Land Equivalent Ratio Analysis and Gross Monetary Returns of Sole and Intercropped Maize and Okra in the Southern Guinea Savanna Agro-ecological Zone of Nigeria

By

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ABSTRACT

Field experiments were conducted to investigate the land equivalent ratio and gross monetary returns of three okra densities of maize/okra mixture in two locations in the southern guinea savannah during the early and late cropping seasons. The two locations are: location 1: University of Agriculture Teaching and Research Farm, Makurdi and location 2: kogi state University Teaching and Research Farm, Anyigba. Treatments were three okra densities via: S.A 1:1.00m x 0.60m (16,670 Plant/ha); S.A 2:1.00m x 0.50m (20,000 plant/ha) and S.A 3:1.00m x 0.3m (33,333 plant/ha). The cultivar of maize used was Downy mildew streak-resistant, early maturing – yellow (DMSR-EY), while that of okra used for the experiment was NHAe 47-4-a photoperiodic neutral variety sourced from the Nigeria Institute of Horticultural Research and Training (NIHORT), Ibadan, Nigeria. . Trials were laid out in a Randomized Complete Block Design (RCBD) with a spilt-plot arrangement, replicated three times. NPK 20:10:10 fertilizer was applied to maize stands at pre-emergence and two Weeks after Sowing (WAS) at the rate of 70kgN ha^{-1}, 35kg P_2O ha^{-1}, 35kgK ha^{-1} using the ring method of fertilizer application, while urea was applied to supply the remaining half of N(70kgN ha^{-1}) at second application for top dressing just before tassel initiation and the onset of okra flowering. Intercropping reduced the yield and yield component of okra (i.e the number and weight of fresh pods per plant) and that of maize (I.e the number of cobs, cob length and 100grian weight also reducing the spacing of okra in order to increase the planting density of okra resulted in reduction of yield both in the sole and intercropped situation of okra plant. Decreasing the spacing of okra also reduced the gain yield and grain size of maize in okra/maize mixture respectively. The highest yield advantage (35%) of intercropping okra and maize together was obtained at the widest spacing of 1.0m x 0.60m (16,670 okra plant per ha), while the highest monetary return was realized at the highest okra planting density (33,340 plants per ha) i.e the closest plant spacing of 1.0m x 0.30m, intercropped with maize. The combined yield of both crops, made intercropping more profitable than sole cropping.

Keywords: Land Equivalent Ratio, Intercropping, Gross Monetary Returns

INTRODUCTION

Traditional farmers adopt mixed cropping for various reasons – viz insurance against crop failure, control of pests and diseases due to the biological diversity within the system, increased gross monetary returns per unit area of land, and better satisfaction of dietary variability (Ekanayeke *et al.*, 1989). Other reasons include; yield stability, maintenance of soil fertility due to reduction of erosion and nutrient leaching, better use and efficient use of available resources, balanced distribution of labour requirement among others (Asiegbu, 1997).

Climate change has induced rainfall and temperature stresses which reduced maize yield in Nigeria(Moench *et al* 2021) Empirical evidence shows that there is a likely hood that yield will decrease by 15% and 24?% by the year 2030 and 2050 respectively compared to a baseline year of 2000 implying a decline of about 1.4 million tonnes and 2.9million tonnes respectively (considering a simulated yield of 1.3 tons per hectare (Coster and Adeoti, 2015) According to Oludare and Khaldoon (2020) , low yield of maize have huge consequences on food security and income for small holder farmers in Nigeria.

In Nigerian traditional cropping systems, okra and maize are usually sown together in mixture in various spatial arrangements (Fawusi 1985) with variable numbers of plants per unit area.. Okra has also been intercropped with other crops but not in a definite row arrangement. It could be envisaged that with proper row arrangement the overall productivity of the crop in mixture will improve.

Arising from the problem stated above in addition to the dearth of scientific information on the. best or recommended spatial arrangement of okra in maize/okra intercrop, it was considered necessary to determine the spatial arrangement that would reasonably fill that gap since different ecological zones exhibit varied environmental pattern, it becomes imperative to evaluate the yield responses of various classes of crops to variable spatial arrangement (e.g. a fruit vegetable (okra) and maize) in an intercropping situation.

Land equivalent ratio is one of the most common index or indicator adopted in the determination of efficiency or performance of intercropping i.e. land productivity (Seran and

Brintha 2009. The Land Equivalent Ratio (LER) may be defined as the relative land area under sole cropping that is required to produce the yields achieved by intercropping (Kurt, 1984). LER is a relatively simple concept. LER greater than unity (LER>1) is an indication of higher biological efficiency of land resource utilization of the mixture, due to better utilization of environmental factors (WilIey,1979) .

In order therefore to improve the productivity of the system when grown in mixture, there is the need to determine the crop spatial arrangement and the relative population density that could optimally minimize the competitive effect to the advantage of okra. The aim of this present investigation was to explore the possibility of intercropping maize with okra at different spatial arrangements (inter-row and intra-row spacing) with a view to further enhancing the productivity of the maize/okra intercropping system and also to optimize the yield. Analyse the land equivalent ratio and also determine the gross monetary returns for sole and intercropped maize and okro.

MATERIALS AND METHODS

Site Description

Field experiments were conducted in two locations in the southern Guinea Savannah zone of Nigeria. The locations were: Location 1: University of Agriculture, Teaching and Research Farm, Makurdi, Nigeria located at (Lat 7^{0}42' N and long 8^{0}37'E) at an elevation of 97m above sea level. The area has annual rainfall of 1200 – 1500mm bimodally distributed (Kowal and Knabe 1972, Ikeorgu, 2001). The Meteorological information for Makurdi during January-December, 2010 is shown in table 13 .Location 2: Kogi State University, Teaching and Research Farm, Anyigba, Nigeria located at (Latitude 7^{0}62'N and Longitude 6^{0}4Y'E) also in the Southern Guinea Savanna zone of Nigeria as described by Kowal and Knabe (1972). The Meteorological information for Anyigba during January-December, 2010 is shown in Table 4. The climate is hot-humid, characterized by ambient temperature range of 25-30^{0}C with the hottest period of the year extending between February and May. The annual rainfall ranges from 1400 - 1500mm lasting for about 6 – 7 months. The area has two distinct seasons (wet and dry). The experiment was carried out during the early and late cropping seasons of 2011.

Soil Sampling/Analysis

Pre-planting soil samples were collected from a depth of 0-30cm from the two locations and the physico-chemical analysis were carried out in the Soil Science laboratory of the University of Agriculture, Makurdi .Below are the values obtained for University of Agriculture Teaching and Research Farm, Makurdi, The pH of the soil was determined using the pH meter with calomel electrodes (IITA, 1979).Organic carbon was determined using the chromic acid digestion of Walkey-Black(1934).Total Nitrogen in the soil was determined using the regular micro-kjeldahl method (Black, 1965).Available phosphorus was determined using the method of Bray and Kurtz(1945).Using the EDTA titration method to determine Exchangeable Potassium by (Chapman *et al* 1965). Soil characterized as sandy loam with a pH of 7.40 in water, organic carbon 2.2 1%, total Nitrogen 0.69%, available phosphorus (Bray's P1) 34.O0ppm, exchangeable potassium 0.12 meq $100g^{-1}$ of soil for both early and late cropping season .For location 2(KSU Anyigba), the physico-chemical analysis were carried out in Government Science Secondary School Laboratory, Dekina, Kogi State and the soil was also characterized as sandy loam with a pH of 7.0 in water, organic carbon 2.19%, total Nitrogen 0.73%, available phosphorus (Bray's P1) 32.50ppm, exchangeable potassium 0.16 meq $100g^{-1}$ of soil for both early and late cropping.

Land Preparation, Planting and Cultural Practices

In each location, the land was ploughed; harrowed and 1.0m ridges were constructed for both maize and okra on the same plot .Each plot was made up of five rows (ridges). The cultivar of maize used for the study was downy mildew and streak- resistant early maturing – yellow (DMSR – EY) developed at the international Institute of Tropical Agriculture (IITA), Ibadan, Nigeria while the cultivar of okra used was NHAe 47-4-a photoperiodic neutral variety sourced from the National Horticultural Research Institute (NIHORT) Ibadan , Nigeria. The varieties of both crops are high yielding and show wide adaptation to different environment.

The planting density of maize was kept constant at 40,000 plants/ha at spacing of 1.00mx0.25m, while the planting density of okra was varied as follows: The treatments were Treatment 1- S.A1: 1.00m x0.60m giving a plant population density of 16, 667 plants/ha, Treatment2 - S.A2: l.00m x 0.50m giving a plant population density of 20,000 plants/ha, Treatment 3:S.A3:.00mx0.30m giving a plant population of 33,333 plants/ha.

A mixture of pre-emergence and post-emergence herbicides (primextra Gold and Paraquat(gramozone) was applied for weed control after the ridges were made. Intercrop with maize. The treatments were; Treatment 1 - S.Al: 1.00m x 0.60m giving a plant population density of 16, 667 plants/ha, Treatment2 - S.A2: 1.00m x 0.50m giving a plant population density of 20,000 plants/ha, Treatment 3:S.A3 :1.00mx0.30m giving a plant population of 33,333 plants/ha, while maize was kept at a spacing of 1.00m x 0.25m giving a constant optimum plant density of 40,000 plants/ha.

To the number of seedling emerging within that interval plus the number of seedling that emerges between the beginning of the test and the end of a particular interval speculated.

NPK (20:10:10) fertilizer was applied to maize stands two weeks after sowing (WAS) at the rate of 70kgN ha^{-1}, 35kg $P_2 0_5$ ha^{-1} and 35kgKha^{-1} using the ring method .while urea was applied to supply the remaining half of N(70kgN ha^{-1}) at second application for top dressing just before tassel initiation and at the onset of okra flowering .Fertilizer was not directly applied to okra crop but in stand replacement treatment, since okra stands would benefit from fertilizer applied to maize stands .Beginning from ten days after swing(DAS) to 70 DAS the okra stands were spraye d with insecticide called BEST - Cypermethrin 10% EC on weekly basis at the rate of 30g a.i ha^{-1} to control flea beetles (*Podagrica sjostedti Jack*,). The spraying was stopped seven day before harvesting. For both maize and okra, the dilution rate of the chemical formulation in water is 500-1000 litres/ha to control pests such as diamond black moth (*spodoptera*) for maize, cut worm, stern borer. The insecticide is a broad spectrum insecticide for Agricultural and Horticultural crop to control insect pest. Air =100gm/litre w/v solvent + Emusifiers.

At seven days after emergence, carbofuran (Furadan 3 G) was applied to control stem borers in the maize stands at the rate of 750g a.i ha^{-1} and prometryne at 2.0 kg a.i ha^{-1} to effectively control weeds on the maize/okra field (Onwueme and Singh, 1991) Other weeds were manually removed using hoe to ensure that the plots were kept weed free.

Data Collection

The various relevant biometric observations on growth parameters and yield/components of maize and okra were obtained 12 WAP. Four okra plants were also randomly harvested from two central rows at four-five days interval starting from ten days after the first flower opening. A sample of five plants were selected at random and observations were made and recorded on the growth characters up to twelve (12) weeks after planting when all the vegetative characters of both crops had attained their maximum growth. The following yield components of okra and maize were recorded at 12 weeks after planting.

At twelve weeks after sowing (12 WAS), two-five plants of each crop were randomly selected from within the three middle inner rows from the sub-plot. The Five plants randomly sampled per plot were oven dried to a constant weight at 70^0C. These were used in the determination of the total dry matter (TDM) of the above ground portions at harvest.

Total dry matter weight (TDM) per plant. At twelve weeks after sowing (12 WAS), two-five plants of each crop were randomly selected from within the three middle inner rows from the sub-plot. The Five plants randomly sampled per plot were oven dried to a constant weight at 70^0C. These was used in the determination of the total dry matter weight of the above ground portion (TDM) at harvest. Number of pods per plant was obtained by physically counting the pods in the two middle rows of each plot after harvesting.pod weight was determined by weighing the pod produced by okra stand from two middle rows of each plot, bulked together using weighing scale the mean weight are recorded in g .Fresh pod yield per hectare was determined by using weighing scale to weigh fresh pods collected from each treatment plot weight are expressed in tons ha^{-1}

Experimental Design and Treatments

The experiments were laid out in a Randomized Complete Block Design with a 2x2x3 split plot arrangement of treatment, replicated three times in a gross plot size of 25.00m x 10.00m and a net plot size of 4.00m x 3.00m. In each location and season, the spatial arrangement (intra-row spacing) of okra constituted the main plots.

Treatment consisted of three spatial arrangements of okra and their corresponding plant population densities per hectare in both sole and intercrop with maize. The treatments were; Treatment 1 - S.Al: 1.00m x 0.60m giving a plant population density of 16, 667 plants/ha, Treatment2 - S.A2: 1.00m x 0.50m giving a plant population density of 20,000 plants/ha, Treatment 3:S.A3:1.00mx0.30m giving a plant population of 33,333 plants/ha, while maize was kept at a spacing of 1.00m x 0.25m giving a constant optimum plant density of 40,000 plants/ha

Statistical Analysis

All data collected on okra and maize were subjected to statistical analysis using GENSTAT 5 Release 3.2 (1995) following the analysis of variance procedures (Gomez and Gomez, (1984) for a randomized complete block Design as described by Steel and Torrie (1980). Treatment means were separated by Least Significant Difference (LSD) at $p<0.05$(Obi, 1990 described by Gomez and Gomez, (1984), Obi, (1990).

Land Equivalent Ratio(LER) and Gross Monetary Returns Determination

The LER is determined or calculated as follows:

$$LER = L_A + L_B + \text{----------} + L_N = \frac{Y_A}{S_A} + \frac{Y_B}{S_B} + \text{--------} \frac{Y_N}{S_N}$$

Where LA, L_B----L_N is the LER for the individual crops,

Y_A,Y_B Y_N are the individual crop yields in intercropping.

S_A, S_B ----S_N is their yield as sole crops.

The gross monetary returns was determined using the current market prices of maize and okra in relation to their total yields.

RESULTS AND DISCUSSION

Soil Analysis

Table 1: shows the physical and chemical properties of the experimental sites of the two locations (UAM and KSU). The soils from both locations were classified as sandy loam. Bake *et.al*.,(2017), recommended a well drained soil preferably clay loam or silt loam as ideal for okra production, though they further opined that soil type does not appear to influence growth and development to any extent as wide range of soil types have been found suitable ,except laterite and acidic soils. Janidks *et.al* (1981) also was of the view that okra tolerates poor soils with intermittent moisture, for maize the reverse is the case, this may suggest that pre-planting soil analysis may be more important for maize than for okro. Ikan and Amusa (2004) also recommended well drained loamy soil for maize production. The calcium, phosphorus, magnesium and nitrogen contents of both samples were adequate for maize production (Ikan and Amusa 2004) and okro production (Bake *et.al*.,(2017). The pH values hovers around the optimum 6.5 recommended for okra production by Bake *et.al*. (2017).

Land Equivalent Ratio and Gross Monetary Returns

The land equivalent ratio analysis and the gross monetary returns are presented in Table 2. The population density of 33,333 plants/ha gave the highest partial land equivalent ratio of okra of 0.51 and maize(1.58) in UAM location while in KSU location the highest partial LER okra (0.56) and that of maize was 1.46 during the early cropping season. The population density of 33,333 plants/ha gave the highest partial okra of 0.30 and maize (1.18) in UAM location, while in KSU location the highest partial

LER of okra (0.35) and that of maize was 1.24 during the late cropping season. The gross monetary return of 26,850.00 Naira in UAM location and 20,695.00 Naira in KSU location was superior with the planting density of 33,333plants/ha during the early cropping season than that of 20,000plants/ha and 16,667plants/ha. Intercropping increased the gross monetary returns of both crops in the two locations. Maize contributed most to yield advantage in both location and seasons. The gross monetary return of #22,550.00 in UAM location and #13,860.00 in KSU location was superior to the planting density of 33,333plants/ha during the late cropping season than that of 20,000plants/ha and 1 6,667 plants/ha.

There is substantial yield advantage(okra plot with spatial arrangement(1.00mx0.30m) in the KSU location show superiority in terms of LER as high as 1.29 during the early cropping season and 1.89 during the late cropping season. But in most of the intercropping situations, maize contributed majorly to the yield advantage in both locations and seasons. The contribution of each component to total LER accounted for the levels yield advantage of the intercrop as evidenced from the partial land equivalent ratio of the two component crops in the mixture especially as contributed by the maize component.

Intercropping increased the gross monetary returns as the planting density of okra increased from medium-highest especially when the yields of both components crops in the mixture is high such as it was obtained in this present study.

Also the LER was highest at the lowest okra planting density indicating advantage of intercropping at low okra density. In 2010, there was even a disadvantage of growing okra and maize together at the highest okra planting density of 33,340 plants ha-1.The gross monetary return was highest when the highest okra planting density (33,340 plants ha-1) was intercropped with maize. Although Willey (1979) observed that the practical significance of LER can only be fully assessed when related to the actual economic yield. Kumar and Yusuf (1991), concluded that a times the highest LER values of certain crops component in mixture may or may not reflect the highest gross monetary return to farmers.

In this present study, the non-significant effect of row planting pattern or spatial arrangement on the growth, yield, and yield components of okra and maize in okra/maize mixture was in agreement with the result obtained by Osiru and Kibira (1981) in sorghum/pigeon pea and finger millet/ground SA mixtures, and also in agreement with the result obtained by Olofintoye and Olaoye (1992) in sorghum/rice mixture. The best spatial arrangement to recommend for farmers in the UAM/KSU is 1.00m x 0.60m (16,670 plants ha-1). But more research is needed or worthy of further investigation.

Conclusion and Recommendations

In this study, there is substantial yield advantage (okra plot with the closest spatial arrangement (1.00mx0.30m) in the KSU location showing superiority in terms of LER as high as 1.29 during the early cropping season and 1.89 during the late cropping season. But in most of the intercropping situations, maize contributed majorly to the yield advantage in both locations and seasons. The contribution of each component to total LER accounted for the s yield advantage of the intercrop as evidenced from the partial land equivalent ratio of the two component crops in the mixture especially as contributed by the maize component. Intercropping increased the gross monetary returns as the planting density of okra increased from medium-highest especially when the yields of both components crops in the mixture was high

Also the LER was highest at the lowest okra planting density indicating advantage of intercropping at low okra density. There was a disadvantage of growing okra and maize together at the highest okra planting density of 33,333 plants ha-1. However, despite the higher LER in lowest okra planting density in mixture with maize, the gross monetary return was highest when the highest okra planting density (33,340 plants ha-1) was intercropped with maize.

Recommendations

1. Intercropping maize with okro at lowest okro planting density is recommended. The best spatial arrangement to recommend in the two experimental locations is 1.00 by 0. 30 m 33,333 plants /ha.
2. Early cropping as against late cropping is recommended in both experimental locations

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Table 1: Physical and Chemical Properties of the soils of the two experimental locations.

Physical Properties	**Makurdi**	**Anyigba**
% Sand	9.40	9.30
% Silt	69.70	70.00
% Clay	20.90	20.70
Textural class	7.00	6.00
Chemical properties		
% Organic Carbon	2.21%,	2.19%,
% Total Nitrogen	0.69%,	0.73%,
Available P(ppm)	34.00	32.50
Ca (meq/100g)	1.50	1.50
Mg (meq/100g)	1.00	0.98
Exch. K (meq/100g)	0.55	0.57
Exch. Al3+ (meq/100g)	0.03	0.04
Extr. Zn (ug g^{-1})	9.40	9.30
p^H in H_2O	7.40	7.00
p^H in C_aCl_2	5.00	5.10

Table 2: Land equivalent ratio and gross monetary return of sole and intercropped okra and maize at 12 weeks after planting in the early and late cropping season of 2010

Treatment	Land	Equivalent Early cropping season	Ratio			Late cropping season			
Location	Spatial arrangement	Partial okra	Partial maize	Total	Gross monetary Return	Partial Okra	Partial maize	Total	Gross monetary Return
UAM	Sole maize	-	1.00	1.00	18.650	-	1.00	1.00	16.900
	l.00mx0.60m	0.31	1.58	1.91	19.050	0.22	1.07	1.29	17.180
	1.00mx0.50m	0.28	1.55	1.83	25.520	0.26	1.09	1.35	21.230
	1.00mx0.30m	0.26	1.31	1.57	26.850	0.30	1.18	1.48	22.550
KSU	Sole maize	-	1.00	1.00	157.50	-	1.00	1.00	8.670
	1.00x0.60m	0.50	1.46	1.96	16.350	0.28	1.06	1.34	9.450
	1.00x0.50m	0.42	1.44	1.86	18.175	0.32	1.10	1.42	11.640
	1.00x0.30m	0.38	1.37	1.75	20.695	0.35	1.24	1.59	13.860

KEY:
UAM= University of Agriculture, Makurdi.
KSU=Kogi State University, Anyigba.
LSD 0.05=Least Significant Difference at 5% level of probability

Table 3; Meteorological Information for Anyigba during January-December, 2010.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rainfall(mm)	0.0	0.2	0.2	0.2	2.7	3.3	10.1	5.4	4.1	4.5	1.1	0.0
Max Temp .0 c	32.8	34.0	33.6	32.6	31.1	29.0	26.3	25.5	25.5	25.6	26.7	26.6
Mm .Temp .o c	16.1	16.8	17.8	18.5	19.4	19.4	19.2	19.0	19.0	19.8	20.6	16.9
Mean Temp .o C	24.5	25.4	25.7	25.5	25.6	24.2	22.8	22.3	22.3	22.7	23.7	21.8
Relative humidity%	82.9	84.8	84.7	83.8	82.9	81.6	82.3	82.8	82.7	82.0	82.6	82.8

SOURCE: Meteorological Station, weather records for 2010. Department of Geography and planning, Kogi State University Anyigba.

Table 4: Meteorological Information for Makurdi during January-December, 2010.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rainfall(mm)	0.0	0.0	126.0	131.	134.0	134.7	230.2	221.5	196.0	98.5	10.0	0.0
Max Temp .0 c	36.4	38.3	33.6	35.0	32.0	31.8	30.0	30.3	30.5	31.5	24.2	31.1
Mm .Temp .o c	18.7	25.9	26.4	26.4	25.1	24.0	22.7	23.1	21.2	23.3	18.6	17.3
Mean Temp .o C	27.6	32.1	32.5	30.7	28.6	27.7	26.4	26.7	22.3	22.7	23.7	21.8
Relative humidity%	46.0	46.8	44.7	52.8	68.4	76.6	76.8	77.4	77.8	75.2	52.6	4