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EFFECTS OF VARIED TILLAGE METHODS ON YIELDS OF MAIZE-OKRA INTERCROPPING SYSTEM IN MAKURDI, NIGERIA

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Abstract

Field experiments were conducted from July to October, during the 2012 and 2013 cropping seasons, at the Research Farm, University of Agriculture, Makurdi, Nigeria, to evaluate the effects of varied tillage methods on yields of maize-okra mixture and to assess the advantage of the intercropping system. The treatments consisted of sowing maize-okra mixture under three tillage methods, which consisted of maize-okra mixture sown on conventional tillage (CT); maize-okra mixture sown on minimum tillage (MT) and maize-okra mixture sown on zero tillage (ZT), while the sole crops of maize and okra sown on conventional tillage (CT) constituted the fourth and fifth treatments, which also served as controls. The five treatments were replicated three times in a randomized complete block design. The results obtained showed that the greatest intercrop yields of maize and okra were obtained when sown on CT. Planting maize and okra on CT not only recorded the lowest competitive pressure but gave the highest land equivalent ratio (LER) values of 1.59 and 1.60 respectively, in years 2012 and 2013, indicating that greatest productivity per unit area was achieved by growing the two crops together on CT than growing them separately. The LER values obtained, implied that 59.0 % and 60.0 % more land would be respectively required in years 2012 and 2013 as sole crops to produce the yields under intercropping situation. Both crops were found most suitable in mixture when sown on CT. This should be recommended for Makurdi location, Nigeria.

Key words: Tillage methods, maize, okra, intercropping, guinea savannah.

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INTRODUCTION

Maize (*Zea mays* L.) ranks third following wheat and rice in the world production (Kamara *et al*., 2005). In Nigeria, based on the area cropped and quantity produced, maize was 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 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 rich in vitamins, calcium, potassium and other minerals (Poggio, 2005). The immature pods are used as boiled vegetable, while its dried form is used as soup thickener (Yadev and Dhanker, 2002).

Tillage practices have been reported to have a significant and positive impact on crop production, especially through the improvement of soil properties and good establishment of seedling through enhanced root growth (Okeleye and Oyekanmi, 2003; Bary, 2007).

Research works on the performance of monocropped maize and monocropped okra as affected by varied tillage practices have been conducted by many researchers (Tindal, 1986; Biaf, 2003; Chian, 2007). In these studies, significant and non-significant differences in growth and yield of sole maize and sole okra on conventional, minimum and zero tillage were reported. However, there exist paucity of information on the performance of intercrop maize and okra as influenced by varied tillage methods. An investigation was therefore undertaken to evaluate the effects of varied tillage methods on yields of maize-okra mixture with the objectives of identifying the appropriate tillage method that will maximize intercrop yields of maize and okra, as well as to assess the advantages of the intercropping system.

MATERIALS AND METHODS

The experiments were conducted from July to October, in years 2012 and 2013 cropping seasons, at the Research Farm of the University of Agriculture, Makurdi, Nigeria, to evaluate the effects of varied tillage methods on yields of maize-okra intercropping system.

The variety of maize used was 'Oba 98', while that of okra was 'NH47-4'. The varieties of crops are commonly grown by farmers within the locality. The experimental area (123.5 m^2) which consisted of sandy-loam soil was divided into 15 plots. Each plot had an area of 6.0 m^2. The plot consisted of a total of 20 maize plants sown at an intra-row spacing of 30 cm (33,000 plants per hectare equivalent). Okra was spaced at an intra-row spacing of 30 cm to give a plant population of 16 okra plants per plot (26,666 okra plants per hectare equivalent).

The trial area consisted of five treatments replicated three times in a randomized complete block design. The three intercrop treatments consisted of maize-okra mixture sown on conventional tillage (CT); maize-okra mixture sown on minimal tillage (MT); maize-okra mixture sown on zero tillage (ZT). Sole maize and sole okra sown on conventional tillage (CT) at their recommended intra-row spacing of 30 cm constituted the fourth and fifth treatments, which also served as control plots. Conventional tillage (CT: involves clearing, ploughing, harrowing and planting); minimum tillage (MT: involves clearing, ploughing and planting); while zero tillage (ZT: involves clearing and planting). In the intercrop plots, seeds of okra and maize were sown at the depth of 2-3 cm, with okra sown in-between maize plants.

The plots were manually weeded with the native hoe 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 Kha^{-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 fertilizer application. The fertilizers were applied twice to each plot at 3 and 8 weeks after planting (WAP) for the sole crops and the intercrops.

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 WAP, when the leaves turned yellowish and fallen off, which were signs of senescence and cob maturity (Ijoyah, 2011).

Data taken for maize include days to 50 % flowering, maize plant height at 50 % flowering (measured as the distance in cm from the soil surface to the collar of the top most leaf), number of leaves per plant, leaf area (cm^2), cob length (cm), cob diameter (the diameters at the head, centre and tail ends of the cob were measured in cm and averaged). The number of cobs per plant was also taken, while the cobs were weighed using an electronic weighing balance to obtain cob weight (g). The cobs were later shelled manually and the total weight for each plot weighed to obtain the yield (t ha^{-1}). Data taken for okra include days to 50 % flowering, okra 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 leaves per plant, number of branches per plant, leaf area (cm^2) taken at 50 % flowering, number of pods per plant, pod length (cm), pod diameter (cm), pod weight (g) and yield (t ha^{-1}). 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= Lm/Lo, where Lm: partial LER for maize; Lo: Partial LER for okra. These calculations were used to assess the advantages of the intercropping system under varied tillage methods.

RESULTS AND DISCUSSION

The yield parameters of maize as affected by varied tillage methods in a maize-okra mixture in years 2012 and 2013 is given in Table 1.

Days to attain 50 % flowering for maize, either as a sole crop or in intercrop with okra was not significantly ($P \leq 0.05$) affected by the tillage methods (Table 1). Irrespective of tillage method used, longer days were taken for intercropped maize to attain 50 % flowering, compared to that recorded for sole maize sown on conventional tillage (CT). In both years, intercropped maize sown on minimum tillage (MT) and that sown on zero tillage (ZT) took more days to attain 50 % flowering, while earlier days to flowering was recorded for intercropped maize sown on CT. The loose soil structure provided by CT could have enhanced earlier seed emergence, thereby inducing early days to attain 50 % flowering.

The tallest plant height was produced from sole maize sown on CT (Table 1). This might be attributed to lesser degree of competition for growth resources. This finding agreed with Asie (2007), who reported highest height of maize in sole cropping than intercropping. Intercropped maize sown on conventional tillage (CT) produced the tallest height compared to intercropped maize sown on minimum tillage (MT) and that sown on zero tillage (ZT). The CT could have provided ample depth of loose fertile soil, easy root penetration, as well as having its supplied nutrients securely in place for maximum absorption, thus, enhancing tallest maize height.

Though, number of maize leaves per plant was not significantly ($P \leq 0.05$) affected by the varied tillage methods (Table 1), however, largest leaf area was obtained from intercropped maize sown on CT. The CT could have provided more favorable condition for better moisture and nutrient retention, which could have enhanced a larger leaf area.

While cob length and cob diameter were not significantly ($P \leq 0.05$) affected by the varied tillage methods, number of cobs per plant, cob weight and yield were greater for intercropped maize sown on CT than those obtained from intercropped maize sown on MT and ZT (Table 1). The largest leaf area and highest number of cobs produced from intercropped maize sown on CT, could have influenced the greatest yield. Yield of intercropped maize sown on CT was significantly ($P \leq 0.05$) increased by 14.3 % and 21.7 % respectively, in years 2012 and 2013, than that produced from intercropped maize sown on MT and by 42.9 % and 43.5 % respectively, in years 2012 and 2013, compared to that obtained from intercropped maize sown on ZT. The significant differences in maize yield among CT, MT and ZT, show the sensitivity of maize to tillage treatments (Rashidi and Keshavarzpour, 2007).

The yield parameters of okra as affected by varied tillage methods in a maize-okra mixture in Makurdi, Nigeria in 2012 and 2013 cropping seasons is given in Table 2.

Days to attain 50 % flowering for okra was not significantly ($P \leq 0.05$) affected by the tillage methods. It took more days for intercropped okra sown on the varied tillage methods to attain 50 % flowering, compared to that recorded for sole okra sown on CT (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 okra. Days to attain 50 % flowering for okra occurred earliest when sown as a sole crop on CT, and flowering was delayed when okra was sown as an intercrop on ZT (Table 2).

Taller plants were produced from intercropped okra sown on CT and MT compared to that obtained from sole okra sown on CT. (Table 2). Competition for light under intercropping might have induced taller plants. The shortest height was produced from intercropped okra sown on ZT. Lack of moisture, inadequate aeration and difficulty of root penetration caused by the hard pan of the soil could have been responsible for the shortest okra height.

Sole okra sown on CT gave the highest number of leaves per plant, highest number of branches per plant and largest leaf area, significantly ($P \leq 0.05$) greater than those produced from intercropped okra sown at the varied tillage methods (Table 2). This view agreed with Silwana and Lucas (2002) who reported that intercropping reduced vegetative growth of component crops. In addition, shading from maize plants could have also contributed to the reduction in vegetative growth of intercropped okra. Crops with C4 photosynthetic pathways such as maize have been known to be dominant when intercropped with lower growing crops (Hiebsch *et al*., 1995).

Although pod length and pod diameter were not significantly ($P \leq 0.05$) affected by the different tillage methods, however, number of pods per plant, pod weight and yield were greater for sole okra sown on CT, compared to those obtained from intercropped okra sown on the different tillage methods. Under

intercropping, more pods per plant, greatest pod weight and best yield were produced from intercropped okra sown on CT (Table 2). Greater competition for available nutrients and light could have been responsible for the decrease in the production of pods, pod weight and yield obtained from MT and ZT. In addition, the largest leaf area produced from intercropped okra sown on CT, could have also influenced the greatest yield.
Intercropped yield of okra produced when sown on CT was greater than the intercrop yield of okra sown on MT (20.0 % and 14.3 % respectively, in 2012 and 2013) and greater than the yield obtained from intercropped okra sown on ZT (50.0 % and 40.5 % respectively, in 2012 and 2013).
The land equivalent ratio (LER) values recorded from CT and MT were above 1.0, indicating yield advantage, while that recorded for ZT was less than 1.0, indicating that it was not advantageous intercropping both crops on ZT. Intercropping maize with okra on CT gave the highest LER values of 1.59 and 1.60 respectively, in years 2012 and 2013, signifying that the greatest productivity per unit area was achieved by growing the two crops together on CT, than growing them separately. The LER of 1.59 and 1.60 obtained from CT implied that 59 % and 60 % more land would be respectively required in years 2012 and 2013 as sole crops to produce the yields under intercropping situation.
The average of both years indicate that the highest competitive pressure was recorded when planting of both crops was done on ZT.

CONCLUSION

From the results obtained, it can be concluded that intercropping maize and okra on CT is best. This is associated with highest intercrop yields, highest total intercrop yield and highest land equivalent ratio. It is however recommended that further investigation be done across a wider range of soil types and across different locations within the Guinea savannah agro-ecological zone of Nigeria.

Table 1: Yield parameters of maize as affected by varied tillage methods in a maize-okra mixture in Makurdi, Nigeria in 2012 and 2013 cropping seasons.

Tillage methods	Days to 50% flowering		Maize plant height at 50% flowering (cm)		Number of leaves per plant		Leaf area (cm^2)		Cob length (cm)		Cob diameter (cm)		Number of cobs per plant		Cob weight (g)		Yield ($t\ ha^{-1}$)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Sole maize (CT)	54.7	53.0	95.2	91.3	10.4	9.5	478.2	538.3	15.7	14.2	10.8	11.2	1.5	1.8	65.2	69.2	3.0	3.2
Maize+ Okra (CT)	55.4	53.3	84.4	77.8	10.2	10.0	450.1	500.1	14.3	12.1	10.6	10.4	1.3	1.6	52.0	56.4	2.1	2.3
Maize+ Okra (MT)	56.1	55.3	63.2	49.1	8.6	9.0	400.7	364.0	12.2	11.0	10.3	10.2	1.0	1.1	39.0	37.3	1.8	1.8
Maize+ Okra (ZT)	56.0	54.3	58.5	50.9	8.4	8.5	315.0	326.7	10.4	10.2	9.6	10.2	1.0	1.0	31.2	34.0	1.2	1.3
Mean	55.6	54.0	75.3	67.3	9.4	9.3	411.0	432.3	13.2	11.9	10.3	10.5	1.2	1.4	46.9	49.2	2.0	2.2
LSD ($P \leq 0.05$)	Ns	Ns	8.4	10.2	Ns	Ns	12.7	15.0	Ns	Ns	Ns	Ns	0.3	0.5	6.2	8.5	0.4	0.3
Cv (%)	8.5	10.8	18.2	15.4	10.2	8.4	7.0	4.6	5.4	2.7	8.6	5.2	12.4	11.3	10.4	8.0	10.0	17.8

Sole maize (CT): Sole maize sown on conventional tillage
Maize + Okra (CT): Maize-okra mixture sown on conventional tillage
Maize + Okra (MT): Maize –okra mixture sown on minimum tillage.
Maize + Okra (ZT): Maize-okra mixture sown on zero tillage
Ns: Not Significant.

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Table 2: Yield parameters of okra as affected by varied tillage methods in a maize-okra mixture in Makurdi, Nigeria in 2012 and 2013 cropping

Tillage methods	Days to 50% flowering		Okra plant height at 50% flowering (cm)		Number of leaves per plant		Number of branches per plant		Leaf area (cm^2) at 50% flowering		Number of pods per plant		Pod length (cm)		Pod diameter (cm)		Pod weight (g)		Yield ($t\ ha^{-1}$)	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
Sole okra (CT)	53.2	52.0	40.2	38.0	9.6	10.8	4.0	4.2	584.7	615.0	3.6	3.8	17.0	15.3	7.0	7.8	29.8	30.3	4.5	4.8
Maize + Okra (CT)	56.7	58.2	48.0	46.2	8.0	8.2	3.2	3.0	520.3	542.3	3.1	3.4	17.0	16.4	7.0	7.4	26.2	28.7	4.0	4.2
Maize + Okra (MT)	57.0	58.3	39.2	39.0	6.2	7.0	2.4	2.6	400.1	421.8	2.0	2.4	16.8	13.5	6.8	7.5	21.0	23.9	3.2	3.6
Maize + Okra (ZT)	59.4	60.1	31.0	34.3	4.6	5.0	1.2	1.5	185.3	191.8	1.0	1.2	16.3	12.5	6.3	6.5	10.2	12.5	2.0	2.5
Mean	56.6	57.2	39.6	39.4	7.1	7.8	2.7	2.8	422.6	442.7	2.4	2.7	16.8	14.4	6.8	7.3	21.8	23.9	3.4	3.8
LSD ($P \leq 0.05$)	Ns	Ns	5.2	4.1	0.5	1.0	0.2	0.3	16.2	12.4	0.2	0.1	Ns	Ns	Ns	Ns	2.5	0.7	0.04	0.02
Cv (%)	14.2	12.0	7.6	5.9	11.7	15.2	9.3	7.4	15.8	18.3	7.8	6.4	13.1	16.0	8.4	10.3	14.2	18.0	12.5	14.8

Sole okra (CT): Sole okra sown on conventional tillage
Maize + Okra (CT): Maize-okra mixture sown on conventional tillage
Maize + Okra (MT): Maize–okra mixture sown on minimum tillage.
Maize + Okra (ZT): Maize-okra mixture sown on zero tillage
Ns: Not Significant.

Table 3: Yield of maize and okra, intercrop yields, total intercrop yield, partial land equivalent ratio, land equivalent ratio (LER) and competitive ratio (CR) as affected by different tillage methods at Makurdi, Nigeria in 2012 and 2013 cropping seasons.

Tillage methods	Sole crop yields (tha^{-1})				Intercrop yields (tha^{-1})				Total intercrop yield ($t\ ha^{-1}$)		L_m		L_o		CR		LER	
	Sole maize		Sole okra		Maize		Okra											
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Soles (CT)	3.0	3.2	4.5	4.8	__	__	__	__	__	__	__	__	__	__				
Maize + Okra (CT)	__	__	__	__	2.1	2.3	4.0	4.2	6.1	6.5	0.70	0.72	0.89	0.88	0.79	0.82	1.59	1.60
Maize + Okra (MT)	__	__	__	__	1.8	1.8	3.2	3.6	5.0	5.4	0.60	0.56	0.71	0.75	0.85	0.75	1.31	1.31
Maize + Okra (ZT)	__	__	__	__	1.2	1.3	2.0	2.5	3.2	3.8	0.40	0.41	0.44	0.52	0.91	0.79	0.84	0.93

Soles (CT): Sole crops sown on conventional tillage.
Maize + Okra (CT): Maize-okra mixture sown on conventional tillage.
Maize + Okra (MT): Maize-okra mixture sown on minimum tillage.
Maize + Okra (ZT): Maize-okra mixture sown on zero tillage.
Lm: Partial LER for maize; Lo: Partial LER for okra.

- $CR: \frac{L_m}{L_O}$ (Division of partial LERs of intercrops).

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