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MAIZE (*Zea mays* L.) - OKRA (*Abelmoschus esculentus* (L.) Moench) INTERCROP AS AFFECTED BY CROPPING PATTERN IN KOGI STATE, NIGERIA

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ABSTRACT
Trials were conducted at the Kogi State University Research Farm (Longitude 7^0 06^1N, 6^0 43^1E) Anyigba, Nigeria, in the Southern Guinea Savanna ecological zone during 2005 and 2006 cropping seasons. The experiment, a Randomized Complete Block Design with three replications had a variety of maize intercropped with a variety of okra at one stand of maize alternated with one stand of okra; one stand of maize alternated with two stands of okra; one row of maize alternated one row of okra; one row of maize alternated with two rows of okra in addition to sole crops. Results of statistical analysis reveal significant ($P< 0.05$) influence of cropping pattern on final heights of maize and okra, total number of okra pods harvested/ha, total pod weight/ha and maize yield. The treatment did not however, influence leaf number in maize and okra, pod length and diameter in okra. In all the systems investigated Land Equivalent Ratios (LERs) were less than unity except for 1:2 alternate rows, thus cropping maize and okra at 1:2 alternate rows is recommended for farmers engaged in this practice.

KEYWORDS: Intercrop, maize, okra, cropping pattern, yield components and yield.

INTRODUCTION

The need for scientific approach towards farming in Nigeria is becoming increasingly important as the country struggle with population explosion with the usual attending increase in food demand, stiffer competition for land and its resources, dwindling soil fertility, among other limiting factors cumulating in food insecurity. Feeding the rapidly growing population is becoming a major development concern. Efforts made by governments as well as by development projects of industrialized nations to increase food production by introduction of new technologies relying on commercial inputs have not produced expected results (Steiner, 1982) as these efforts often ignored farmer's peculiar environment (Oyewole, 2009).

Crop production in many parts of Nigeria is dominated by subsistence farming bias towards multiple cropping with over 75 per cent of the cultivated land area based on crop mixtures (Giller and Wilson, 1991) of varying complexities. The planting patterns followed by subsistence farmers involved in these multiple cropping systems are complex and divers. These, vary from simple replacement mixtures to complex superimposed mixtures. These mixtures may be planted either in alternate rows, or intra-row. Multiple cropping has long been recognized as a valuable practice among subsistence farmers in West Africa and Nigeria in particular (Kumar, 1993; Odion, *et al*., 2000). Its advantages include: flexibility of labor use; reduced risk of total harvest failure; better utilization of land, water, labour and capital and greater stability of annual returns (Kumar, 1993; Okereke and Eaglesham, 1992; Pierce and Lal, 1994; Odunze *et al.*, 1997; Smith, 1993). Until the 1980s researchers generally assumed that single crop field is the ideal towards which African farmers should be moving (Edwards, 1993), but doubts had been raised whether it would be possible to introduce even rotational system of agriculture based on pure stands so long as the hoe is the main agricultural implement (Evans, 1960). Resources of most subsistence farmers simply do not allow the use of equipment, fertilizers and pesticides need to practice the kind of farming found on research stations (Edwards, 1993). Yet, multiple cropping systems seem to be sustainable even in the absence of such inputs. Thus, almost all crop production on small farms in the tropics involved more than crop specie (Giller, 1992).

Two most common practices of multiple cropping systems are crop rotation and intercropping (Giller, 1992). However, the various classifications of intercropping systems found in literature are somewhat arbitrary. Their main objective usually being to provide some sense of order for the purpose of research, but in reality, there is a broad continuum of type ranging from the simple intercropping of different crops in different rows through to mixed random planting incorporating various tree crops (Edwards, 1993). Multiple cropping involving vegetables and cereals are not uncommon. However, except in the Sudan savanna part of the country, where horticultural crops like onions, garlic and peppers are grown in commercial quantities in the dry season, in most other parts of Nigeria, vegetables are regarded as secondary crops, thus they form the minor crop in a mixture of two or more crop combinations when ever they exist in the cropping system. Based on their secondary status, little literature exists on the impact of the association between commonly grown farmers' crops (cereals and legumes) with vegetables. Research was bypassing small - holders who are engaged in such practice. Yet, it is clear that much of the potential for increasing okra production lies with such farmers, considering that these farmers make up the bulk of the farming families (at least 75 per cent of the total crop production systems).

Okra (*Abelmoschus esculentus* (L) Moench) is an important vegetable crop which is grown and consumed throughout Nigeria (Chriso and Onuh, 2005; Katung and Kashina, 2005). Considering the importance of vegetables in the diet of man, this research can not be more justified, particularly when one observes that okra is rich in both minerals and protein (Karakoistsides and Constantimde, 1975), which are both vital to man's growth and development, and most often lacking in most dietary in-takes in Africa. The research evaluated the effects of cropping pattern of maize and okra on growth, development, and yields of the mixture with a view to recommending the most suitable system to farmers engaged in such practices.

MATERIALS AND METHODS

Trials were conducted at the Kogi State University Research Farm (Longitude 7^0 06^1N, 6^0 43^1E) Anyigba, Nigeria, in the Southern Guinea Savanna ecological zone, during 2005 and 2006 cropping seasons. The location of the site lies within the warm humid climate of the North central zone of Nigeria with a clear distinctive dry and wet season dichotomy, an average annual temperature of 27 ^{0}C with high level of uniformity through out the year. Annual temperature does not usually exceed 38 ^{0}C, while annual rainfall of approximately 1260 mm is common with peaks in the month of July and September. A short dry spell in August marks the start of the second half of the rainy season. Details of the soil characteristics of the experimental site are shown on Table 1.

The experimental site was ploughed and harrowed, without ridging, as seeds were sown on the flat, spaced 25 x 75 cm for both maize and okra. 2 seeds of both maize and okra were sown per stand, which were latter thinned to one plant per stand two weeks after sowing (2 WAS). Weed control was by the use of hoes and cutlasses at 2, 5 and 7 WAS. N.P.K (20:10:10) fertilizer was applied to maize stands 2 WAS at the rate of 70kg Nha^{-1}, 35kg Pha^{-1} and 35kg Kha^{-1} using the ring method of fertilizer application. Second application of urea 70kg Nha^{-1} was given just before maize heading. Fertilizer was not applied directly to Okra crop, but in stand replacement treatment, incorporated okra stands may have benefited from fertilizer applied to maize stands. The experiment, a Randomized Complete Block Design (RCBD) with three replications had a variety of maize (Obatanpa yellow) intercropped with a variety of okra (V.35) at one stand of maize alternated with one stand of okra (1 M:1 O alternate stands); one stand of maize alternated with two stands of okra (1 M:2 O alternate stands); one row of maize alternated one row of okra (1 M:1 O alternate rows); one row of maize alternated with two row of okra (1 M: 2 O alternate rows) in addition to sole maize and okra.

Data collected on okra include height of plant, number of leaves, number and weight of harvested okra pods ha^{-1}, pod length and diameter, while data collected on maize crop include plant height, number of leaves and fresh cob yield. Collected data were subjected to analysis of variance (ANOVA) using Microcomputer Statistical Programme (MSTAT) MSU (Michigan State University) (1985). Treatment means found to be statistically significant were compared using the Least Significant Difference described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of Cropping Pattern on Final Height of Maize and Okra

Possible means for reduction in competition for growth resources which occur in multiple-cropping systems is through manipulating the arrangement of the component crops in the mixture (Olufajo, 1995). Results of statistical analysis reveal significant ($P< 0.05$) influence of cropping pattern on final maize and okra heights (Table 2 and 3). Though maize plants were consistently tallest at 1:1 alternate stand; 219.0 and 225.0 cm in 2005 and 2006 cropping seasons, respectively observed plant heights were not significantly different from those of 1:2 alternate stands or sole maize stands. 1:2 alternate row gave the shortest plants, which were also not significantly ($P >0.05$) different from 1:1 alternate rows. Maize plants intercropped with okra at alternate stands were consistently significantly taller than those in alternate rows. 1:1 alternate stands gave consistently the tallest okra plants (103.0 and 115.9 cm in 2005 and 2006, respectively) probably as a result of greater plant shading from the maize component while the least plant height was in sole okra (32.3 and 30.3 cm in 2005 and 2006, respectively).

Since crops are not generally grown in isolation but in closely spaced population, it is expected that at some point, as seedlings grow, they will begin to interfere and compete for growth factors (Hay and Walker, 1989). As the leaf canopy develops the leaves of individual neighboring plants will start to overlap and compete for light. The primary effect of this competition is an increase in the level of gibberellins (Hay and Walker, 1989) thus promoting leaf sheath and blade extension and accelerating developmental processes, including increase in plant height. The impact of competition for solar radiation should be expected to increase as maize components in the treatment increase, which must have been responsible for the observed outcome in the various systems. It has been emphasized that photosynthesis is probably the single most important process, which needs to be controlled during crop production (Adams *et al*., 1998) and any factor that will affect crop photosynthetic ability will certainly influence its growth and development.

Elemo and Chobe (1995) reported that improved productivity of a mixture has been shown to be associated with varietal differences in height and maturity date of the component crops. Most of the advantages obtained from growing crops in intercrops come mainly from the ways in which the crop mixtures complement each other in their exploitation of the environment (Giller and Wilson, 1991). Often the overall benefit of growing two crops in a mixture will be a net benefit in which the increase in growth of one crop exceeds a small competitive reduction in the growth of the other and this is often seen where a low growing legume is intercrop with a tall cereal. However, the correct plant spacing is required to obtain the desired result of the impact of intercropping on plant vegetative characters.

In a related trial Olasantan and Lucas (1996) reported the effect of intercropping maize with crops of different canopy heights and similar or different maturities using different spatial arrangements (1:1, 2:1, 2:2). The growth of maize in these systems was similar to that of sole cropped maize. Intercropped maize had greater effect on melon with similar maturity than on those crops with greater maturity period. When maize was intercropped with cocoyam, the height of maize in the cropping patterns (1: 1, 1: 2, and 2: 2) did not differ significantly from that of sole crops. While sole cropped cocoyam, plants had shorter canopy heights compared to the intercrops. Intercropping maize with cassava, irrespective of the pattern, showed no significant difference in maize height.

Effect of Cropping Pattern on Mean Number of Leaves

Crop biomass accumulation depends on light interception by leaves and on the efficiency, with which the intercepted light is used to produce dry matter (Plenet *et al*., 2000). Analysis of data indicated that cropping pattern did not significantly ($P>0.05$) impact on leaf number in maize and okra (Table 4 and 5). The implication of this outcome is that cropping pattern investigated may not interfere with the potential of the components in the mixture to intercept solar energy; as most of the solar radiation incident on the crop canopy is intercepted by its leaves, except if the treatment could have influenced leaf size, or leaf architecture, among other factors that determine leaf ability to intercept solar radiation. That the rate of leaf unfolding from the terminal bud is controlled primarily by air temperature (Hay and Walker, 1989) may have accounted for the observed non-significant influence of the treatment on leaf number.

Effect of Cropping Pattern on Yield and Yield Related Parameters in Okra and Maize

Yield is determined primarily by crop biomass, which in turn is determined by the quantity of radiation intercepted by the crop canopy (Hay and Walker, 1989). Any influence on the plant canopy either as a result of plant shading, which may result from intercropping, or other means will affect yield. Data of 6 harvests revealed that the total number of okra pods harvested ha^{-1} (Table 6), total pod weight ha^{-1} (Table 7), but not pod length (Table 8) nor, pod diameter (Table 9) were significantly ($P<0.05$) influenced by the cropping pattern investigated. The highest number of okra pods harvested ha^{-1} (approximately 129,333 and 92,857 in 2005 and 2006, respectively) and the total pod yield ha^{-1} (4356.83 and 4198.35 kg, respectively in 2005 and 2006 cropping seasons) were obtained in sole plot, which was significantly reduced when intercropped with maize. The lowest total okra yield ha^{-1} was observed in 1:1 alternate stands.

Analysis of data revealed that fresh cob yield in maize and grain yield (Table 10) were significantly ($P<0.05$) influenced by the cropping pattern investigated, while shelling percentage did not respond significantly to cropping pattern investigated ($P>0.05$). The highest fresh cob yield (122266.59 kg ha^{-1}) and grain yield (5660.86 kg ha^{-1}) were observed in sole plot, which was significantly reduced when intercropped with okra. Reduction in fresh maize yield and grain yield as a result of intercropping was basically due to reduction in maize population in the intercrops rather than any other factor. LER values were less than unity (LER<1) in all the treatments, except in 1:2 alternate rows (Table 11). There was a drastic reduction in okra yields as a result of intercropping with maize compared to the sole crop. This reduction could not be compensated for by the combined intercrop yields in most of the treatments investigated. Therefore, for all the treatments, except 1:2 alternate rows, the combinations were not advantageous, thus not recommended. LER value was greater than unity (LER>1) at 1:2 alternate rows, thus the system was advantageous (Table 11). The greater than unity (LER>1) LER value obtained in this treatment is an indication of higher biological efficiency of the mixture, due to better utilization of environmental factors (Willey, 1979) compared to other treatments.

CONCLUSION

Trials were conducted at the Kogi State University Research Farm (Longitude 7^0 06^1N, 6^0 43^1E) Anyigba, Nigeria, in the Southern Guinea Savanna ecological zone during 2005 and 2006 cropping seasons. The experiment, a Randomized Complete Block Design with three replications had a variety of maize intercropped with a variety of okra at one stand of maize alternated with one stand of okra; one stand of maize alternated with two stands of okra; one row of maize alternated one row of okra; one row of maize alternated with two rows of okra in addition to sole crops. Results of statistical analysis reveal significant ($P< 0.05$) influence of cropping pattern on final heights of maize and okra, total number of okra pods harvested ha^{-1}, total pod weight ha^{-1} and maize yield. It was observed that intercropping involving maize: okra should avoid treatments that impose greater shading on the okra component as observed in alternate stand arrangements. Where maize – okra system is practiced, the option should be on alternate rows rather than alternate stands, preferably 1:2 alternate rows, which gave marginal advantage (1 per cent) this study.

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Table 1: Pre-planting soil (0 – 30 cm) test value for the experimental site in 2005 and 2006 cropping seasons

Soil Characteristics	2005	2006
P^H (H_20)	5.30	5.40
P^H (CaCl)	5.00	5.10
% Organic carbon	2.50	2.52
% Total N	0.15	0.17
Available P (ug g^{-1})	14.9	15.4
Ca meg 100g	1.50	1.50
Mg (meg / 100g)	0.99	1.00`
K (meg / 100g)	0.54	0.56
Exch. Al^{3+}(meg / 100g)	0.02	0.03
Extr. Zn (ug g^{-1})	9.40	9.40
% Sand	9.40	9.40
% Silt	69.7	70.0
% Clay	23.3	24.0
Textural class	7.00	6.00

Table 2: Effect of cropping pattern on maize height in 2005 and 2006 cropping seasons

Treatment	Final maize height (cm)		
	2005	2006	Mean
Cropping Pattern (Maize: Okra)			
1:1 alternate stand	219.0a	225.0a	222.0a
1:2 alternate stand	216.0a	223.0a	219.5a
1:1 alternate row	179.9b	181.1b	180.5b
1:2 alternate row	167.1b	177.7b	172.4b
Sole maize	218.0a	224.0a	221.0a
SE±	8.56	3.66	5.98

Treatment means within the same column followed by unlike letter are statistically significant at 5%

Table 3: Effect of cropping pattern on okra height in 2005 and 2006 cropping seasons

Treatment	Final okra height (cm)		
	2005	2006	Mean
Cropping pattern (Maize: Okra)			
1:1 alternate stand	103.0a	115.9a	109.5a
1:2 alternate stand	96.0a	98.2a	97.1a
1:1 alternate row	51.0 b	46.0b	48.5b
1:2 alternate row	41.7bc	37.3bc	39.5bc
Sole Okra	32.3c	30.3c	31.3c
SE±	3.56	6.56	5.37

Treatment means within the same column followed by unlike letter are statistically significant at 5%

Table 4: Effect of cropping pattern on number of leaves in maize in 2005 and 2006 cropping seasons

Treatment	Mean leaf number in maize		
	2005	2006	Mean
Cropping pattern (Maize: Okra)			
1:1 alternate stand	13	13	13
1:2 alternate stand	12	13	13
1:1 alternate row	12	12	12
1:2 alternate row	12	12	12
Sole maize	12	13	13
SE±	0.6 ^{ns}	0.5 ^{ns}	0.9 ^{ns}

ns. not significant at 5% probability

Table 5: Effect of cropping pattern on number of leaves in okra in 2005 and 2006 cropping seasons

Treatment	Mean leaf number in okra		
	2005	2006	Mean
Cropping pattern (Maize: Okra)			
1:1 alternate stand	10	12	11
1:2 alternate stand	10	10	10
1:1 alternate row	11	10	11
1:2 alternate row	12	12	12
Sole Okra	11	12	12
SE±	1.2 ^{ns}	0.39 ^{ns}	0.8 ^{ns}

ns. not significant at 5% probability

Table 6: Effect of cropping pattern on number of pods of okra in 2005 and 2006 cropping seasons

Treatment	Number of pods harvested ha^{-1}		
	2005	2006	Mean
Cropping pattern (Maize: Okra)			
1:1 alternate stand	45083.32c	50718.74c	47901.03c
1:2 alternate stand	37999.98d	47749.98d	40374.98d
1:1 alternate row	49195.75b	51889.23b	50542.49b
1:2 alternate row	24201.01e	26301.33e	25251.17e
Sole Okra	129333.31a	92857.10a	111095.21a
SE±	122.568	126.984	119.886

Treatment means within the same column followed by unlike letter are statistically significant at 5%

Table 7: Effect of cropping pattern on pod yield of okra in 2005 and 2006 cropping seasons

Treatment	(kg ha^{-1})		
	2005	2006	Mean
Cropping pattern (Maize: Okra)			
1:1 alternate stand	101.49d	133.66d	117.75d
1:2 alternate stand	132.13d	167.69d	149.91d
1:1 alternate row	2472.18b	2562.36b	2517.27b
1:2 alternate row	1286.52c	1333.23c	1309.88c
Sole Okra	4356.83a	4198.35a	4277.59a
SE±	44.668	68.992	55.664

Treatment means within the same column followed by unlike letter are statistically significant at 5%

Table 8: Effect of cropping pattern on pod length in 2005 and 2006 cropping seasons

Treatment	Mean pod length (cm)		
	2005	2006	Mean
Cropping pattern (Maize: Okra)			
1:1 alternate stand	3.84	3.42	3.63
1:2 alternate stand	3.41	3.76	3.59
1:1 alternate row	3.36	4.55	3.96
1:2 alternate row	3.39	4.75	4.07
Sole Okra	3.52	4.16	3.84
SE±	0.881 ^{ns}	0.556 ^{ns}	0.661 ^{ns}

ns. not significant at 5% probability

Table 9 Effect of cropping pattern on mean pod diameter in 2005 and 2006 cropping seasons

Treatment	Mean pod diameter (cm)		
	2005	2006	Mean
Cropping pattern (Maize: Okra)			
1:1 alternate stand	4.10	3.92	4.01
1:2 alternate stand	4.65	4.04	4.35
1:1 alternate row	5.12	4.53	4.83
1:2 alternate row	4.36	3.90	3.41
Sole Okra	4.00	5.06	4.53
SE±	0.556 ^{ns}	0.886 ^{ns}	0.772 ^{ns}

ns. not significant at 5% probability

Table 10: Effect of cropping pattern on mean yield of maize in two cropping seasons

Treatment	Fresh cob yield (kg ha^{-1})	Shelling percentage	Grain yield (kg ha^{-1})
Cropping pattern (Maize: Okra)			
1:1 alternate stand	10088.75c	66.33	3608.31c
1:2 alternate stand	9370.03b	64.11	4722.67b
1:1 alternate row	5333.40d	65.11	2400.03d
1:2 alternate row	3674.14e	67.32	1579.87e
Sole maize	12266.59a	62.23	5660.86a
SE±	23.568	4.691 ^{ns}	115.363

Treatment means within the same column followed by unlike letter are statistically significant at 5%

Table 11: Effect of Cropping Pattern on mean Yield and Land Equivalent Ratio (LER) in two cropping seasons

Treatment	(kg ha^{-1})		LER
	Okra	Maize	
Cropping pattern (Maize: Okra)			
1:1 alternate stand	117.75d	3608.31c	0.67
1:2 alternate stand	149.91d	4722.67b	0.87
1:1 alternate row	1309.88c	1579.87e	0.59
1:2 alternate row	2517.27b	2400.03d	1.01
Sole crop	4277.59a	5660.86a	
SE±	55.664	115.363	

Treatment means within the same column followed by unlike letter are statistically significant at 5%

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