**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 2018 and 2019 rainy seasons 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. 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).

In Africa, major producers include Côte d’Ivoire, Ghana, Nigeria, Egypt, Sudan, Benin, Burkina Faso, Togo, Cameroon, Tanzania, Zambia, and Zimbabwe (De Lannoy, 2001). As of 2005, global annual production was approximately 5 million metric tonnes (Mmt), with India as the largest producer (3.55 Mmt). Other notable producers include Nigeria (0.73 Mmt), Pakistan (0.11 Mmt), Ghana (0.1 Mmt), and Benin (0.085 Mmt) (FAO, 2015). Africa's total annual production was estimated at 1.08 Mmt, led by Nigeria, Ghana, Benin, and Egypt. The highest yields were recorded in Egypt (14.17 t/ha), followed by Burkina Faso (10.00 t/ha), Kenya (6.25 t/ha), and Ghana (5.56 t/ha) (FAO, 2015). In Nigeria, okra is grown as a rainfed and irrigated crop, with an average yield of 2.6 t/ha. It is often intercropped with legumes, cereals, and root/tuber crops (MacDonald & Low, 1984).

Okra is nutritionally rich, with its edible pods containing approximately 86.1% moisture, 9.7% carbohydrates, 2.2% protein, 1.0% fiber, 0.2% fat, and 0.9% ash. It is a good source of vitamins A, B, and C, as well as minerals such as iodine (Martins, 1982). Popular in traditional West African cooking, immature pods are often sliced and cooked to prepare soups or viscous sauces (De Lannoy, 2001). The pods can also be sun-dried and powdered for later use during periods of scarcity. Additionally, young shoots and leaves are used as pot herbs, while the stem's fibers have local and commercial applications, including the production of paper and rugs (Sanders, 2001).

1. **MATERIAL 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 average temperature is 28.50 C with relatively low humidity during the dry season and high humidity during the wet season. The soils are generally sandy loam.

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 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.

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) in the General Linear Model (GLM) of SPSS.

1. **RESULTS AND DISCUSSION**

The results of the analysis of soil samples taken from the experime3ntal 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 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 weeding 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 weedings 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 season.**

**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 fruits weight/plant of okra in Maiduguri during 2018, 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** \* \* \*

**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)*

**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**

Generally, from the result of the present study, the growing of okra and cucumber in mixture at the planting pattern of 1:2 row arrangements with two weeding appeared more advantageous. However, if a farmer is more interested in okra yield, he should go for 2:1 row arrangements with weed free.

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