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# Evaluation of yield and yield components of Maize (*Zea mays* L.) and Okra (*Abelmoschus esculentus* L. Moench) intercropping system at Makurdi, Nigeria

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## Abstract

Field experiments were conducted from July to October during 2009 and 2010 cropping seasons at the Research Farm, University of Agriculture, Makurdi, Nigeria, to evaluate the yield and yield components of maize and okra in mixture and to assess the advantages of the intercropping system. The three cropping systems (sole maize, sole okra and the intercrop of maize and okra) constituted the treatments, which were laid out in a randomized complete block design with four replications. Results of study showed that maize yield was not significantly affected by intercropping with okra. However, intercrop okra yield was significantly ($P \leq 0.05$) depressed by 24.5 % and 25.9 % respectively, in 2009 and 2010 compared to monocropped okra. Total intercrop yield was greater than the component crop yield, either planted as sole or in mixture. Intercropping okra and maize gave land equivalent ratio (LER) values of 1.84 and 1.80 respectively, for years 2009 and 2010, indicating that higher productivity per unit area was achieved by growing the two crops together than by growing them separately. With these LER values, 45.7 % and 44.4 % of land was saved respectively, in 2009 and 2010, which could be used for other agricultural purposes. In addition, maize was about three-fifths (3/5) as competitive as okra, indicating that both crops are complimentary and suitable in mixture.

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## Introduction

Intercropping of crops by smallholder and peasant farmers has been a common practice throughout the years. Monocropping of pure stands have been emphasized because of its advantages (Gondwe, 1992). Despite the advantages of monocropping, almost all smallholder and peasant farmers in the developing world still practice intercropping (Ijoyah, 2011). This practice may allow complementary interactions in crops that have greater system resilience (Wolfe, 2000), reduce insect pest incidence (Ramert, 2002), reduce disease transfer (Wolfe, 2000) and deliver environmental benefits such as greater soil and water conservation potential (Gilley *et al.*, 2002).

Over 75 % of maize and 60 % of okra grown in Nigeria are produced under intercropping system (Ofosu-Anin and Limbani, 2007; Ijoyah and Jimba, 2011). Unamma (1999) in his studies on yields obtained from crops under intercropping reported that maize depressed the yield of yam by about 28 % in a yam-maize mixture even though the maize population used was only 50 % of the optimum for sole maize. Similarly, Ijoyah (2011) reported that tuber yield of yam-minisetts intercropped with maize was significantly ($P \leq 0.05$) depressed by 15.0 % and 16.3 % respectively, in 2003 and 2004 compared to monocultured yam-minisett.

In Nigeria, apart from interplanting maize with field crops such as yam, farmers do also intercrop with vegetable such as okra (Norman, 1992). Despite the fact that intercropping of maize and okra is a common practice in Nigeria, studies have not been conducted to evaluate the effect of intercropping on the yields of the crops. The present study was therefore carried out to determine the yield performance of maize and okra in mixture and to assess the advantages and suitability of the intercropping system.

## Materials and methods

*Site description*

The study was conducted at the Research Farm, University of Agriculture, Makurdi, Nigeria during the planting seasons of 2009 and 2010 to evaluate the yields and yield components of maize and okra in mixture and to assess the advantages and suitability of the intercropping system. The study location (7° 48/N, 8° 39/) and at an altitude of 228 m, falls within the Southern Guinea savanna 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 °C to 32.4 °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.

*Land preparation, experimental design, planting and varieties*

The experimental field was ploughed, harrowed, ridged and divided into twelve treatments plots, each measuring 3 m x 2.1 m. Each plot consisted of 3 ridges spaced 1 m apart. The three cropping systems (sole maize, sole okra and the intercrop of maize and okra) constituted the treatments. The treatments were arranged in a randomized complete block design (RCBD) with four replications.

In the sole maize plot, seeds were planted in mid-July in each year, on top of ridges, at a depth of about 2 cm using 30 cm intra-row spacing. Two maize seeds were sown per hole and later thinned to one plant per stand at 3 weeks after planting (WAP) giving a plant population density of 21 maize stands per plot (35,000 plants per hectare equivalent). In the sole okra plot, seeds were planted at a depth of 2 cm, on top of ridges, using 30 cm intra-row spacing, giving a plant population of 21 okra stands per plot (35,000 plants per hectare equivalent). The third treatment consisted of the intercrop of maize and okra at equal population densities. Okra was planted in between the stands of maize, on top of the ridges.

**Table 1.** Meteorological information for Makurdi (July– October) 2009, 2010.

| Years/ Months | 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 |
| **2010** | | **Max.** | **Min.** | | |
| 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 |

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

Both maize and okra were planted at the same time in mid-July as soles and in intercrop. The variety of maize used was 'Downy mildew early streak resistance-white' (DMESR-W), while that of okra was 'NH47-4'. Both varieties of crops are popularly grown by farmers and shows good adaptation to the local environment (Ijoyah and Kalu, 2003; Ijoyah and Jimba, 2011).

*Cultural practices*

The plots were manually weeded as the need arose. The recommended rates of compound fertilizer (NPK) for sole maize: 100 Kg N ha$^{-1}$, 40 Kg P ha$^{-1}$ and 60 Kg K ha$^{-1}$ (Ekpete, 2000); for sole okra: mixed fertilizer NPK (15:15:15) at the rate of 100 Kg ha$^{-1}$; and for the intercrop of maize and okra: 100 Kg N ha$^{-1}$, 100 Kg P ha$^{-1}$ and 100 Kg K ha$^{-1}$ (Enwezor *et al.*, 1989) were applied using the row method of application. The fertilizer was applied twice to each plot at 3 and 8 WAP.

Harvesting of maize and okra were done in late October in each year. Maize was harvested when large portion of the leaves were observed dried and falling off which are signs of senescence (Ijoyah, 2011). Okra was harvested when the tip of pod was observed to break easily when pressed with the finger tip (Usman, 2001).

*Data collection*

Data taken for okra included plant height at flowering (measured as the distance 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 (determined by the length-width method as described by Wuhua, 1985), pod length, pod diameter, number of pods per plant and yield (t $ha^{-1}$).

Data taken for maize included maize plant height (cm) at flowering, days to 50 % flowering, number of cobs per plot, cob length (cm) and cob diameter (cm) were determined using a measuring tape. The diameters at the head, centre and tail ends of the cobs were measured and averaged. The cobs were weighed using an electronic weighing balance to obtain cob weight (g). The cobs were later shelled manually, while the total grains for each plot weighed to obtain the yield (t $ha^{-1}$). Thereafter, 1000 grains were taken from the whole bulk of grains and weighed to obtain weight of 1000 grains (g).

*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:

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

The competitive ratio (CR) as described by Willey and Rao (1980) was determined using the formula: CR= Lo/Lm  Zo/Zm, where Lo: Partial LER for okra; Lm: Partial LER for maize; Zo and Zm: are the sown proportion of okra and maize respectively.

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

% Land saved= 100- 1/LER x 100. These calculations were used to assess the advantages of the intercropping system.

**Results and discussion**

The yield and yield components of okra as affected by intercropping with maize at Makurdi, Nigeria in years 2009 and 2010 is given in Table 2. The height of okra plant was significantly ($P \leq 0.05$) greater under intercropping compared to sole cropping. The greater population of plants under intercropping and competition for light and other growth resources might have induced higher plant height of okra.

Although the number of branches per plant and number of leaves per okra plant were not affected by intercropping, however, leaf area of okra was significantly ($P \leq 0.05$) greater for monocultured okra than for intercropped okra. This might be due to the competitive effect for growth resources when both crops are in mixture. Maize could have exhibited a shading effect over okra, thus promoting a reduction in the leaf area. This view agreed with that of Madu and Nwosu (2001) who reported that yams planted sole, generally have greater efficiency in utilizing the growth environment, thus promoting a larger leaf area.

In both years, pod length and pod diameter were not significantly ($P \leq 0.05$) affected by intercropping, but number of pods and okra yield were significantly ($P \leq 0.05$) greater for monocropped okra than for intercropped okra. The greatest number of pods produced for monocropped okra could have been influenced by the greater number of branches and leaves per plant. This view supports Ijoyah *et al.*, (2010) who reported that the number of pods would depend on the intensity of growth of the plant. In addition, the larger leaf area produced for sole crop might have promoted its greater yield. This view supports Moniruzzaman *et al.*, (2007) who observed a correlation between leaf area and yield. Intercropping significantly ($P \leq 0.05$) depressed okra yield by 24.5 % and 25.9 % respectively, in 2009 and 2010 compared to when okra was planted sole (Table 2).

**Table 2.** Yield and yield components of okra as affected by intercropping with maize at Makurdi, Nigeria in 2009 and 2010 planting seasons.

| Cropping system | Okra plant height at flowering(cm) | | Number of branches per plant | | Number of leaves per plant | | Leaf area at 50% flowering($cm^2$) | | Pod length(cm) | | Pod diameter(cm) | | Number of pod per plant | | Yield ($tha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 |
| Sole | 75.0 | 70.6 | 4.8 | 4.6 | 11.5 | 12.9 | 210.3 | 203.4 | 8.9 | 8.1 | 8.4 | 8.5 | 12.4 | 13.8 | 5.3 | 5.8 |
| Intercrop | 85.2 | 83.2 | 4.6 | 4.2 | 11.3 | 11.0 | 179.2 | 180.3 | 8.6 | 8.2 | 7.5 | 8.0 | 10.0 | 9.5 | 4.0 | 4.3 |
| Means | 80.1 | 76.9 | 4.7 | 4.4 | 11.4 | 12.0 | 194.8 | 191.9 | 8.8 | 8.2 | 8.0 | 8.3 | 11.2 | 11.7 | 4.7 | 5.1 |
| LSD(P=0.05) | 6.4 | 5.2 | ns | ns | ns | ns | 12.7 | 10.3 | ns | ns | ns | ns | 1.2 | 3.5 | 0.7 | 0.3 |
| Cv (%) | 13.0 | 11.2 | 17.3 | 18.5 | 13.4 | 10.5 | 9.8 | 6.4 | 18.2 | 20.4 | 15.4 | 12.0 | 8.5 | 10.2 | 8.8 | 6.7 |

Maize plant height at flowering, days to 50 % flowering, number of cobs per plot, cob length, cob diameter, cob weight, weight of 1000 grains and maize yield were not significantly affected by intercropping (Table 3) but maize yield in an okra and maize intercrop was greater by 8.2 % and 5.7 % respectively, in 2009 and 2010 compared to the yield obtained from sole maize at equivalent population density. This view agreed with Ijoyah (2011) who reported that maize yield in a yam-minisett and maize intercrop was greater by 11.7 % and 10.0 % respectively, in 2003 and 2004 compared to the yield obtained from sole maize at equivalent population density. The greater maize yield obtained under intercropping with okra could be attributed to a greater soil moisture conservation, thus, promoting a greater absorption of other growth resources. Intercrops have been identified to conserve water (Ogindo and Walker, 2005). Barhom (2001) also reported that water capture by intercrops was higher by about 7 % compared to monocrop.

The total intercrop yield was greater than the component crop yield (Table 4). Intercropping okra and maize gave land equivalent ratio (LER) values of 1.84 and 1.80 respectively, in years 2009 and 2010, indicating that higher productivity per unit area was achieved by growing the two crops together than by growing them separately (Table 4). With these LER values, 45.7 % and 44.4 % of land was saved respectively, in 2009 and 2010 and which could be used for other agricultural purposes.

Maize was about three-fifths (3/5) as competitive as okra. The competitive pressure of the component crops was low, thus, indicating that both crops are complementary and suitable in mixture.

## Conclusion

From the results obtained, it can be concluded that it is advantageous to intercrop okra with maize. This is associated with a greater total intercrop yield, higher land equivalent ratio greater than 1.0, indicating a greater productivity per unit area. In addition, a greater percentage of land was saved that can be used for other agricultural purposes. The competitive pressure between the component crops was low, indicating that both crops are complementary and suitable in mixture. It is however recommended that further investigation of study be evaluated across a wider combination of okra and maize varieties and across different locations within the Southern Guinea savanna ecological zone of Nigeria.

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