Effects of Location, Cropping Season and Spatial Arrangements interactions on Growth and Yield Components of Maize in a Maize/Okra Mixture in The Southern Guinea Agro-Ecological Zone of Nigeria

By

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Abstract

Field experiments were carried out to investigate the effects of location, cropping season and spatial arrangement interactions on the growth and yield components of maize in a maize/okra mixture in two locations in the southern guinea savannah during the early and late cropping seasons. The two locations were: location 1: University of Agriculture Teaching and Research farm, Makurdi ,Nigeria and location 2:Kogi state University Teaching and Research farm, Anyigba., Nigeria. Treatments comprised of 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 plant height and the Leaf Area Index (LAI) increased as the intra-row spacing decreased and the planting density increased in sole or intercropped okra, Intercropping reduced the yield and yield component of maize. Decreasing the spacing of okra also reduced the grain 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 yield was realized at the highest okra planting density (33,340 plants per ha). The combined yield of both crops, gave higher yields than sole cropping interactions amongst location, cropping season and spatial arrangements as well as interactions between location and cropping season and location and spatial arrangements influenced the yield and growth of maize in the maize/ okra intercrop. Early planting was recommended in both study location.

Keywords: Maize, Intercropping, interactions, Yield, Spatial Arrangements

INTRODUCTION

Maize (*Zea mays* L.) originated in Mexico in Central America. Maize belongs to the family gramineae to which most of the grass species belong. Maize is the third most economically important monoecious cereal annual crops of the world after wheat (*Triticum spp*.) and rice (*oryza sativa* L.) but in Nigeria after sorghum, (*Sorghum bicolor(L)Moench*) and millet

(*Pennisetum glaucum*). Maize features prominently in intercropping systems involving legume components such as cowpea (*vigna unguiculata*), soyabean (*Glycine max(L*), mungbean (*vigna radiate(L.*) and non-legume species such as cassava (*Manihot esculentum*), yams (*Dioscorea spp*), okra (*Abelmoschus esculentus (L) Moench*) and, melon(*citrullus vulgaris*) etc .According to Kunwa *et.al*.(2016), maize is grown under diverse cropping patterns and environments Maize requires deep medium textured well drained fertile soil with high water holding capacity and a pH range of 5.5 – 8.0. Currently maize production is mainly done under rain fed agriculture which is low yield and little profits for farmers. Low yields of maize have huge consequences on food security and income for small holder farmers in Nigeria. Problems associated with maize farming include poor post-harvest processing and storage, pest and diseases, poor extension services, lack of insurance for farmers, inadequate access to input, soil fertility, climate change and planting dates (Oludare *et al.*, 2020*)*

Climate change has induced rainfall and water stresses which reduced maize yields in Nigeria (Nwaogu *et al.*, 2020; Moench *et al.*, 2021). Empirical evidence show that there is a likelihood that yield will reduce by 15% and 24% by the 2030 and 2050 respectively compared to a baseline year of 2000,impling a decline of about 1.4 million tons and 2.9 million tons respectively (considering a mean simulated yield of 1.3 tons per year (Coster and Adeoti, 2015).

Maize provides the major source of calories in Nigeria .In most African and Asian countries, maize products comprise about 80% or more of the, average, diet, in central and western Europe where its products form 50% of the average diet, in the United State of America, cereal crop products comprise 20-25% of the average diet (Onwueme and Sinha, 1991). Okra (*Abelmoschus esculentus (L) Moench*) is an important vegetable crop belonging to the mallow family (family malvacea). Okra is an allopolyploid vegetable of uncertain parentage, although the proposed parents include; *Abelmoschus ficulnes*, *Abelmoschus tuberculatus* and it was also reported diploid" in form (ie may likely be truly wild and cultigens).Okra is grown and consumed throughout Nigeria (Janidks *et al.* 1981).

One of the attractive strategies for increasing productivity of food and labour was to intensify the use of compatible crops that can utilize the available resources per unit area of the available, land. Intercropping of compatible crops was seen as one of the advanced agro technique or type of mixed cropping or agricultural practice involving the cultivation of two or more crops in the same space at the same time (Andrew and Kassam, 1976). Several factors have influenced the practice of intercropping in the past decades. The factors include, selection of compatible crops, maturity of the crops, time of planting, socio-economic status of the farmers, spatial arrangement of the crops, and population densities of the crops.

Okra has also been intercrop with other crops but not in a definite row arrangement. It could be envisage 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.

Although previous studies were carried out in this zone yet some factors that influence the performance of maize in mixture need to be properly addressed such as interactions amongst location, cropping season and spatial arrangements as well as responses of the crops (maize/okra) to varied spatial arrangement under intercropping situation. The beneficial effect of intercropping maize/okra have not fully be exploited by farmers in the southern guinea savannah Agro-ecological zone due to lack of definite row planting pattern and scanty plant population . This study therefore examined the influence of location, planting seasons and spatial arrangements interactions on the growth and yield components of maize in a maize/okra intercropping system.

MATERIALS AND METHODS

Experimental Site Description

Field experiments were conducted in two locations in the Southern Guinea Savannah zone of Nigeria to determine the effects of intra-row spacing of okra on the performance of component crops in maize/okra intercrop during the early and late cropping seasons of 2010. The locations were: Location 1: University of Agriculture, Teaching and Research Farm, Makurdi, Nigeria located between (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 bi-modally distributed (Kowal and Knabe 1972; Ikeorgu, 2001).Location 2: Kogi State University, Teaching and Research Farm, Anyigba, Nigeria located (Latitude $7^0$62'N and Longitude $6^0$41'E) also in the Southern Guinea Savanna zone of Nigeria as described by Kowal and Knabe (1972). The climate is hot-humid, characterized by ambient temperature range of 25-30^0C 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 using a soil augar and the physico-chemical analysis were carried out in the Soil Science laboratory of the University of Agriculture, Makurdi. For location 1. For location 2 (KSU Anyigba), the physico-chemical analysis were carried out at Government Science Secondary School la boratory, Dekina, Kogi State 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). .

Seed Bed Preparation, Planting and Agronomic 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. A mixture of pre-emergence and post-emergence herbicides (primextra Gold and Paraquat(gramozone) was applied for weed control after the ridges were made.

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.

NPK (20:10:10) fertilizer was applied to maize stands two weeks after sowing (WAS) at the rate of 70kgN ha^{-1}, 35kg P_20_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 sprayed 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, stem 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. The various relevant biometric observations on growth parameters and yield/yield components of maize and okra were obtained 12 WAP. Plant height was determined by measuring the distance between the base or soil surface to the collar or nodes bearing the flag leaf (topmost leaf) where 0.75 crop factor for maize; (Duncan and Hesketh,1968). Number of days to 50% Silking or Mid-Tasselling was determined by systematic counting of tasselled or silked stands on the middle rows of each plot.

At twelve weeks after sowing (12 WAS), two to 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.

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 using Least Significant Difference (LSD) at $p<0.05$ described by Gomez and Gomez, (1984).

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 Soil characterized was 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) 34.0ppm, exchangeable potassium 0.12 meq $100g^{-1}$ of soil for both early and late cropping season for location 1. The soils for both early and late planting seasons for location 2 were 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.

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 (Light Clay)*	6.00 (sand)*
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. Al^3+ (meq/100g)	0.03	0.04
Extr. Zn (ug g^{-1})	9.40	9.30
pH in H_2O	7.40	7.00
pH in C_aCl_2	5.00	5.10

*ISSS Method of Soil Classification

Effects of location, cropping season and spatial arrangements on the growth and yield components of maize in maize/okra intercrop

The effects of location, cropping season and spatial arrangements are presented in Table 2. The location had significant ($p<0.05$) influence on the days to 50% tasselling, total dry weight, number of grains per cob, 100-grain weight of maize evaluated but did not significantly influence the plant height, leaf area index ,number of cobs per plant and dry grain yield .The highest value for plant height(236.50cm),leaf area index (4.40),days to 50% tasselling (58.81%),and dry grain yield(3.21 t/ha) were observed in the UAM location and KSU location gave higher total dry weight(92.0lg/plant) and number of grains per cob(443.40), 100- grain weight(23.81g), while the lowest value for plant height(234.88cm),leaf area index (4.22),days to 50% tasselling (58.25%),and dry grain yield(3.13 tons/ha) were observed in the KSU location and the lowest values for total dry weight(89.47g/plant), number of grains per cob(374.30) and 100-grain weight (18.76g) were observed in the UAM location. The number of cobs per plant were the same for both UAM and KSU location.

The cropping season were consistently significant (p<0.05) on all the growth and yield parameter of maize with the highest values of all these growth and yield parameters observed during the early cropping season in both locations. Early Cropping gave the highest value for plant height(237.88cm), leaf area index (4.47), days to 50% tasselling (59.84%), total dry weight(97.65g/plant), number of cob per plant(1.12), number of grains per cob (515.93), 100-grain weight (24.55g),and dried grain yield(3.44 tons/ha) were observed during the early cropping season ,while the lowest value for plant height(233.50cm), leaf area index (4.15), days to 50% tasselling (57.22%) total dry weight(83.84g/plant), number of cob per plant(0.95),number of grains per cob(301.78), 100-grain weight(18.03 g), and dry grain yield(2.90 tons/ha) were observed during the late cropping season. This corroborates the view of Oludare *et al* (2020) that planting dates was one of the problems of maize farming in Nigeria and that late planting gave lower yields

The spatial arrangement of okra in maize /okra mixture had significant (p<0.05)effect on the plant height, leaf area index, days to 50% tasselling, total dry weight, number of cobs per plant, number of grains per cob, 100-grain weight and did not significantly influence the dry grain yield of maize. The plant population of 33, 333 plants/ha with spatial arrangement of 1.00mx0.30m gave the highest values for plant height (262.25cm), and days to 50% tasselling (60.08%), while sole maize gave the highest values for leaf area index (5.10), total dry weight (117.92g), number of cobs per plant (1.29), number of grain per cob(448.), 100-grain weight

(24.38g) and dried grain yield (3.34t/ha). The height of maize increased as the plant spacing of okra decreased .In both early and late cropping seasons at the two different locations, the sole maize plants were shorter in height than that of maize intercropped with various intra-row spacing of okro.

Manipulation of spatial arrangement of component crops in mixture plays vital roles in the reduction of competition for growth resources in multiple cropping (Olufajo, 1995). Plant responses arising from these may differ according to locations or eco-typic environments. The result of this study revealed a consistent significant ($p>0.05$) influence of location, cropping season and spatial arrangement on the height of maize and though the height of maize was about three to four times taller than that of okra. Similar results were reported by Muoneke and Asiegbu *et al.,* (1997). This may probably be as a result of greater shading effect from the maize component on the okra which may have reduced the ability of okra to tap solar radiation for the formation of photosynthesis and other available growth resources at some point as the seedling grows (Hay and Walker, 1989). The primary effect of this competition is that it will increase the level of gibberellins -a plant growth hormone, thus promoting the extension of the leaf sheath and blade and in-turn accelerate growth and development processes including increase in plant height. Obasi (1989) and Orkwor *et al.,* (1991) opined that in maize/okra mixture maize uses its height advantage to successfully compete with okra for light as it has its foliage at the higher canopy layer. Palaniappan (1985) also observed that in an intercropping situation where there are height differences such as maize/okra mixture, the taller component intercepts major share of the incident light on the plant. The growth rate of maize component whose foliage canopy is at the higher layer and okra whose foliage is at lower canopy layer is proportional to the quantity of the photosynthetically active solar radiation they intercepted. In the present study, maize was about three to four times taller than okra as it displays its foliage at higher canopy and shaded okra .The leaf area index of maize was also higher than that of okra

The yield reduction in okra were 44%, 50% and 48% while that of maize were 18%, 23% and 24% for the three intra-row spacing of okra via: 0.60m x 1.0m (16,670 plants/ha); 0.50m x 1.0m (20,000 plants/ha and 0.30m x 1Mm (33,330 plants/ha). Ikan and Amusa (2004) recommended a plant population of 53,333 plants/ha at 75cm by 50 cm at 2 plants /hill or 75cm by 25cm at one plant/hill they further reported that farmers prefer wide spacing so as to afford easy movement for weeding and other farm operations.

Table 2: EFFECTS OF LOCATION, CROPPING SEASON AND SPATIAL ARRANGEMENT INTERACTIONS ON THE GROWTH AND YIELD COMPONENTS OF MAIZE IN MAIZE/OKRA MIXTURE.

Treatment	Plant height (cm)	Leaf area Index	Days 50% tassel ling	Total dry weight (g/plant)	Number of cobs per plant	Number of grains per Cob	100-grain-weight (g)	Dry grain Yield (t/ha)
LOCATION								
UAM	236.50	4.40	58.81	89.47b	1.03	374.30^{a}	18.76^{a}	3.21
KSU	234.88	4.22	58.25	92.01^{a}	1.03	443.40^{b}	23.81^{a}	3.13
LSD(0.05)	5.751	0.2020	0.0646	0.311	0.9481	2.143	0.1255	0.2020
Cropping season								
Early	237.88^{a}	4.47^{a}	59.84^{a}	97.65^{a}	1.12^{a}	5l5.93^{a}	24.55^{a}	3.44^{a}
Late	233.50^{b}	4.15^{b}	57.22^{b}	83.84^{b}	0.95^{b}	301.78^{b}	18.03^{b}	2.90^{b}
LSD (0.05)	1.814	0.2698	0.1349	0.774	0.2728	0.567	0.2424	0.0866
Spatial arrangement								
SOLE maize	204.25^{b}	5.10a	57.30	117.92^{a}	1.29^{a}	448.18^{a}	24.^{38a}	3.34
l.00x0.60m	227.92^{a}	4.48^{b}	58.08	97.00^{b}	0.98^{b}	409.45b	21.92^{b}	3.23
1.00x0.50m	248.33^{b}	4.03^{a}	58.67	78.23^{a}	0.95	393.68	20.45	3.11
	262.25a	3.63^{b}	60.08	69.83^{b}	0.90	384.10	18.40	3.00
1.00x0.30m								
LSD(0.05)	2.157	0.3644	0.5013	0.644	0.2765	0.686	0.2738	0.4151

UAM = University of Agriculture, Makurdi.
KSU = Kogi. State University, Anyigba.
LSD0.05=Least Significant Difference at 5% level of probability
a,b Treatment Means on the Same Row with Different Superscripts Differ Significantly

Interaction between Location and cropping season on the growth and yield components of maize in the maize/okra mixture.

The interaction between location and cropping season on the growth and yield components of maize in a maize/okra mixture is presented in Table 3.Location and cropping season interaction significantly ($P<0.05$) influenced plant height, days to 50% tasselling, total dry weight, number of grains per plant, 100-grain weight in maize evaluated, but did not significantly ($p<0.05$) influence the leaf Area index, number of cobs per plants, and the dry grain yield of maize. The highest plant height (241.25 cm) was obtained at the KSU location during the early cropping season while the UAM location gave highest leaf area index(4.48), days to 50% tasselling (60.28%), total dry weight(99. 14g/plant), number of cobs per plant (1.17), number of grains per cob (525.95), dry grain yield (3.52t/ha), during the early cropping season.

The lowest plant height(228.50cm) was obtained at the KSU location during the late cropping season while the KSU location gave the lowest leaf area index(3.98), days to 50% tasselling (57.09%) during the late cropping season and, UAM location gave the lowest total dry weight(79.80g/plant), number of cobs per plant(0.90),number of grains per cob(222.65) during the late cropping season, 100-grain weight(12.85g), dry grain yield(2.90t/ha), during the late cropping season at both UAM and KSU location

Francis *et al* (1978) reported the complex factors that influence yield of crops to include water supply, temperature, solar radiation, nutrient, damage by pests and disease, adverse radiation, adverse weather conditions, these factors varies from one location to another. But, the most complicated factor apart from climatic condition is water supply as this is dependent on the soil type, and the amount of water available in the soil for plant uptake. Where there is a considerable difference in yield in the same ecological zone that may be caused by difference in water supply as a result of possible difference in soil types. Differences in weather conditions during the growing seasons could probably be the main cause for the differences in yield levels in the two locations of the study.

There was a clear substantial season to season variation in okra yield probably due to variation in rainfall. The results are in conformity with those of Bisaria and Shamshery (1979) who reported that early sown okra out- yielded the late sown okra crop probably as a result of some physiological stress from a periodic dry spell. Lai Cruishan and Singh (1969) reported that late sowing adversely affected crop yield.

Table 3; LOCATION AND CROPPING SEASON INTERACTION ON GROWTH AND YIELD COMPONENTS OF MAIZE IN MAIZE/OKRA INTERCROPPING SYSTEM.

Location	Cropping season	Plant Height (cm)	Leaf Area Index	Days to 50% Tasselling	Total dry weight (g/plant)	No. of cobs per plant	No. of grains per cob	100-Grain-weight(g)	Dried Grain Yield (t/ha)
UAM	Early	234.50	4.48	60.28	99.14a	1.17[a]	525.95[a]	24.67[a]	3.52[a]
	Late	238.50	4.33	57.35	79.80b	0.90[b]	222.65b	12.85[b]	2.90[b]
KSU	Early	241.25[a]	4,46[a]	59.40	96.15a	1.05	505.90[a]	24.43	3.36a
	Late	228.50[b]	3.98[b]	57.09	87.88b	1.00	380.90b	23.20	2.90[b]
LSD (0.05)		4.748	0.2702	0.1332	0.765	0.7966	1.829	0.2392	0.1601

KEY:
UAM=University of Agriculture, Makurdi.
KSU=Kogi State University, Anyigba.
LSD0.05 = Least Significant Difference at 5% level of probability
a,b Treatment Means on the Same Row with Different Superscipts Differ Significantly

Location and spatial arrangement of okra interaction on growth and yield of maize in maize/okra mixture

Table 4 presents the effect of interaction between location and spatial arrangements on the growth and yield of maize in maize/okra mixture. The location and spatial arrangement interaction had significant effect ($P < 0.05$) on the plant height, total dry weight, and number of grains per cob and 100-grain weight of maize but did not significantly influence, leaf area index, days to 50% tasselling, number of cobs per plant, and dry grain yield of maize. The plant population of 33,333 plants/ha with spatial arrangement of 1.00mx0.30m gave the highest plant height (263.50cm),days to 50% tasselling(60.45%) at UAM location. Highest leaf area index (5.15), total dry weight (118.53g/plant), number of cobs per plant (l.38g) and dry grain yield (3.43)t/ha) were observed in the sole maize plots at the UAM Location; while the highest value for number of grains per cob (477.30) and 100-grain weight (26.40g) were observed in the sole maize at the KSU location. The plant population of 33,333 plants/ha gave the lowest values for plant height (203.00cm) in UAM location in sole maize, Leaf area index(3.50) in KSU location ,Sole maize gave the lowest days to 50% tasselling (57.15%) in KSU location , dry matter weight (65.50g/plant) in UAM location at the plant population of 33,333 plants/ha ,number of cobs per plant (0.90) in both UAM and KSU location , number of grains per cob (347.70), 100-grain weight (15.80g) in UAM location at the plant population of 33,333 plants/ha. with spatial arrangement of 1.00mx0.30m and dried grain yield of 3.0 t/ha in both UAM and KSU location respectively .Kunwa *et.al*., (2016) recorded significant differences in yield for maize grown under different environments.

Table 4: LOCATION AND SPATIAL ARRANGEMENT OF OKRA INTERACTION ON GROWTH AND YIELD OF MAIZE IN MAIZE/OKRA INTERCROPPING SYSTEM.

Location	Cropping system	Plant Height (cm)	Leaf Area Index	Days to 50% Tasselling	Total dry weight (g/plant)	No. of cobs per plant	No. of grains per cob	100-Grain-weight (g)	Dried Grain Yield
UAM	Sole maize	203.00b	5.15a	57.45	118.53^{a}	1.38^{a}	419.0^{a}5	22.35a	3.43
	1.00x0.60m	228.33a	4.60b	58.65	100.50b	0.95^{b}	373.00b	19.28b	3.30
	1.00x0.50M	251.17b	4.10a	58.70	73.35^{a}	0.90	357. 5^{a}	17.60	3.10
	1.00x0.30m	263.50a	3.75b	60.45	65.50^{b}	0.90	347.70b	15.80	3.00
KSU	Sole maize	205.50b	5.05b	57.15	117.30a	1.20a	477.30	26.40	3.25
	1.00x0.60m	227.50a	4.37a	57.50	93.50^{b}	1.00	445.90a	24.55	3.15
	1.00x0.50m	245.50b	3.95	58.63	83.10^{a}	1.00	429.90	23.30	3.12
	1.00x0.30m	261.00a	3.50	59.70	74.15^{b}	0.90	420.50	21.00	3.00
	LSD(0.05)	4.393	0.455	0.6146	0.801	0.7194	1.620	0.3398	0.5161

KEY:
UAM=University of Agriculture, Makurdi. KSU=Kogi State University, Anyigba.
LSD0.05=Least Significant Difference at 5% level of probability
a,b Ttreatment Means on the Same Row with Different Supersripts Differ Significantly

CONCLUSION AND RECOMMENDATIONS

Location, season and spatial arrangements significantly influenced the growth and yield components of maize when intercropped with okra. The yield reduction in okra was higher than that of maize. The yields of maize and okra were better during the early cropping season. In this study, there was substantial yield advantage (okra plot with the closest spatial arrangement, 1.00mx0.30m) in the KSU location). But in most of the intercropping situations, maize contributed majorly to the yield advantage in both locations and seasons. The best spatial arrangement to recommend for farmers in the UAM/KSU is 1.00m x 0.60m (16,670 plants ha-1). This may however require further research. Early cropping is recommended in both locations

REFERENCES

Andrews, D.J; A. H. Kassam, 1976. The importance of multiple cropping in increase world food supplies. Pp. 1-10, In: R.. I. Papendick, A. Sanchez (eds)

Black, C.A. D.D., Evans, J.L. White, L.E. Ensminger, and F.E. Clark, (Ed) 1965. Method of soil analysis. Part 2. ASA. Madison, W.I.

Coaster,A.S and Adeoti, A.L(2015). Economic Effects of Climate Change on Maize Production and Farmers Adaptation Strategies in Nigeria :A Ricardian Approach. J Agric Sc. 7(5):67

Duncan, W.G. and Hesketh, J.D.(1968).Net photosynthetic rates ,relative leaf growth and leaf number of 22 races of maize grown at eight temperatures .Crop Science 8:670-67.

Francis, C.A., Flor. C.A. and Pragar, M. (1978), Effect of bean association on yield and yield components of maize. Crop Sci. 18:760-764.

Gomez, K.A. and Gomez A.A. 1984. Statistical procedures for Agricultural research, 2nd edition John Willey, and sons, New York. Pp. 693.

Hay, R.K.M. and J.A. Walker (1989). An introduction to the physiology of crop yield. Longman Group UK. Ltd.p.292.

Ikan, E.A and Amusa, N.A(2004)Maize Research and Production in Nigeria . *African Journal of Biotechnology* 3(6):302 – 307

Ikeorgu J.E.G. (2001). Determination of Compatible Components population in Yam minisett/soybean inter crop in the southern Guinea Savannah of Nigeria J. Applied Chem. Agric. Res. 7:75-79.

Janicks, J. Robert, W.S., Frank W. Woods and Vamon W.R. (1981) Plant Science: An Introduction to World Crops. 3rd ed. W.H. Freeman and Company. P. 572-573

Kowal, J.M., and Knabe, D.T. (1972). An Agricultural Atlas of Northern States of Nigeria, Ahmadu Bello University, Press..

Kunwar,C.B, Kantuwal, R.B, Thapa, S, and Shrestha, J. (2016) Grain Yield Stability of Early Maize Genotypes. Journal of Maize Research and Developmen. 2(1):94 – 99.

Kurt, G.S 1984. Intercropping in tropical smallholder Agriculture with special reference to West Africa. GTZ pp.1-233.

Lai Cruishan and R.P. Singh (1969) Effects of sowing time and nitrogen levels on seed yield of 3hindi. Plant Science 11: 69-99.

Moench, S, Miroslava, B and Pradhon, P (2021). Climate Change Adaptation by Smallholder Farmers . Acase study of Nepal . *Environmental Science* 116:136 - 196

Muoneke C.O, Asiegbu J.E(1997)Effects of Okra planting density and spatial arrangement in intercrop with maize on the growth and yield of the component species. J. Agron. Crop Sci. 179:201-207.

Obasi, M.O. 1989;some studies on the Growth, Development and Yield of Ground bean (kerstingella geocarpa Harms) in Derived savanna environment of Southern Nigeria. Ph.D. thesis .University of Nigeria,Nsukka.pp.3 75.

Ofori, F., and R. Stern, 1987. Relative sowing Time and Density of Component Crops in a maize/cowpea intercrop system, Expl. Agric, 23;41-52.

Ogbuchi, C.R.A, and M.D, Orzolek, 1987, Intercropping Carrot and Sweet corn in a multiple Cropping system Sci.Hort.3 1; 17-24.

Oludare, S.A and Khaldoon, A.M (2021) Modelling Maize Yeild and Water requirements Under different Climatic Change Scenario. Climate 8(11):127 - 136

Onuwerne, I.C. and T.D. Singh, (1991). Field Crop production in tropical Africa, Principles and practice. CTA, Ede, the Netherlands pp. 480.

Orkwor, G.C.O.U. Okereke, F.O.C. Ezedinma, and H.C. Ezumah (1991). Critical Period of weed interference in maize (zea mays L.) Intercropped with yam (Dioscorea rotundata poir), Okra (Abelmosch esculentus L. Moench) and sweet potato (Ipornoea batatas L. Lam O, Niger. Agric.J.26 :61-70.

Palaniappan, S.P 1985. Cropping systems in the Tropics, Principles and management, Willey Eastern Ltd.india.pp2 15.

Sharma, P Kattel, R.D, and Suhebi, A,.P (2017). Climate Change and Maize Agriculture Among Communities in Nepal: A Review. 3(1):53 – 66..

Sinha, S.B., K. Singh and S.P. Singh (1981). Effect of time of weeding on growth and seed yield of okra. *India Journal of Weed Science.* 3(1):11-17.

Torrie, J.H. (1980). Principles and Procedures of Statistics, McGraw Hill Book Company Inc. New York, Pp. 481.

Walkey, A. and Black, I.A. (1934), An examination of the pagtiareff method for determining soil organic matter and a proposed modification of chromic acid titration method. *Soil science* 120: 212 – 218.