attain 50 % flowering when sown as a sole crop and in intercrop with maize compared to other sesame varieties sown as soles and in intercrop (Table 2). This could be attributed to varietal response, since varieties differ in the length of time they may remain at the vegetative stage before flowering. Sesame variety 'Ex Sudan' produced the tallest plants when sown as sole and in intercrop (Table 2). This could also be linked to its varietal characteristic. Highest number of branches per plant and highest number of leaves per plant were produced from sesame variety 'Ex Sudan' sown as sole and in intercrop with maize (Table 2). The tallest plants produced by the variety might have enhanced high phothosynthetic absorption, which could have promoted the highest number of branches per plant and highest number of leaves.

Variety 'Ex Sudan' produced the highest number of seeds per capsule and highest seed yield when compared to those obtained from other sesame varieties sown as a monocrop and in intercrop with maize (Table 2). In sole cropping, sesame seed yield obtained from 'Ex Sudan' was significantly ($P \leq 0.05$) greater than that produced from 'SN 603' by 25.6 % and 24.4 % respectively, in years 2012 and 2013, and significantly ($P \leq 0.05$) greater than that produced from the commonly grown variety 'E-8' by 20.9 % and 20.0 % respectively, in years 2012 and 2013. Under intercropping with maize variety 'Oba 98', sesame yield produced from 'Ex Sudan' was significantly ($P \leq 0.05$) greater than that obtained from 'SN 603' (26.8 % and 25.6 % respectively, in 2012 and 2013), and significantly ($P \leq 0.05$) greater than that produced from the popular variety 'E-8' (19.5 % and 20.9 % respectively, in 2012 and 2013).

3. 3. Assessment of intercropping advantages as influenced by intercropping maize variety 'Oba 98' with sesame varieties

In both years, the total intercrop yields were greater than the component crop yields (Table 3). The highest total intercrop yield was obtained when maize variety 'Oba 98' was intercropped with sesame variety 'Ex Sudan' (4.21 t ha^{-1} and 4.23 t ha^{-1} respectively, in years 2012 and 2013). The land equivalent ratio (LER) values were all above 1.00, signifying that it was advantageous intercropping maize variety 'Oba 98' with each of the sesame varieties. This could be due to greater efficiency of resource utilization in intercropping. Mohta and De (1980) reported that LER increased to maximum of 48.0 % by intercropping compared with the cereal sole crops. Intercropping maize variety 'Oba 98' with sesame variety 'Ex Sudan' gave the highest LER values of 1.86 respectively, in 2012 and 2013, indicating that the greatest productivity per unit area was achieved intercropping maize variety 'Oba 98' with sesame variety 'Ex Sudan' than growing the crops separately (Table 3).

Table 2. Yield and yield parameters of sesame varieties planted as soles and in intercrop with maize variety 'Oba 98' at Makurdi, Nigeria, during 2012 and 2013 cropping seasons.

Varieties	Days to 50 % flowering		Sesame plant height (cm) at maturity		Number of branches per plant		Number of leaves per plant		Number of capsules per plant		Number of seeds per capsule_		Seed yield (t ha^{-1})	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**1213**	**2012**	**2013**	**2012**	**2013**
Ex Sudan	51.2	51.7	48.4	46.1	9.3	9.0	48.4	46.2	124.3	126.6	78.2	80.4	0.43	0.45
SN 603	50.1	50.0	39.2	37.4	7.6	7.8	42.3	43.1	110.2	101.8	68.0	70.2	0.32	0.34
E-8	52.9	52.7	40.1	38.8	8.6	8.3	44.0	44.4	106.4	104.6	68.2	74.0	0.34	0.36
Oba98+ExSudan	50.4	50.0	56.7	54.4	9.0	9.3	47.6	45.8	96.2	93.3	76.7	79.3	0.41	0.43
Oba98+SN 603	49.9	49.7	47.2	45.4	7.9	7.7	40.2	39.2	70.0	66.9	65.8	67.2	0.30	0.32
Oba 98+E-8	53.4	53.0	49.0	47.0	8.7	8.5	45.0	43.2	80.1	76.2	69.0	70.0	0.33	0.34
LSD ($P \leq 0.05$)	0.5	0.3	1.5	2.1	0.4	0.5	2.5	1.2	6.5	8.2	3.2	3.6	0.05	0.08
Cv (%)	10.4	12.0	14.2	18.6	9.4	7.0	4.8	12.6	10.4	9.2	18.2	14.0	8.4	10.6

Table 3. Assessment of intercropping advantages as influenced by intercropping maize variety 'Oba 98' with sesame varieties at Makurdi, Nigeria, during 2012 and 2013 cropping seasons.

	Sole Crop Yields (t ha^{-1})				Intercrop Yields (t ha^{-1})													
	Solemaize		Sole sesame		Maize		Sesame		Total intercrop yield		LER		% Land Saved		ATER			
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013		
Soles	4.4	4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Ex Sudan	-	-	0.43	0.45	-	-	-	-	-	-	-	-	-	-	-	-		
SN 603	-	-	0.32	0.34	-	-	-	-	-	-	-	-	-	-	-	-		
E-8	-	-	0.34	.0.36	-	-	-	-	-	-	-	-	-	-	-	-		
Oba98+Ex Sudan	-	-	-	-	3.8	3.8	0.41	0.43	4.21	4.23	1.81	1.86	44.8	46.2	1.60	1.63		
Oba 98 + SN 603	-	-	-	-	3.6	3.4	0.30	0.32	3.90	3.72	1.76	1.75	43.2	42.9	1.55	1.55		
Oba 98 + E-8	-	-	-	-	3.4	3.2	0.33	0.3	3.73	3.56	1.74	1.70	42.5	41.2	1.55	1.55		

LER: Land Equivalent Ratio $\quad LER = \frac{\text{intercrop yield of crop A}}{\text{sole crop yield of crop A}} + \frac{\text{intercrop yield of crop B}}{\text{sole crop yield of crop B}}$;

% Land saved = $100 - \frac{1}{\text{LER}} \times 100$
ATER: area × time equivalency ratio
ATER = (Yai/Yam x ta) + (Ybi/Ybm x tb) + (Yci/Ycm x tc) / T
Where:
Yai, Ybi, Yci: yields of intercrop A, B and C
Yam, Ybm, Ycm: yields of A, B and C as monocrop
ta, tb, tc: duration of crop A, B and C in days
T: duration of the intercropping system in days

Table 4. Degree of competition, productivity coefficient and biological efficiency of component crops as influenced by intercropping maize variety 'Oba 98' with sesame varieties at Makurdi, Nigeria, during 2012 and 2013 cropping seasons.

Varieties	Lm		Ls		CR		Aggresivity		LEC		RYT	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
Oba 98 + Ex Sudan	0.86	0.90	0.95	0.96	0.91	0.94	-0.09	-0.06	0.82	0.86	0.87	0.91
Oba 98 + SN 603	0.82	0.81	0.94	0.94	0.87	0.86	-0.20	-0.13	0.77	0.76	0.83	0.82
Oba 98 + E-8	0.77	0.76	0.97	0.94	0.79	0.81	-0.20	-0.18	0.75	0.71	0.79	0.78

Lm, Ls: Partial land equivalent ratios (LER's) of component crops

CR: Competitive ratio
CR = Lm/Ls (Division of partial LER's of component crops)

$$\text{Aggressivity(A)} = \frac{\text{intercrop yield of crop A}}{\text{sole crop yield of crop A}} - \frac{\text{intercrop yield of crop B}}{\text{sole crop yield of crop B}}$$

where:
A = O: Crops are equally competitive
A = +value: Dominant crop
A = -value: Dominated crop

LEC: Land equivalent coefficient
LEC = La × Lb (product of the partial LER of main and intercrop)
RYT: Relative yield total

$$\text{RYT} = \frac{\text{Yield of component crop 'A' in intercrop with componenet crop 'B'}}{\text{Yield of component crop 'A' in pure stand}} + \frac{\text{Yield of component crop 'B' in intercrop with component crop 'A'}}{\text{Yield of component crop 'B' in pure stand}}$$

Table 5. Sole crop monetary returns, intercrop monetary returns, total intercrop monetary returns and monetary equivalent ratios as affected by intercropping maize variety 'Oba 98' with sesame varieties at Makurdi, Nigeria, during 2012 and 2013 cropping seasons.

	Sole crop monetary Returns (₦ ha^{-1})				Intercrop monetary Returns (₦ ha^{-1})				Total intercrop monetary returns			
	Sole maize		Sole sesame		Maize		Sesame		(₦ ha^{-1})		MER	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
Soles	572,000	546,000	-	-	-	-	-	-	-	-	-	-
Ex Sudan	-	-	94,600	99,000	-	-	-	-	-	-	-	-
SN $_{603}$	-	-	70,400	74,800	-	-	-	-	-	-	-	-
E-8	-	-	74,800	79,200	-	-	-	-	-	-	-	-
Oba98+ExSudan	-	-	-	-	494,000	494,00	90,200	94,600	584,200	588,600	1.02	1.08
Oba 98 + SN 603	-	-	-	-	468,000	442,000	66,000	70,400	534,000	512,400	0.93	0.94
Oba 98 + E-8	-	-	-	-	442,200	416,000	72,600	74,800	51,460	490,800	0.90	0.90

₦ : denotes Naira (Nigeria currency)
MER: monetary equivalent ratio
MER = $(r_1 + r_2 + r_3)/ R$
where:
r_1, r_2 and r_3: monetary returns of component crops in mixture
R: higher sole crop monetary return compared to others

With these LER values, 44.8 % and 46.2 % of lands were respectively saved in years 2012 and 2013, which could be used for other agricultural purposes. Intercropping maize variety 'Oba 98' with sesame variety 'Ex Sudan' gave the highest area x time equivalent ratio (ATER) of 1.60 and 1.63 respectively, in 2012 and 2013 (Table 3). Highest competitive ratio (CR) was recorded for maize variety 'Oba 98' intercropped with sesame variety 'Ex Sudan' (Table 4). Sesame variety 'Ex Sudan' could have been as competitive as maize in the acquisition of growth resources. The tallest plants produced from sesame variety 'Ex Sudan' when sown as sole and in intercrop could have also promoted its competitive ability. The aggresivity values for both crops in mixture were negative for all the intercrop treatments, indicating that both crops dominated each other at particular stages of their growth cycles (Table 4). This could be attributed to their growth habit and vegetative structure. The land equivalent coefficient (LEC) recorded for the intercrop treatments were all above 0.25, indicating yield advantage of the intercropping system (Table 4). The highest LEC values were recorded for the intercrop of maize variety 'Oba 98' with sesame variety 'Ex Sudan'. The highest biological efficiency was achieved intercropping maize variety 'Oba 98' with sesame variety 'Ex Sudan', recording the relative yield total (RYT) of 0.87 and 0.91 respectively, in 2012 and 2013 (Table 4). The total intercrop monetary returns were higher than the sole crop and intercrop monetary returns (Table 5). Intercropping maize variety 'Oba 98' with sesame variety 'Ex Sudan' gave the highest total intercrop monetary returns (₦584,200 and ₦588,600 respectively, in years 2012 and 2013) and highest monetary equivalent ratios (1.02 and 1.08, respectively, in 2012 and 2013).

4. CONCLUSION

From the results obtained, it can be concluded that under intercropping with maize variety 'Oba 98', yield produced from sesame variety 'Ex Sudan' was greater than that obtained from the rest intercropped sesame varieties. It is most advantageous intercropping maize variety 'Oba 98' with sesame variety 'Ex Sudan'. This was associated with the highest total intercrop yields, highest RYT values, highest LER values, highest LEC values, highest area x time equiuvalent ratio (ATER) values, highest total intercrop monetary returns and highest monetary equivalent ratio (MER) values.

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(Received 08 August 2014; accepted 15 August 2014)