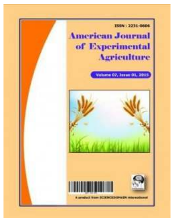

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Evaluation of Temporal Variations for Intercropping Maize and Sesame in the Southern Guinea Savanna of Nigeria

G. O. Kolawole[1*], A. B. Babalola[1], E. O. Akinola[1], T. F. Fadahunsi[1] and A. T. Ajibola[1]

[1]*Department of Crop Production and Soil Science, Ladoke Akintola University of Technology, P.M.B. 4000, Ogbomoso, 210001, Oyo State, Nigeria.*

Authors' contributions

This work was carried out in collaboration between all authors. Author GOK designed the study, wrote the protocol, managed the analyses of the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors ABB, EOA and TFF executed the field trials and collected agronomic data. Author ATA managed the literature search. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The experiments were conducted to determine effects of time of introducing sesame into maize or vice versa on the performances of the intercrops.
Study Design: Randomized complete block design replicated four times.
Place and Duration of Study: Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria in 2008 and 2009 cropping seasons.
Methodology: The treatments were (i) Sole Sesame (0 week) (ii) Sole maize (0 week) (iii) Sole Sesame – established 2 weeks later (iv) sole Maize – established 2 weeks later (v) Maize/Sesame (0 week) (vi) Maize/Sesame (sesame introduced into maize after 2 weeks) and (vii) Sesame/Maize (maize introduced into sesame after 2 weeks). The test crops were sesame *(Sesamum indicum)* variety E8 and Maize *(Zea mays)* variety ACR-9931-DMR-SR-Y. Five sesame plants were randomly selected per plot and tagged for collection of data on plant height and podding nodes. At maturity,

**Corresponding author: E-mail: ogkolawole@lautech.edu.ng;*

maize and sesame were harvested and the grain yields determined. Sub samples of the grains were taken to the laboratory and analyzed for N, P, and K contents.

Results: Both years, simultaneous sowing of maize/sesame had no adverse effect on maize yield. Introducing sesame into maize two weeks later caused significant reduction in grain yield and NPK uptakes compared with sole maize. Simultaneous planting and introducing sesame into maize 2 weeks later reduced sesame seed yield by mean of 134.5 and 1392.5% respectively compared with sole planting. Based on calculated LER, intercropping maize and sesame was superior to sole cropping and such advantage was in the range of 16 to 85%.

Conclusion: Simultaneous intercropping maize/sesame had no adverse effect on maize yield but sesame was a weak competitor, therefore, for commercial cultivation sole cropping of sesame is recommended.

Keywords: Intercropping; land equivalent ratio; maize/sesame; nutrient uptake; seed yield.

1. INTRODUCTION

Farmers in the tropics cultivate their crops through intercropping, which is the common form of traditional farming [1]. Intercropping involves planting together on the same piece of land crops that differ in productivity, growth habit and phonological characteristics [2]. Intercropping is widely practiced under low soil fertility- and low input conditions in the tropics. It may have several advantages of which general higher overall yield, higher use efficiency of natural resources and improved yield stability are important ones [3,4,5,6]. Other advantages ascribed to intercropping include insurance against crop failure thereby minimizing risk, better use of resources by plants of different heights, rooting depths and nutrient requirements and a more equal distribution of labor through the growing season [7]. Maximization of yields in crop mixtures will always be on the basis of high species compatibility [8] and the minimization of above and below ground competition for growth [9].

In the traditional framing systems of the tropics, the component crops in the mixture are not always planted on the same day [10]. The crops may be sown at the same time or different times, depending on the farmer's preference [11,12,13]. Crops may not be sown at the same time due to various reasons such as spreading labor peaks, minimizing interspecific competition for growth resources, and extending the growing periods [13]. Harper [14] reported that the earlier sown component usually becomes more aggressive than when both crops are sown simultaneously. It seems that differences in the maturity time and growth habit of the component crops are important determinants of the productivity under intercropping systems [15].

Farmers in southern Guinea savanna of Nigeria practice intercropping of maize with other crops. Okigbo and Greenland [16] reported that about seventy-five percent of the area of maize in Nigeria is in association with other crops. Maize is the more important crop as it secures the basic food requirements of the household.

Sesame (*Sesamum indicum L.*) is an important oilseed crop in the tropics and subtropics; however most of its cultivated area is in the developing countries where it is usually grown by small holders. Sesame seeds are used use for snacks, confectionery, and other bakery products. Minor uses of sesame oil include pharmaceutical and skin care products and are synergetic for insecticides. Sesame seed contain 50-60% edible oil and seed cake contains 42% protein rich in tryptophan and methionine which is an excellent feed for animals and layers [17]. Due to its multi-dimensional uses, there is increasing interest by Nigerian government to encourage farmers to cultivate sesame. Among the measures adopted to increase the production of sesame is the introduction of new varieties with high yield potentials as well as application of suitable cultural practices.

Intercropping maize (*Zea mays* L.) and sesame (*Sesamum indicum* L.) was found to maintain maize yield while producing an important cash crop to supplement small holder income. This means, it is a technique to add extra income on top of a farmers staple crop [18]. The main benefit of adding sesame to a maize crop is the possibility to generate cash shortly after harvest, when maize prices are still low. Maize and sesame are partially complementary in resource use and are hence good companion crops.

Since maize intercrop is the most dominant cropping system in Nigeria and because of the economic importance of sesame, it will be interesting to assess its performance under the dominant maize-based cropping system in

Nigerian savanna. However, there is no tangible/systematic research that has been done so far to explore the appropriate time of introducing sesame into maize or vice versa in southern Guinea savanna of Nigeria. Thus, this study was planned to determine the effect of time of introducing sesame into maize or vice versa on the performance of maize/sesame intercrops.

2. MATERIALS AND METHODS

The experiments were conducted at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Nigeria between June and October 2008 and May and September 2009. The fields used had predominantly *Imperata cylindrica* vegetation and were cleared, ploughed twice and harrowed. Top soil (0-15 cm depth) samples were taken randomly on the field using stainless soil auger before planting and bulked to form a composite. The soil was air-dried and sieved to pass through 2 mm mesh-size sieve and sub sample was drawn from the composite and taken to the laboratory for analysis. The pH was determined in 1:1 H_2O. Soil organic C was determined by a wet combustion method. Total N was determined using Kjeldahl digestion followed by distillation and titration. For exchangeable, plant available cations, soil samples were extracted with 1 N NH_4OAc (ammonium acetate), Ca and Mg were determined with an atomic absorption spectrophotometer and K by a flame photometer. The soil chemical analyses followed the procedures described by [19]. The soil of the experimental sites had sandy loam texture, neutral pH and low in N and P contents (Table 1). The monthly rainfall data for the two years is presented in Table 2.

The treatments were (i) Sole Sesame (0 week) (ii) Sole maize (0 week) (iii) Sole Sesame – established 2 weeks later (2 WAP) (iv) sole Maize – established 2 weeks later (2WAP) (v) Maize/Sesame (0WAP i.e. maize and sesame were planted the same day) (vi) Maize/Sesame (2WAP i.e. introduction of sesame into maize plot after 2 weeks of maize establishment) and (vii) Sesame/Maize (2WAP i.e. introduction of maize into sesame plot after 2 weeks). The seven treatments were replicated four times. The test crops were sesame *(Sesamum indicum)* variety E8 and Maize *(Zea mays)* variety ACR-9931-DMR-SR-Y. The experimental design was randomized complete block. Each plot measured 5 x 4 m with 1 m gap between plots and 2 m gap between replicates.

Four maize seeds were planted per hole at a depth of 2-3 cm. Sesame seeds were planted by drilling method at a depth of 1-2 cm in 50 cm inter rows. The seedlings were thinned later to achieve 25 cm intra row spacing. Inter and intra row spacing for sole maize was 75 x 25 cm respectively and that of sole and intercropped sesame was 50 x 25 cm.

For the intercrop where sesame was introduced into maize plots, 2 rows of sesame were planted between 2 maize rows leaving a distance of 12.5 cm away from each maize row. For the intercrop where maize was introduced into established sesame plots, maize was sown at 100 x 25 cm i.e., one maize row between two sesame rows.

Table 1. Particle size distribution and selected soil chemical properties of the experimental sites

Properties	2008	2009
Sand (g kg^{-1})	730	728
Silt (g kg^{-1})	110	108
Clay (g kg^{-1})	160	164
Soil pH-H_2O	7.1	6.8
Ex.Ca (cmol kg^{-1})	3.60	3.04
Ex. Mg (cmol kg^{-1})	1.30	0.35
Ex. K (cmol kg^{-1})	0.48	0.12
Ex. Na (cmol kg^{-1})	ND*	0.17
Ex. Fe (ppm)	ND	123.46
Available P (µg g^{-1})	4.04	5.12
Total N (g kg^{-1})	7.1	3.82
Organic C (g kg^{-1})	8.7	5.60

ND = Not determined

Maize and sesame was thinned to one seedling per stand at two weeks after planting. The plots were weeded manually with hoe thrice before harvesting. Fertilizer application was done twice. N.P.K 15:15:15 fertilizer was first applied to each plot a week after planting at the rate of 120 kg/hectare while side dressing was done at 3 WAP using urea at the rate of 60 kgN/hectare.

Five sesame plants were randomly selected per plot and tagged for collection of data on plant height and podding nodes. At maturity, maize and sesame were harvested and the grain yields determined. Sub samples of the grains were taken to the laboratory and analyzed for N, P, and K contents. The grain sample was ground to pass through a 20 mesh-size sieve (0.85 mm). Total N was analyzed by micro-Kjeldahl method. For determination of P and K, samples were wet-digested with a mixture of $HClO_4$-HNO_3. Phosphorus was measured colorimetrically by molybdate blue method in an auto-analyzer, K was measured by flame photometry [20].

Table 2. Monthly rainfall data (mm) at the experimental site

Month	2008	2009
January	2.6	16.4
February	8.5	16.1
March	50.5	53.2
April	83.5	158.1
May	183.9	131.3
June	220.2	208.0
July	376.8	234.9
August	252.6	275.8
September	288.8	219.5
October	176.7	160.1
November	9.2	13.7
December	5.8	12.0
Annual total	1658.1	1499.1

The net area harvested for maize and sesame was 3 x 4 m and 4 x 4 m respectively. Excluding the border rows, at 133 days after planting, sesame plants in each plot were harvested by cutting the shoot at ground level with field knife. The harvested plants/plot with pods attached was arranged in bundles, tied upright and sun dried for few days. The dry pods were thereafter separated and threshed with pestle in wooden mortar to remove the seeds. After shelling, winnowing was done to remove the chaff and unwanted residues. Clean sesame seeds were collected and weighed with electronic balance. The land equivalent ratio (LER) was calculated to ascertain the productivity of the intercropping system using the formula of [21]:

$$\text{LER (\%)} = \frac{\text{sesame seed yield in mixture}}{\text{sesame seed yield in pure stand}} + \frac{\text{maize grain yield in mixture}}{\text{maize grain yield in pure stand}}$$

Data collected were subjected to analysis of variance (ANOVA) using the SAS programme [22]. Treatment means were separated using LSD at 5% probability level.

3. RESULTS

3.1 Maize Grain Yield and Nutrient Contents

For both years, simultaneous planting of both maize and sesame had no adverse effect on maize grain yield. However, delayed planting of maize either as sole crop or introduced into sesame 2 weeks later caused significant reduction in maize grain yield (Table 3). Introducing sesame into maize 2 weeks after maize crop establishment also reduced maize grain yield significantly compared with sole maize and maize/sesame simultaneous cropping.

In 2008, delayed planting of sole maize for two weeks and introducing sesame two weeks later into maize plot significantly enhanced N, P and K contents in maize grain compared with other treatments (Table 4). Sole maize (0 week), simultaneous sowing of maize/sesame and introducing maize two weeks later into sesame had similar effects on NPK contents in maize grain. Introduction of sesame two weeks later into maize enhanced significantly N uptake in maize grain compared with other treatments (Table 3). NPK uptakes were similar in sole maize (0 week) and simultaneous sowing of maize/sesame. Delayed planting of sole maize for two weeks and introducing maize into sesame two weeks later adversely affected NPK uptakes in maize grain.

In 2009, sole maize and maize/sesame intercrops (0 and 2 WAP) had significantly higher K uptake than sole maize (2WAP) and sesame/maize (2WAP). Sole maize (0 week) and simultaneous planting of maize/sesame had significantly higher N and P uptakes than the other treatments (Table 3). The treatments had no significant effect on grain N, P, K, and Mn contents (data not shown). But all maize/sesame intercrop treatments had significantly higher Ca, Mg, Cu, Zn and Na contents than the sole cropped maize. On the other hand, sole maize had significantly higher Fe content than the other treatments (Table 5).

3.2 Sesame Seed Yield and Number of Podding Nodes

Generally, sesame seed yield was higher in 2008 than in 2009. In 2008, sesame seed yield was significantly highest in sole sesame plot (0 week) than for all other treatments (Table 6). Delayed planting of sole sesame for two weeks though reduced seed yield by about 43% compared with sole sesame planted two weeks earlier but, still produced significantly higher seed yield compared with maize/sesame intercrops. In essence, either simultaneous intercropping of maize/sesame, introducing sesame into maize established two weeks earlier or introducing maize into sesame two weeks later had adverse effect on seed yield of sesame. Number of podding nodes was significantly higher in sole sesame plots than in the intercropped plots. Sesame introduced into maize established two weeks earlier had the least number of podding nodes (Table 6).

In 2009, sole sesame (0 and 2 WAP) produced significantly more seeds than sesame/maize (2WAP) and maize/sesame (2WAP) treatments. Introducing sesame into maize after 2 weeks of maize establishment caused pronounced reduction in sesame seed yield (Table 6). Sole sesame (0 and 2 WAP) had significantly more podding nodes than maize/sesame (2 WAP) (Table 6).

Table 3. Effect of time of intercropping maize and sesame on maize grain yield and N, P and K uptakes

2008				
Treatments	**Grain yield**	**N**	**P**	**K**
	(kg/ha)	**uptake (kg/ha)**		
Sole maize (0 week)	2720a	35.09b	12.78a	11.15a
Sole maize (2WAP)	1198c	25.52b	7.31b	5.99b
Maize/sesame (0 week)	2533ab	32.93b	14.94a	10.39a
Maize/sesame (2WAP)	2088b	42.80a	13.78a	10.86a
Sesame/maize (2WAP)	1143c	14.06c	4.80b	5.03b
$LSD_{0.05}$	630	15.23	4.91	3.73

2009				
Treatments	**Grain yield**	**N**	**P**	**K**
	(kg/ha)	**uptake (kg/ha)**		
Sole maize (0 week)	2302a	33.8a	6.59a	6.97a
Sole maize (2WAP)	1233bc	16.5bc	2.82b	4.13b
Maize/sesame (0 week)	2000ab	31.5ab	5.97a	6.44a
Maize/sesame (2WAP)	1577b	22.5b	4.29ab	5.43ab
Sesame/maize (2WAP)	838c	13.0bc	2.31b	2.88b
$LSD_{0.05}$	579	11.0	2.55	2.08

Table 4. Effect of time of intercropping maize and sesame on N, P and K contents in maize grain in 2008

Treatments	**N**	**P**	**K**
		(%)	
Sole maize (0 week)	1.29b	0.47b	0.41c
Sole maize (2WAP)	2.13a	0.61a	0.50a
Maize/sesame (0 week)	1.30b	0.59a	0.41c
Maize/sesame (2WAP)	2.05a	0.66a	0.52a
Sesame/maize (2WAP)	1.23b	0.42b	0.44b
$LSD_{0.05}$	0.49	0.17	0.06

Table 5. Effect of time of intercropping maize and sesame on cation contents in maize grain in 2009

Treatments	**Ca**	**Mg**	**Cu**	**Fe**	**Zn**	**Na**
		(%)			**(ppm)**	
Sole maize (0 week)	0.213e	0.110b	0.41c	49.30a	19.46b	9.83bc
Sole maize (2WAP)	0.263d	0.133ab	0.59bc	14.38b	22.69ab	11.43ab
Maize/sesame (0 week)	0.325c	0.143ab	0.73b	15.21b	23.66ab	12.57a
Maize/sesame (2WAP)	0.373b	0.168a	0.99b	17.13b	28.12a	12.31ab
Sesame/maize (2WAP)	0.420a	0.145ab	1.34a	15.81b	25.80ab	10.66b
$LSD_{0.05}$	0.009	0.055	0.30	31.06	7.01	1.36

Table 6. Effect of time of intercropping maize and sesame on seed yield and number of podding nodes of sesame

2008		
Treatments	**Seed yield (kg/ha)**	**Number of podding nodes**
Sole sesame (0 week)	318.2a	209a
Sole sesame (2WAP)	182.0b	110b
Maize/sesame (0 week)	73.8bc	95bc
Maize/sesame (2WAP)	19.2c	21d
Sesame/maize (2WAP)	109.3b	89bc
$LSD_{0.05}$	82.9	40

2009		
Treatments	**Seed yield (kg/ha)**	**Number of podding nodes**
Sole sesame (0 week)	179.3a	176a
Sole sesame (2WAP)	158.7a	164ab
Maize/sesame (0 week)	112.9ab	136b
Maize/sesame (2WAP)	15.9c	125b
Sesame/maize (2WAP)	92.6b	152ab
$LSD_{0.05}$	69.9	37

3.3 Land Equivalent Ratio

For both years, intercropping was superior to sole cropping. In 2008, intercropping maize/sesame two weeks after the establishment of either of the two crops had greater benefits than simultaneous intercropping of both crops (Table 7). However in 2009, simultaneous cropping of maize and sesame was 50% better than sole cropping while delay in introducing sesame into maize or maize into sesame reduced the advantage of intercropping over sole cropping (Table 7).

Table 7. Land equivalent ratio of maize/sesame intercropping in 2008 and 2009

Treatments	2008	2009
Maize/sesame (0 week)	1.16	1.50
Maize/sesame (2WAP)	1.85	1.37
Sesame/maize (2WAP)	1.55	1.26

4. DISCUSSION

Simultaneous cultivation of maize and sesame for both years had no adverse effect on maize grain yield but seed yield of sesame was adversely affected. This observation is in consonance with the findings of [23,24] who reported that maize yield was not affected by the presence of soybean, but grain yield of soybean was reduced in the mixture. In the present study, when either sesame or maize was sown at different times in the mixture, the earlier sown component depressed the growth and yield of the later sown crop. Apparently the earlier sown component had an initial advantage in establishing and competing for the available resources before the later crop was introduced in the mixture. May [25], Ofori and Stern [13] have reported similar depression in growth and yield by the earlier sown crop component in *Phaseolus* beans/millet and maize/cowpea intercrop, respectively. Eagles [26] reported that early root growth was a major factor determining competitive ability with faster growing species exploiting nutrients in successive horizons of the soil much earlier than slow or later growing species. The difference in efficiency of the root system may later lead to reduced growth of the shoot of the slower growing component and ultimately shading of its leaves by those of the aggressive component [26].

The higher sesame seed yield in 2008 than in 2009 may be due to the higher rainfall amount in 2008 than in 2009 (Table 2). Sesame introduced two weeks after maize was feeble because of the shading effect of the maize associate. This shading effect apparently increased with time resulting in the reduction of photosynthetic activity and poor capsule filling. Other workers have reported similar effects [11,7]. Francis [11] showed that the yield of climbing beans in mixtures sown 15 days after maize was reduced by 77% compared with the reduction of 64% in simultaneous or same day sowing. This implies that satisfactory yields of both crops were obtained in simultaneous or same day planting as introducing one component crop ahead of the other, substantially reduced the yield of the later sown crop.

The result of this study has shown that sesame is a weak competitor when grown in mixtures with maize. Even when it was given head start of two weeks before maize was introduced, seed yield was still reduced by about 48 percent compared with sole cropping.

All intercropped maize treatments had higher cation contents in grain than sole maize. The probable reason for this complementary effect of sesame on maize may be that in the intercropping system, the component crops may exploit different soil layers, and thus in combination they may exploit a greater total volume of soil. Also, improvement in nutrient content of maize grain grown with sesame may be attributed to "mutual avoidance" [5], which imply that the roots tend to avoid the areas that have already been depleted of resources by an associated crop. Slightly higher NPK content in pearl millet/ groundnut intercrop compared with sole millet has been reported by [27] and they attributed this phenomenon to a greater competitive ability of millet.

The higher LER values obtained for both years implies that the relative grain production per unit area was substantially higher under intercropping which is especially important in areas where grain is major staple food of the people. LER was higher when the yield of the major crop (maize in this case) in the mixture was least affected by the minor or companion (sesame in this case) crop.

5. CONCLUSION

In areas where maize is the staple food, intercropping maize with sesame will be feasible without adverse effect on maize yield. The best way to do this will be to plant maize and sesame simultaneously. Sesame is a weak competitor when grown in mixture with maize, therefore, for commercial production of sesame, sole cropping is recommended.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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