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Yield Response of Intercropped Maize (Zea mays L.) and Okra (Abelmoschus esculentus L. Moench) to Seasonal Conditions at Makurdi, Nigeria

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Abstract
Field experiments were conducted during the wet seasons (May-August) in years 2008 and 2009 and dry seasons (November-February) 2008/2009 and 2009/2010, at the Research Farm, University of Agriculture, Makurdi, Nigeria, to evaluate the yield response of maize and okra mixture to seasonal conditions. The two seasons (wet and dry) affecting the three cropping systems (sole maize, sole okra and the intercrop of okra and maize) constituted the treatments, which were laid out in a randomized complete block design with four replications. Results of study showed that in the wet season, intercropping with maize significantly (P=0.05) depressed okra yield by 25.0 % and 31.0 % respectively, in 2008 and 2009, while in the dry season, yield of intercropped okra was significantly (P=0.05) depressed by 40.6 % and 43.0 % respectively, in 2008/2009 and 2009/2010, compared to that obtained from monocropped okra. Irrespective of season, intercropping did not significantly (P=0.05) affect maize yield but maize yield obtained when planted as sole and in mixture with okra was greater for the wet season compared to that obtained under dry season condition. In addition, total intercrop yield was greater in the wet season than in the dry season. Intercropping okra and maize gave greater land equivalent ratio (LER) values of 1.53 and 1.47, respectively in the wet seasons of years 2008 and 2009, than that recorded for the dry seasons of 2008/2009 and 2009/2010, thus, indicating that greater productivity per unit area was achieved by growing the two crops together than by growing them separately in the wet season compared to that under dry season condition. With these LER values, greater percentage of land were saved intercropping maize and okra in the wet season, compared to that obtained under dry season condition.
Keywords: Cropping system, seasonal conditions, maize, okra

1. Introduction

Maize (*Zea mays* L.) which ranks as the third most cultivated crop in Nigeria (Uzozie, 2001) has an annual cropping area of 1.8 million hectares of land with a national average yield estimated at 1.7 tonnes per hectare per annum (Iken and Amusa, 2004). Maize is used mainly for human food and livestock feed while in the industry, it is also very important as it is used in the production of starch, oil and alcohol (Kling and Edmeades, 1997).

Okra (*Abelmoschus esculentus* L. Moench) is one of the priority vegetable crops in Nigeria and ranks third in production area following tomato and onion (Grubben, 1999). It is a nutritious vegetable, rich in vitamins, calcium, potassium and other minerals (Tindall, 1986; Poggio, 2005).,

Over 60 % of the okra and 75 % of the maize grown in Nigeria are produced under intercropping systems (Iken and Amusa, 2004). Intercropping generally not only minimizes risks due to crop failure under adverse environmental conditions but also gives a higher total return per unit area of land (Ijoyah and Jimba, 2011).

In Makurdi, Nigeria, two distinct seasons are noticeable and these are the wet (May to October) and dry (November to April) seasons. The wet season is characterized by longer days and warm humid weather while the dry season is associated with relatively shorter days, high day and low night temperatures (Owonubi and Yayock, 1981). These changes in weather have been recorded to affect the growth pattern and consequently the yield of crops (Alfredo and Arturo, 1999).

Maize and okra planted as soles are sensitive to low temperature and develops poorly below 15 ^{0}C (Marsh, 1992). Studies on the optimum weather requirement for high yields from monocropped maize and okra under rainfed conditions showed that the crops perform best when the minimum and maximum temperatures are respectively between 18 ^{0}C and 35 ^{0}C (Grubben, 1999; Oyolu, 2002 and Ezeakunne, 2004). Katung (2007) reported that monocropped okra under rainfed conditions require high temperature of about 28 ^{0}C and long day length for optimum growth and development. He also reported an improvement in the performance of okra when rainfall was about 750 mm, evenly distributed with relative humidity between 80-85 %. These studies have dwelt extensively on the optimal weather requirements for the crops when planted as soles under rainfed conditions. However, there is a dearth of information on the yield response of maize and okra, either planted as soles or in intercrop under different seasonal conditions. This study was designed to augment the currently available information.

2. Materials and Methods

2.1 Site Description and Varieties

The experiment was conducted during the wet seasons (May-August), in years 2008 and 2009 and dry seasons (November-February) in 2008/2009 and 2009/2010, at the Research Farm of the University of Agriculture, Makurdi, Nigeria, to evaluate the yield response of intercropped maize and okra to seasonal conditions. The study location (7^0 44/N, 8^0 35/E) and at an altitude of 228 m above sea level falls within the Southern Guinea savanna agroecological zone of Nigeria. The dry season trial was carried out under irrigated water while the wet season trial was done under rainfed condition. Irrigated water was supplied daily throughout the period of the dry season experiment.

The average monthly rainfall, temperature, relative humidity and mean daily solar radiation during the two wet seasons of 2008 and 2009 and two dry seasons of 2008/2009 and 2009/2010 are shown in Table 1. Maximum temperatures were higher in the dry season than in the wet season while minimum temperatures recorded were higher in the wet season than in the dry season. Relative humidity values were higher in the wet than in the dry season. Mean daily sunshine hours were similar for both seasons (about 6.0 hours). Greater amount of rainfall and greater number of rainy days were recorded in the wet than in the dry season.

The variety of okra used was 'NH47-4', while that of maize was 'Oba 98' (an open pollinated variety). Both varieties are popular varieties grown by farmers and shows good adaptation to the local environment.

2.2 Treatment Plots, Planting and Design

The experimental area (175.0 m^2), which consisted of sandy-loam soil was ploughed, harrowed, ridged and divided into 12 plots each for the wet and dry seasons experiment. Each plot had an area of 12 m^2. The plot consisted of 4 ridges in which 10 okra plants per ridge were planted at a spacing of 100 cm x 30 cm, giving a total plant population of 40 okra plants per plot (33,333 okra plants per hectare equivalent). Okra seeds were planted about 2-3 cm deep in a single row on top of the ridges. Maize was planted at the same time as okra in early May for the wet season trial and in early November for the dry season trial, at the intra-row spacing of 30 cm, in a single row on top of the ridges but in between okra plants to give a plant population of 40 maize stands per plot (33,333 maize plants per hectare equivalent). Three maize seeds were planted per position, which were later thinned to one plant per position at 5 days after planting (DAP). The two seasons (wet and dry) and the three cropping systems (sole maize, sole okra and the intercrop of okra and maize) constituted the treatments, laid out in a randomized complete block design (RCBD) with four replications.

2.3 Cultural Practices

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 okra: mixed fertilizer NPK (15:15:15) at the rate of 100 kg ha^{-1} and for okra-maize mixture: 100 kg N ha^{-1}, 100 kg P ha^{-1} and 100 kg K ha^{-1} were applied (Enwezor et al., 1989). The row method of fertilizer application was employed. The fertilizer was applied twice to each plot at 3 and 6 weeks after planting (WAP) for the sole crops and the intercrops. Weeding was done using the native hoe as the need arose. The use of native hoe is a typical practice by farmers in the area.

Okra was harvested when the tip of pod was observed to break easily when pressed with the finger tip (Usman, 2001). 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. The entire plots were harvested for yield measurements.

2.4 Data Collection

Data taken for okra include plant height at 50 % flowering (measured as the distance in cm from the soil surface to the tip of the top most leaf), number of branches per plant, number of leaves per plant, leaf area at 50 % flowering, pod length (cm), pod diameter (cm), number of pods per plant and yield (t ha^{-1}).

Data taken for maize include 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 leaves per plant, number of cobs per plant, cob length (cm), cob diameter (the diameters at the head, centre and tail ends of the cob was measured in cm and averaged). The cobs were weighed using an electronic weighing balance to obtain 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 & 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 percentage (%) land saved as described by Willey (1985) using the formula:

% Land saved= 100- 1/LER x 100. These calculations were used to determine the productivity of the

intercropping system and to assess the compatibility and suitability of the crops for intercropping.

3. Results and Discussion

3.1 Yield Response of Okra to Seasonal Conditions

Yield response of okra planted as sole and in intercrop with maize to seasonal conditions at Makurdi, Nigeria is given in Table 2. Plant height of okra sown either as sole or in mixture with maize was greater in the wet season than in the dry season. The wet season experienced greater amount of rainfall and relative humidity than in the dry season. This could have influenced a greater okra height obtained in the wet season than that produced from the dry season planting. This view agreed with that of Grubben (1999) who reported an improvement in okra height when rainfall was about 750 mm, evenly distributed with relative humidity between 75-80 %. Irrespective of season, okra height was significantly ($P \leq 0.05$) greater under intercropping compared to sole cropping (Table 2). The greater plant population under intercropping and competition for light could have prompted a greater okra height (Ijoyah and Jimba, 2012).

Planting okra as sole or in mixture with maize in either of the season did not significantly ($P \leq 0.05$) affect number of branches per plant and number of leaves per plant, however, in both seasons, leaf area of okra taken at 50 % flowering was significantly ($P \leq 0.05$) greater for monocultured okra than that obtained from intercropped okra (Table 2). This view agreed with that of Madu and Nwosu (2001), who reported that crops planted as sole generally have greater efficiency in utilizing the growth environment, thus promoting a larger leaf area.

Although, pod length and pod diameter of okra planted as sole and in mixture with maize were not significantly ($P \leq 0.05$) affected by seasons, however, greater number of pods were produced in the wet season than in the dry season. The greater number of branches per plant obtained could have led to its greater number of pods produced. This view supports Ijoyah et al., (2010) who reported that the number of pods would depend on the intensity of growth of the plant. Irrespective of seasonal condition, greater number of pods were produced from monocropped okra than that obtained from intercropped okra. The greater efficiency in utilizing the growth environment under sole cropping could have promoted a greater number of pods.

Generally, greater yield of okra was obtained under the wet season condition than in the dry season condition (Table 2). The highest relative humidity range of 78.3 % and 79.6 % recorded during the two wet seasons could have prompted its greater yield compared to that obtained under dry season condition. Katung (2007) reported an improvement in the yield of okra when relative humidity was between 75.0 % - 80.0 %. Irrespective of seasonal condition, greater yield of okra was produced when planted as sole compared to that obtained from intercropped okra. The larger leaf area produced from sole okra might have promoted its greater yield. This view supports Moniruzzaman et al., (2007) who observed a correlation between leaf area and yield. During the wet season, intercropping significantly ($P \leq 0.05$) depressed okra yield by 25.0 % and 31.0 % respectively, in 2008 and 2009 compared to monocropped okra, while for the dry season planting, intercropping significantly ($P \leq 0.05$) depressed okra yield by 40.6 % and 43.3 % respectively, in 2008/2009 and 2009/2010 compared to monocropped okra (Table 2).

3.2 Yield Response of Maize to Seasonal Conditions

Irrespective of the season, intercropping okra and maize did not significantly ($P \leq 0.05$) affect maize plant height, days to 50 % flowering, number of leaves per plant, number of cobs per plant, cob length, cob diameter, cob weight and yield (Table 3), however, maize yield, either as sole or in intercrop was greater under the wet season condition compared to that produced under dry season condition (Table 3). The higher rainfall recorded during the wet season, might have promoted a greater conservation of soil moisture, thereby, facilitating greater absorption of soil nutrients, which could have led to a greater yield.

3.3 Assessing Intercropping Advantages

Total intercrop yield was greater under the wet season condition compared to that obtained under dry season condition (Table 4). In addition, the wet season planting recorded greater land equivalent ratio (LER) values of 1.53 and 1.47, respectively, in 2008 and 2009, compared to that recorded for the dry season planting. The higher LER values obtained, indicate that it is more productive having the crops in mixture in the wet season than having them together in the dry season. With these LER values, 34.6 % and 32.0 % of lands, which could be used for other agricultural purposes, were respectively saved when planting was done under the wet season conditions of 2008 and 2009, greater than that saved under the dry season conditions of 2008/2009 and 2009/2010.

4. Conclusion

From the results obtained, it can be concluded that it is more advantageous to intercrop maize and okra under the wet season condition compared to intercropping under dry season condition. This is associated with a greater total intercrop yield, higher land equivalent ratio and greater percentage of land saved. It is, however, recommended that further investigation be evaluated across a wider combination of okra and maize varieties and

across different locations within the Southern Guinea savanna agroecological zone of Nigeria.

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Table 1: Meteorological information for the two seasons, Makurdi, Nigeria

Year/ Month	Average monthly rainfall (mm)	Average monthly temperature (0C)		Average relative humidity (%)	Mean daily solar radiation (Sunshine hours)
2008 Wet Season		Max.	Min.		
May	132.00 (10)+	30.2	21.3	78.3	6.3
June	180.2 (14)	30.0	22.1	77.4	6.2
July	250.0 (20)	29.8	22.3	77.2	6.4
August	237.3 (18)	30.0	22.4	77.8	6.3
2008/ 2009 Dry Season					
November	5.0 (0)+	30.6	20.2	50.0	5.5
December	0.0	30.9	19.4	45.3	5.9
January	0.0	31.4	20.0	19.6	6.3
February	0.0	32.0	20.2	18.3	6.3
2009 Wet Season					
May	125.6 (8)+	23.9	21.0	79.6	6.1
June	224.0 (13)	32.2	23.0	77.0	6.3
July	230.2 (18)	30.0	22.4	77.2	6.4
August	221.5 (16)	30.1	23.2	79.0	6.2
2009/ 2010 Dry Season					
November	10.0(4)+	28.6	20.2	54.2	5.6
December	0.0	35.2	20.2	48.0	6.2
January	0.0	31.4	17.0	21.4	6.0
February	0.0	30.5	20.2	18.8	6.4

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

Table 2: Yield response of okra as sole and in intercrop with maize to seasonal conditions at Makurdi, Nigeria.

Season	Cropping systems	Okra plant height at 50% flowering (cm)		Number of branches per plant		Number of leaves per plant		Leaf area at 50% flowering		Pod length (cm)		Pod diameter (cm)		Number of pods per plant		Yield(t ha^{-1})	
		2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Wet	SO	73.0	70.0	4.6	4.7	12.6	11.3	209.0	210.1	8.8	8.2	8.3	8.4	14.6	13.2	5.6	5.8
	OM	82.4	85.0	4.5	4.6	12.3	11.1	175.2	182.0	8.5	8.0	7.9	8.2	10.2	9.0	4,2	4.0
	Means	77.7	77.5	4.6	4.7	12.5	11.2	192.1	196.1	8.7	8.1	8.1	8.3	12.4	11.1	4.9	4.9
	LSD (P≤ 0.05)	5.2	7.5	ns	ns	ns	ns	10.3	15.2	ns	ns	ns	ns	2.3	3.5	0.3	0.2
		2008/ 2009	2009/ 2010	2008 / 2009	2009 / 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010
Dry	SO	55.8	56.2	4.0	4.1	8.6	8.4	153.2	156.5	7.3	7.4	7.4	7.5	12.5	10.0	3.2	3.0
	OM	58.0	59.0	3.8	3.7	8.2	8.0	130.1	134.2	7.0	7.2	7.1	7.2	9.3	7.2	1.9	1.7
	Means	56.9	57.6	3.9	3.9	8.4	8.2	141.7	145.4	7.2	7.3	7.3	7.4	10.9	8.6	2.6	2.4
	LSD (P≤ 0.05)	1.0	1.5	ns	ns	ns	ns	8.5	7.2	ns	ns	ns	ns	2.0	1.7	0.3	0.5

SO: Sole okra OM: Okra-maize mixture

Table 3: Yield response of maize as sole and in intercrop with okra to seasonal conditions at Makurdi, Nigeria.

Season	Cropping systems	Maize plant height at 50% flowering (cm)		Days to 50% flowering		Number of leaves per plant		Number of cobs per plant		Cob length (cm)		Cob diameter (cm)		Cob weight (g)		Yield(t ha^{-1})	
		2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Wet	SM	175.2	172.5	47.4	48.0	14.2	12.3	1.5	1.2	18.6	18.0	16.2	15.8	379.0	376.0	4.8	4.6
	OM	163.8	169.0	46.2	46.3	12.0	10.6	1.4	1.3	17.2	16.4	15.2	15.0	360.3	353.0	3.7	3.6
	Means	169.5	170.8	46.8	47.2	13.1	11.5	1.5	1.3	17.9	17.2	15.7	15.4	369.7	364.5	4.3	4.1
	LSD (P≤ 0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
		2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010
Dry	SM	130.2	137.5	55.5	56.0	11.0	11.3	1.1	1.2	14.0	13.2	14.5	13.2	237.3	241.0	3.2	3.0
	OM	139.0	138.4	54.3	53.3	10.5	10.0	1.2	1.3	13.2	13.1	13.0	12.1	221.0	225.4	2.2	2.0
	Means	134.6	138.0	54.9	54.7	10.8	10.7	1.2	1.3	13.6	13.2	13.8	12.7	229.2	233.2	2.7	2.5
	LSD (P≤ 0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

SM: Sole maize OM: Okra-maize mixture

Table 4: Yield of okra and maize, total intercrop yield, land equivalent ratio (LER) and percentage (%) land saved from intercropping okra and maize as affected by seasonal conditions.

Season	Cropping systems	Okra yield (t ha^{-1})		Maize yield (t ha^{-1})		Total intercrop yield(t ha^{-1})		LER		% land saved	
		2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Wet	SM	-	-	4.8	4.6	-	-	-	-	-	-
	SO	5.6	5.8	-	-	-	-	-	-	-	-
	OM	4.2	4.0	3.7	3.6	7.9	7.6	1.53	1.47	0.96	0.88
		2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010	2008/ 2009	2009/ 2010
Dry	SM	-	-	3.2	3.0	-	-	-	-	-	-
	SO	3.2	3.0	-	-	-	-	-	-	-	-
	OM	1.9	1.7	2.2	2.0	4.1	3.7	1.28	1.24	0.86	0.85

SM: Sole maize SO: Sole okra OM: Okra-maize mixture

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

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