**Performance of Okra(*****Abelmoschus esculentus* [L]**[**Moench**](https://en.wikipedia.org/wiki/Conrad_Moench)***.)* as influenced by Row Arrangement and Weeding Regime Grown in Intercrop with Cucumber(*Cucumis spp.)* in Sudan Savanna**

**ABSTRACT**

Field trials were conducted during the rainy season of 2018 and 2019 at the Teaching and Research Farm, Faculty of Agriculture, University of Maiduguri, Borno State, Nigeria, to evaluate the performance of okra in an okra-cucumber intercrop under different row arrangements and weeding regimes in the Sudan savanna agroecological zone. The experiment utilized a factorial combination of three-row arrangements of okra and cucumber (1:1, 1:2, and 2:1) and four weeding regimes (W0, W1, W2, and WF) arranged in a split-plot design with three replications. Weeding regimes were assigned to the main plots, while row arrangements were allocated to the subplots.

The study assessed okra parameters including the number of fruits per plant, fruit length, fruit diameter, fruit weight per plant, and yield per hectare. Results revealed that the 1:2 row arrangement produced a higher number of fruits per plant, better fruit weight per plant, and greater fruit yield compared to other arrangements. However, the combination of a 2:1-row arrangement with a weed-free treatment significantly improved fruit yield. In both years and combined mean, the 1:2 row arrangements with weed-free produced the highest monetary return but were not statistically different from the two weddings. The two weddings were therefore optimum for the monetary return of the okra/cucumber mixture. Based on these findings, the 2:1 row arrangement with a weed-free regime is recommended for cultivating okra in an intercrop with cucumber in the Sudan savanna region.

1. **INTRODUCTION**

Okra (*Abelmoschus esculentus* [L.] Moench) is a member of the Malvaceae family and is widely valued for its edible green pods. It originates from West Africa, Ethiopia, and Southeast Asia and is cultivated in tropical, subtropical, and warm temperate regions worldwide (NRC, 2006). Known for its heat and drought tolerance, okra thrives in various soil types, including heavy clay with intermittent moisture, but is sensitive to severe frost. In the southern United States, it is commonly grown in Texas, Georgia, Florida, and Alabama (FAOSTAT, 2012), as well as in home gardens and commercial markets throughout North Carolina (Sanders, 2001).

World production of okra stood at about 9.4 million tonnes with 69% (5.2 million tonnes) produced in India. As an indigenous crop of Africa, Okra is cultivated widely in Africa for its immature fruits used as a vegetable with a yield of 4.18 million tonnes. In Nigeria, it is estimated at 1.82 million tonnes per year (FAOSTAT, 2020). The total area under cultivation has increased over the years. India has been known to be the highest producer of okra in the world, followed by Nigeria and Sudan (Komolafe *et al*., 2021).

Okra thrives well in different soils, but it is best grown in well-drained sandy and clay loam soils, especially with rich organic matter (Sreenivasa *et al.,* 2010). It can tolerate slightly acidic soil. The crop can be grown in soils with a pH range from 4.5 to 7. According to Iyagba *et al*. (2012), okra grows best on loams and sandy loams but will produce good yields on heavier soils. It is a crop of tropical and sub-tropical climates requiring a long warm and humid growing season (Komolafe *et al*., 2021). It is susceptible to frost and cannot thrive well in cold. It may be grown at elevations from sea level up to 30 m (Omotoso *et al.,* 2018) but can tolerate a wide range of rainfall (Omotoso *et al.,* 2015). Seeds fail to germinate below 20oC. The optimum temperature for seed germination is 29oC. Okra is a stout, erect annual herb that grows to about 4 m tall with spirally arranged leaves with leaf blades up to 50 cm in diameter (Olaniyi *et al*., 2009). The fruit is a capsule and grows quickly after flowering. Fruits or pods are green, 5-35cm long, and 1-5 cm in diameter (Adetuyi *et al.*, 2011). The crop is known in many English-speaking countries as ‘ladies’ finger’ or ‘ochro’ (Remison, 2005). In Nigeria, it is made into soups, stews, and sauces with or without palm oil; fish, and other condiments, or it’s boiled as a vegetable. The leaves of okra can also be cooked to make a popular soup called Ilesha in Nigeria (Cooke, 1998). Okra has a high fiber content which helps to stabilize blood sugar by regulating the rate at which sugar is absorbed in the body system (Udoh *et al*., 2005; Ngok *et al.*, 2008).

The adoption of high-yield varieties is emphasized by farmers who still dwell on genotypes with poor yield (Agba *et al.*, 2011). Research studies on okra, point out that, varieties with high-yielding ability should be recommended for food security (Adetuyi *et al.*, 2011). In Nigeria, agricultural production is low due to a lack of proper agronomic practices, and infrastructure, low yields associated with poor soils, and low-yielding and less stable varieties (Omoregie and Nwajei, 2015). In the study area, crop yield from farmers’ fields is low due to soil degradation as a result of oil spillage and exploration (Agba *et al*, 2011; Umeri *et al*, 2018). With regards to high-yielding crop varieties, there is need to increase effort on research to cultivate new crop varieties that can withstand the harsh environment in future as a means of tackling food insecurity among the populace in this zone. Hence, this study was conducted to evaluate the growth and fruit yield performance of some okra varieties in Agbor located in a rainforest zone of Delta State. The study was to determine the appropriate row arrangement and optimum weeding regime for the maximum performance of okra grown in intercrop with cucumber in the Sudan Savanna region.

1. **MATERIALS AND METHODS**

Field experiments were conducted during the wet season of 2018 and 2019 at the Teaching and Research Farm, Department of Crop Production, Faculty of Agriculture, University of Maiduguri (Longitude 13°12' 36.02'' E and Latitude 11°48' 2.32'' N and on an altitude of 354 m above sea level). Maiduguri is in the Sudan Savannah region of Borno State, Nigeria under a semi-arid environment characterized by sparse vegetation with an average annual rainfall of 650mm, spanning 4-5 months (May – September).

The experiment consists of three (3) row arrangements (1:1, 1:2, 2:1) and four (4) weeding regimes (weedy check, hoe weeding once at 3 weeks after sowing(WAS), hoe weeding twice at 3 and 6 WAS, and weed-free). The sole crops of okra and cucumber were also included for the purpose of calculating land equivalent ratio (LER). The weeding regimes were allocated to the main plots while the raw arrangements were allocated to the subplots. The treatments were factorially combined and laid out in a Split Plot Design and replicated three times. There was a total of 36 plots each measuring 3.0 m x 4.5m (gross size of 13.5m2) while the net plots consist of the three (3) most central rows in each gross plot excluding border rows (6.75m2). Within replicate block, rows were separated using 1m apart and 2m between each replicate block. The estimated land area used for the experiment was 0.11ha.

Okra (Jokoso) variety was used for the study, which matures in 65 days. The variety is highly remarkable or consumed, a day-neutral, high-yielding, insect and disease-resistant. It has very thick flesh pods, short to medium in height, and deeply lobed leaves arranged spirally on the stem. The local variety of cucumber known as Gurthli was used for the research. Gurthli as a trialling plant is anticipated to control weeds in the intercrop. Okra sowing was carried out on 15 June in 2018 and 25 June in 2019. Cucumber was planted on 29th June in 2018 and 9th July in 2019. The seeds of Okra (Jokoso) were obtained from the Institute of Agricultural Research Samaru, Zaria Nigeria.

The physical and chemical properties of the soil in the experimental site were analysed by taking soil samples at the depths of 0-15cm and 15-30cm and analysed in Soil Science Laboratory of University of Maiduguri. The collected sample was composited, air-dried, ground and sieved to pass through 2mm screen before subjecting it to physical and chemicals analyses. The particle size distribution was determined using hydrometer method (Bouyocos, 1962), and PH meter was used in the determination of soil reaction. Total nitrogen was also determined by kjeldahl digestion method (Bremner and Malvanes, 1982), and spectrometer was used in the determination of P by Bray I–P method (Bray and Kutz, 1945). The organic matter content was also determined using wet oxidation method. Exchangeable bases were extracted in IM NH4OAc buffed at PH 79 (Page *et al.,* 1992). While the cation exchange capacity (CEC) was obtained by summation of exchangeable bases (Rhode, 1982). The exchangeable acidity was also determined by KCI extraction method according to Mclean (1965). K and Na: Mg and Ca were determined by flame photometer and atomic absorption spectrophotometer respectively.

Parameters of yield components and yield of okra such as number of fruits harvested per plant, fruit weight per plant (g), fruit length (cm), fruit diameter, and total fruit yield per ha were assessed using standard procedure. Data collected were subjected to analysis of variance and difference between means determined according to Duncan’s Multiple Range Test (DMRT)[18] in the General Linear Model (GLM) of SPSS[19].

1. **RESULTS AND DISCUSSION**

The results of the analysis of soil samples taken from the experimental sites are presented in Table The soil of the research site was coarsely textured and well-drained sandy loam at 0-15cm and 15-30cm depth, slightly acidic and low in organic carbon. The soil also has a low cation exchange capacity. Similarly, available phosphorus and Nitrogen were also low. This is in agreement with Rayer, A.J 1987 who reported that the Sudan savanna soils are low in nutrient status.

The effects of row arrangements and weeding regimes on fruit weight/plants of okra in 2018, and 2019 and the combined mean are presented in Table 1. There was a significant effect of row arrangements on fruit weight/plants of okra in both years and combined mean. The 1:2 row arrangements produced significantly higher fruit weight/plants of okra in both the years and combined mean while the least fruit weight/plants of okra was obtained in 2:1 row arrangements in both years and combined mean. Similarly, there was a significant effect of weeding regimes on fruit weight/plants of okra in both years and combined mean. The two wedding were optimum for fruit weight/plants of okra and the least was observed in weedy check in both the years and combined mean

There was a significant interaction between row arrangements and weeding regimes on okra fruit weight/plants in both years and combined mean (Table 3). The 1:2 row arrangements with two weddings were optimum for fruit weight/plant of okra in both years and combined mean while the least fruit weight/plant was observed in 2:1 with the weedy check.

**Table 1: Physico-chemical properties of the surface (0-15) and sub-surface (15-30) soil at the experimental site in Maiduguri during the 2018 and 2019 rainy seasons.**

**Soil properties 2018 2019**

**Particle size Distribution 0-15 15-30 0-15 15-30**

Sand g/kg 76.00 76.00 76.00 76.00

Silt g/kg 10.00 12.00 10.00 12.50

Clay g/kg 14.00 11.50 16.00 11.00

Textural class Sandy loam Sandy loam Sandy loam Sandy loam

**Chemical composition**

pH in water 6.27 6.27 6.28 6.26

Organic carbon 0.43 0.23 0.42 0.22

Total nitrogen 0.13 0.06 0.13 0.06

Available phosphorus (mg/kg) 3.15 4.90 3.15 3.14

Exchangeable cation (mg/kg)

K 0.61 0.47 0.61 0.46

Mg 0.60 0.40 0.60 0.41

Ca 1.20 1.00 1.20 1.01

Na 0.13 0.05 0.13 0.06

CEC 2.54 1.92 2.52 1.91

*Mg kg = Milligram per kilogram CEC = Cation Exchange Capacity*

**Table 2. Effect of row arrangements and weeding regimes on fruit weight/plant of okra in Maiduguri during 2018, and 2019 rainy season and combine mean**

**Fruits weight/plants (g)**

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Treatment 2018 2019 Combined mean**

**Row arrangements (A)**

1:1 401.04a 290.47b 335.90b

1:2 408.74a 403.02a 405.60a

2:1 352.44c 269.70c 321.57c

SE ± 15.05 6.91 14.86

**Weeding regimes (B)**

Weedy Check 118.79c 102.52d 110.66d

1W 315.08b 209.43c 262.75c

2W 547.19ab 533.53ab 540.36ab

WF 560.95a 542.40a 551.67a

SE ± 17.38 9.98 17.11

**Interaction**

**AXB** \* \* \*

\*Significant

**Table 3: Interaction between row arrangements and weeding regimes on fruit weight of okra in Maiduguri during 2018, 2019 rainy seasons and combined mean**

 **Weeding regimes**

 **Weedy Check 1W 2W WF**

 **2018**

**Row arrangements**

**1:1** 115.19f 122.29e 360.39c 482.03b

**1:2** 118.47f 301.29d 591.08ab 623.37a

**2:1** 73.90g 204.50f 360.40c 521.80ab

**SE ±** 13.82

 **2019**

**Row arrangements**

**1:1** 120.72d 247.22cd 462.80c 584.29ab

**1:2** 121.07d 442.94c 571.00ab 648.21a

**2:1** 114.58e 255.08cd 462.82c 595.28ab

**SE±** 30.11

 **Combined Mean**

**Row arrangements**

**1:1** 118.39fg 229.36e 411.20c 526.92ab

**1:2** 116.27fg 183.85ef 543.01ab 588.05a

**2:1** 97.31g 374.99d 477.85bc 585.09a

**SE ±**  29.72

*Means having the same letters(s) are not statistically different at p ≤ 0.05 (DMRT)*

The effects of row arrangements and weeding regimes on okra fruit yield in 2018, 2019 and combined mean is presented in (Table 4). There was no significant effect of row arrangements on okra fruit yield in both years and combined mean. There was significant effect of weeding regimes on okra fruit yield in both years and combined mean. The weed free treatment produced the highest okra fruit yield and the least fruit yields was observed in weedy check treatment in both years and combined mean. The interaction between row arrangements and weeding regimes on okra fruit yield in 2018, 2019 and combined means was significant (Table 4). The 2:1 row arrangement with weed free treatment produced significantly higher okra fruit yield in both years and combined mean in the crops mixture (Table 5).

**Table 4: Effect of row arrangements and weeding regimes on fruit yield of okra in Maiduguri during 2018, 2019 rainy season and combine mean**

**Fruit Yield (t/ha)**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Treatment 2018 2019 Combined mean**

**Row arrangements (A)**

1.1 4.13a  4.52a 4.32a

1.2 4.28a 4.00a 4.14a

2.1 4.74a 4.65a 4.69a

SE ± 0.20 0.21 0.16

**Weeding regimes (B)**

Weedy Check 0.21d 0.41d 0.31d

1W 1.24c 1.42c 1.33c

2W 5.43b 5.82b 5.63b

WF 6.65a 6.91a 6.78a

SE ± 0.24 0.25 0.18

**Interaction**

 **AXB** \* \* \*

*Means having the same letters(s) are not statistically different at p ≤ 0.05 (DMRT)*

*\*Significant*

**Table 5: Interaction between row arrangements and weeding regimes on fruit yield (t/ha) of okra in Maiduguri during 2018, 2019 rainy seasons and combined mean**

 **Weeding regimes**

 **Weedy Check 1W 2W WF**

 **2018**

**Row arrangements**

**1:1** 0.42g 1.41e 5.49c  6.44b

**1:2** 0.62f 1.78e 4.27cd 6.24b

**2:1** 0.58f 1.53e 5.78bc 7.72a

**SE ±** 0.41

 **2019**

**Row arrangements**

**1:1** 0.09e 1.78d 5.99bc 6.38b

**1:2** 0.69e 1.62c 5.24bc 6.31b

**2:1** 0.45e 1.86d 6.24b 8.05a

**SE ±** 0.43

 **Combined Mean**

**Row arrangements**

**1:1** 0.01h1.28g 5.39c  6.38b

**1:2** 0.65h 1.63fg 5.25c  6.24bc

**2:1** 0.25h 1.57fg 6.38b  7.89a

**SE ±**  0.32

*Means having the same letters(s) are not statistically different at p ≤ 0.05 (DMRT)*

The 1:2 row arrangements with two weeding were optimum for fruits weight/plant in both years and combined mean. The 2:1 row arrangements generally produced lower fruits weight/plant particularly with weedy check. The smaller fruits weight/plant obtained at 2:1 row arrangements combined with weedy check could be due to high population of okra which might have resulted on competition for environmental resources such as nutrient, sunlight and water. In all the years and combined mean, the 2:1 row arrangements with weed free gave the highest okra yield/ha. This is due to high population of the okra in the mixture which resulted in higher yield per unit area. The 1:2 row arrangements with weedy check produced the least okra fruit yield/ha. The low yield recorded in 1:2 row arrangements combined with weedy check could be attributed to low plant population of the okra per plot coupled with intense competition for resources due to the heavy presence of weeds. This finding corroborates with the finding of Jeyakumaram and Seran (2007) who reported that low plant per unit area leads to low yield of crops.

the present study has shown significantly larger fruits weight/plant from 1:2 row arrangements than the other row arrangements. Essentially this might be due to the fewer populations of okra in the okra/cucumber mixture, the cucumber serving as live mulch. This finding is in agreement with Hamma *et al.* (2012) who reported that okra fruits weight/plant increased with a decreased plant population. In the present study, there was variation in fruits weight/plant between the years where 2018 had higher fruits weight/plant than in 2019 at 1:2 row arrangements. This could be explained by the variation of rainfall where 2018 had higher rainfall than 2019.

The okra yield/ha from the present study was significantly favoured by 2:1 row arrangements compared with the other row arrangements. This is expected as the 2:1 row arrangements had higher population of okra in the okra/cucumber mixture. It could also be due to the tall height of plant under 2:1 row arrangements in the present study. Though, they are not statistically different in height due to the different row arrangements but value was higher for 2:1 row arrangements. Although the fruit sizes were smaller for plants grown using 2:1 row arrangements, the higher number of plants/plot from this treatment resulted to higher yield/ha. This finding is in agreement with Dantata *et al*. (2020) who reported higher maize yield/ha in 2:1 row arrangements of maize/watermelon mixture compared with 1:1 or 1:2 row arrangements.

1. **Conclusion**

From the result of the present study, it could be concluded that row arrangements of 1:2 (1 row of okra to 2 rows of cucumber) with weed-free appeared more advantageous to produce okra in okra/cucumber intercrop in the Sudan Savanna agroecological zone of Nigeria.

**REFERENCES**

1. Adam, B.K., Kabura, B.H and Dantata, I.J. (2020). Performance of Watermelon (*Citrullus lanatus* [L]*)* as Influenced by Row Arrangements and Cow Dung Rates Grown in Intercrop with Maize (*Zea mays* [L]) in Sudan Savanna. *American Journal of Experimental Agriculture International* 42(5): 8-15
2. Adigun, J.A and Lagoke S.T.O (2003). Critical period of weed interference in rainfall and irrigated tomatoes in Nigeria. *Journal of*
3. *Agricultural Research* & development, faculty of Agriculture, University of Ilorin 2:32-41.
4. Adetuyi, F.O., Osagie, A.U. and A.T. Adekunle (2011). Nutrient, ant-nutrient, mineral and zinc bioavailability of okra {*Abelmoschus esculentus* (L) Moench} variety. *American Journal of Food Nutrition,* 1:49 – 54.
5. Agba, O.A., Mbah, B.N., Asiegbu, J. E. and I.B. Adinya (2011). Effects of spacing on the chemical composition of 13 wild plant foods of Niger. *Journal of Food Compound Analysis*, 13: 83 – 92*.*
6. Aiyeleagbe, I.O.O and Jalaosa, M.A.(1993). Growth and yield response of papaya to intercropping with crops in south western Nigeria. *Journal of Science* 14-17.
7. Akobundu I.O and Agyakwa C.W. (1987). A hand book of West African weeds IITA Ibadan. 521pp.
8. Anonymous (1990) Nigeria stored product research institute. Annual Report, pp: 30-32.

Agricultural Processing Seminar of Fertilizer Development. Nig., 8: 63-77.

1. Anonymous (1992) weed control recommendations for Nigeria. Series No. 3. National committee on weed control, Department of Agriculture, Federal Ministry of Agriculture Ibadan, Africa-Links Books Ltd.
2. Anuebunwa, F.O. (1992). A bio-economic evaluation of intercropping arrangements in a Yam-Cassava based system in the rainforest belt of Nigeria. National Root Crop Research Institute, Umudike. *Biology, Agriculture and Horticulture.* 8(3):251-260
3. Aruna,U. I., Amans, E.B., Mahmud, M., Ahmed, A., Luka, G.L., and Isah A.S.(2013). Yield yield components of maize as influenced by row arrangements, nitrogen and phosphorus levels in maize (*zea mays L)/castor(Ricinus communis)* mixture. *Journal of Agriculture and veterinary science ISSN 2319 – 2380 volume Pp 45-49*
4. Asif, M.I (1997) Estimation of leaf in okra (*Abelmoschus esculentus* [L] Moench). *Tropical Agricultural Journal.* Trinida. Vol. 54 No.2 pp 192
5. Bassi, J. A. (2019). Performance of pearl millet (*Pennicum glaucum* (L.) R, Br) and

Cowpea (*Vigna unguiculata* (L) walp) Intercrop as affected by variety and time of cowpea introduction in Sudan Savanna of Nigeria. PhD Thesis submitted to School of Postgraduate Studies, University of Maiduguri

1. Bouyoucos, G,J. (1962). Hydrometer method improved for making particle size analysis of soils. *Agronomy journal* 54: 564 - 565
2. Bray, R.H. and Kurtz, L.T. (1945). Determination of total organic and available forms of Phosphorus in Soil. Soil Science, 59; 255-259
3. Bremmer, J.M and Malvanes, C. S. (1982). Total nitrogen in method of soils analysis

Agronomy monograph 9(2): 595-625.

1. Cooke, J.A., Jagt, D.J., Pastuszyn, A., Mountalia, G. and R.S. Glew (1998). Nutrient and growth and yield of okra {*Abelmochus esculentus* (L.) Moench} in Obubra, Cross River State. *Global Journal of Agricultural Science,* 1: 57 - 61.
2. Dantata, I.J., Adam, B.K and Kabura, B.H (2020). Performance of Maize (*Zea mays* [L]) as Influenced by Row Arrangements and Cow Dung Rates Grown in Intercrop with Watermelon (*Citrullus lanatus* [L]*)*  in Sudan Savanna. *Asian Journal of Research in Crop Science* 5(4): 45-51.
3. Dariush, M., Madani, A. and Oveysi, M. (2006). Assessing the land equivqlent ratio (LER) of two corn varieties intercropping at various nitrogen levels in Kajal, Iran.*Journal of Central European Agriculture. 7: 2, 359-364.*
4. De Lannoy, G,. (2001). “vegetable In: Remarkable, R.H (Ed) Crop production in tropical Africa. DGIC Belgium, pp.453-458
5. Eskandari, H., Ghanbari A. and Javanmard A. (2009a). Intercropping of cereals and legumes for forage production. Notulae Scientia Biologicae, 1: 07-13.
6. Eskandari, H., Ghanbari A., Bonjar, M. Galavai and Salari, M. (2009c). Forage quality of cow pea (*Vigna sinensis*) intercropped with corn (*Zea mays*) as affected by nutrient uptake and light interception. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 37: 171-174.
7. Eskandari, H., 2012b. Intercropping of maize (*Zea mays*) with cowpea (*Vigna sinensis*) and

mungbean (*Vigna radiata*): effect of complementarity of intercrop components on resource consumption, dry matter production and legumes forage quality. *Journal of Basic and Applied Scientific Research*, 2: 355-360.

1. FAOSTAT (2020). Food and Agriculture Organization Statistics. http://www.fao.org/faostat/en/#data/QCL(Assessed August 2020)
2. Gbadamosi A.A, Iremiren GO, Aladesama R.D. (2003). Effects of weeding regimes and atrazine application on soil factors of growth performance of maize in rain forest area of Nigeria. *Journal of Agriculture*, Forestry and Fisheries 3 &4, 58-62.
3. Ghanbari, A. and Lee. H.C. (2003). Intercropped wheat (*Triticum aestivum* L.) and bean

(*Vicia faba* L.) as a whole-crop forage: effect of harvest time on forage yield and quality. *Grass and Forage Science,* 58(1): 28-36.

1. Gwandzang, M.I. (1992). Guna Programme. Pilot Survey Study (Report). Dept of Agric. Tech. Centre for Appropriate Technology. Ramat Polytechnic, Maiduguri. Borno State Nigeria.
2. Gworgwor, N.A. and Lagoke.S.T.O.(1988). Weed management and control in sorghum based crop mixture in the Nigerian Savannah. In: Improved Agricultural Technology for small-scale farmers: *proceeding of National Farming Research Network held in Jos Plateau State, Nigeria. May 10th – 13th*
3. Gomez K.A and Gomez A. (1984). A statistaical procedures for Agricultural Research John Wiley and Sons, New York, 680pp.
4. Hamma, I. L.., Ibrahim , U and Yusuf, S.M.(2012). Growth and yield of okra as influenced by live mulch in Samaru, Zaria, Nigeria. *European journal of sustainable development,* I(2): 229 - 234
5. IITA (1997). International Institute for Tropical Agriculture. Research highlight for 1997. Weed control and Residue management in intercropping: 15.
6. Ikeogu J.E.G (1991). Effect of maize and cassava on the performance of intercropped egusi melon (*Citrullus lanata (L) thumb*) and Okra (*Abelmochus esculentus (L)* *moench*). In Nigeria sci. *Horti Amsterdam*, 48: pp 261 – 268
7. Komolafe, R.J., Ariyo, O.J. and C.O. Alake (2021). Diversity in phenotypic traits and mineral elements of Okra (*Abelmoschus esculentus* (L.) Moench) genotypes. *International Journal of Agronomy*, 1: 10-14.
8. Lawan A. B. (2000). Response of Cucumber (*Cucumis sativus L.*) to intercropping with maize ( *Zea mays L.)* and varying rates of farm yard manure and inorganic fertilizer Ph. D Agronomy Thesis A. B. U Zaria Pp 268
9. MacDonald I. and J. Low (1984). Fruit and vegetables. Evans brothers (Nigeria Publishers) Ltd. Ibadan 135pp.
10. Mahapatra, S.C. (2011). Study of grass-legume intercropping system in terms of

competition indices and monetary advantage index under acid lateritic soil of India. *American Journal of Experimental Agriculture*, 1(1): 1-6. 485 J. Appl. Environ. Biol. Sci., 1(11)482-486, 2011

1. Mahmoud *et al.* (2013) Growth and yield of okra as influenced by weeding regimes in

Samaru- Zaria, Nigeria. International *Journal of Agronomy and Agricultural Research* (IJAAR)

1. Makinde, A.A., Bello, N.J., Olasantan, F.O., Adebisi, M.A. and Adeniyi H.A. (2011) seasonality and crop combination effects on growth and yield of two sorghum (*Sorghum bicolor)* cultivars in sorghum/maize/okra intercrop in a Forest-Savanna Transition Zone of Nigeria. *Agricultural Journal* 6(3):92-99
2. Martins, M.P.L.D. and R.W. Snaydon, (1982). Intercropping barley and beans I. Effects of planting pattern. Experimental Agriculture, 18: 139-148.
3. Matanyaire, C.M (1998). Sustainability of pearl millet (*pennisetum glaucum)* productivity

in northern Namibia: current situation and challenges. South Africa *Journal of Science*. 94: 157 - 166

1. Mathew, I.P and S.K Karikari (1990). Horticulture: principles and practice. London, Macmillan education, Ltd. 202pp.
2. Mclean, E.O. (1965). Aluminium. In: C. A Black (ed). Method of soil Analysis patt 2.

Chemical and Mineralogical Properties. Agronomy Monograph No. 9 part 2, PP 686-994

1. Melifonwu A.A. (2000). Effect of varying period of weeds interference on yield of okra (*A. esculntus* (L.) Moench) in the humid tropical forest of south-Eastern Nigeria. In: Remison., S.U (Ed) the *Nigerian Agricultural journal*: The Agricultural society or Nigeria pp115-121.
2. Mead, R. And Willey, R. W. (1980). The concept of land equivalent ratio and advantages. *Experimental Agriculture 16:217-226.*
3. National Research Council (2006). [Lost Crops of Africa: Volume II: Vegetables](http://books.nap.edu/openbook.php?record_id=11763). Lost Crops of Africa **2**. National Academies Press. [ISBN](https://en.wikipedia.org/wiki/International_Standard_Book_Number) [978-0-309-10333-6](https://en.wikipedia.org/wiki/Special%3ABookSources/978-0-309-10333-6). Retrieved 2008-07-15.
4. Ndora, O.F, Madakadze, R.M., Kageler, S. And Mashingaidze, A.B. (2007). Indigenous knowledge of the traditional vegetable pumpkin (*Cucurbita maxima/moschata)* from Zimbabwe. *African Journal of Agricultural Research. 2:* 649-655
5. NEAZDP (1992). North East Arid Zone Development Programme. Pilot study of the guna Production. Monitoring and Evaluation Unit; NEAZDP, Garin Alkali-Gashua. Yobe State. Nigeria Report.
6. Nelson, R.E and Sommer, L.E (1982). Total carbon, organic carbon and organic matter. In page (ed) methods of Soil Analysis part 2. Agronomy No. 9 Madison Wisconsin. USA. Pp 539-579.
7. Ngok. T.H., Ngo. Q.N., Van. A.T. and N.V. Phung (2008). Hypolidemic effect of extracts from *Abelmoschus esculentus* (Malvaceae) on tyloxapol- induced hyperlipidemia in mice. *Warasan Phesatchasat.,* 35: 42 – 46.
8. Odhiambo, G.D. and E.S. Ariga, (2001). Effect of intercropping maize and beans on striga incidence and grain yield. Seventh Eastern and Southern Africa Regional Maize Conference, 183-186.
9. Ofori, F. and Stern, W.R. (1987). Cereal-legume intercropping systems. *Advances in Agronomy. San Diego 31:41*
10. Ogunwole, J.O. (2000). The microclimate of a cereal based intercrop at Samaru, Northern Nigeria. Ph.D. Dissertation, Dept of Soil Science, Ahmadu Bello University Zaria.
11. Okigho, B.N. and Greenland, D.J (1976). Intercropping systems in tropical Africa. In Papndick, R.I,; Sanchez, P.A,; Tripplet, G.B. (Eds). *Multiple cropping.* Madison: *American Society of Agronomy, pp.63-101.*
12. Olaniyi, J.O., Akanbi, W.B., Olaniran, O.A. and O.T. Ilupeju (2009). Effects of organo-mineral and inorganic fertilizers on the growth, fruit yield, quality and chemical compositions of okra. Proceedings of the 3rd International e-Conference on Agricultural BioSciences. [*http://www.e-conference.elewa.org/agriculture*](http://www.e-conference.elewa.org/agriculture)*.*
13. Omotoso, S.O. and O.Y. Johnson, (2015). Growth and yield of two varieties of okra *(Abelmoschus esculentus* (L). *Moench)* as affected by potassium fertilizer sources. *Journal of Biology, Agriculture & Healthcare,* 5: 98-104.
14. Omotoso, S.O., Fawole, F.O., Alukoand, A. and F. Kehinde-Fadare (2018). Growth and yield of two okra *(Abelmoschus esculentus* L. Moench) varieties as affected by organic fertilizer grown on an Oxic Paleustalf in Ekiti State. *Global Advanced Research Journal of Agricultural Science,* 7:137-144.
15. Omoregie, A.U. and S.E. Nwajei (2015). Evaluation of some varieties of millet (*Pennisetum typhoides*) in a forest-savanna transition zone of Edo State, Nigeria. In: Omeje, S.I., Emosairue, C.C., Chukwuji, C.C., Bratte, L., Isikwenu, J.O., Isiorhovoja, R.A. and Agbogidi, M.O. (Eds). Agriculture: The Nigerian economy beyond oil. *Proceedings of the 49th Annual Conference of the Agricultural Society of Nigeria* 2:1346-1349.
16. Okuruwa, V. O., Obasdaki, F. O. and Ibrahim, G. (2005). Probability of beef cattle

fattening in the cosmopolitan city of Ibadan, Oyo State. *Moor Journal of Agriculture Research 1*: 45-

1. Page, A. I.., Miller, R.H and Keeney, D.R. (1992). Methods of Soils Analysis, part 2.

Chemical and Mineralogical Properties. *Agronomy Monograph* Number 9 ASA – SSSA Madison

1. Peech, M. (1965). Exchange Acidity; In Methods in Soil Analysis, part 2. Chemical and Microbial Properties Edited by Black, C.A. *et al.*; published American Society of Agronomy, Inc. Madison, Wisconsin (9) 905-913.
2. Quainoo, A.K., Lawson, I.Y.D. and Yawson, A. (2000). Intercrop performance of maize, sorghum and soyabean in response to planting pattern. *Journal of the Ghana Science Association* 2(2):31-35.
3. Remison, S.U. (2005). *Arable and Vegetable Crops of the Tropics*. Gift print associate, Benin City. 39 pp.
4. Quaye MO, Sarkodie-Addo J, Kennedy A, Snr PAP, Kyere CG. Contribution of Okra (Abelmoschus esculentus L. Moench) – Cowpea (Vigna unguiculata L. Walp) Intercropping to Productivity of the System in Semi-deciduous Forest Zone of Ghana. Asian J. Adv. Agric. Res. [Internet]. 2020 Jun. 18 [cited 2025 Feb. 6];13(3):10-2. Available from: https://journalajaar.com/index.php/AJAAR/article/view/250
5. Rhodes, J. A. (1982). Method of Soil Analysis, part 2. Chemical and Mineralogical

Properties. *Agronomy Monograph* No. 9 ASA – SSSSA Madison

1. Sanders, D.C. (2001). *Okra Production*, Horticulture information leaflets, North Carolina State University.
2. Silwama, T.T., and Lucas, E. O.(2002). The effect of planting combinations and weeding and yield component crops of maize bean and maize pumpkin intercrops. *Journal of Agriculture Science* 138: 193-200.
3. Singh I.P (1995). Effect various doses of nitrogen on seed yield and quality of okra (*abelmoschus esculentus* (l.) moench). *Annual Agricultural Research*, 16:227-229.
4. Tsubo, M., Walker, S. and Ogindo, H.O (2003). A simulation model of cereal-legume intercropping system for semi-arid regions. *Field Crop Research.* 93: 23-33.
5. Udoh, D.J., Ndon, B.A., Asaquo, P.E and N.U. Ndueyo (2005). *Crop Production Techniques for the Tropics*. Concept Publishers, Lagos, Nigeria. pp 223 – 247.
6. Unamma, R.P.A., Anuebunwa, F.O., Oputa, C.O. (1990). On farm evaluation of different weed management alternatives in yam-maize intercrop. *Nigerian Journal of Weed Science* 3:59-66
7. Vesterager J,M, Nielson N.E, Hogh-Jensen, H. (2008) Effects of cropping history and phosphorus source on yield and nitrogen fixation in sole and intercropped cowpea-maize systems. *Nutr. Cycl. Agroecosys* 80: 61-73.
8. Willey, R.W. (1990). Resource use in intercropping systems. Journal of Agriculture and

Water Management, 17: 215-231.

1. Zhang, F. and Li, L. (2003). Using competitive and facilitative interactions in

intercropping systems enhance crop productivity and nutrient-use efficiency. Plant and Soil, 248: 305-312.