Afropolitan Journals

ISSN: 3027-2637 www.afropolitanjournals.com

Growth and Yield of Okra (*Abelmoschus esculentus* (L.) Moench) as Affected by Weeding Regimes in Mubi, Adamawa State

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DOI: *https://doi.org/10.62154/dbqmeh77*

Abstract

The two years experiments were conducted to evaluate the effect of weeding regimes on the growth and yield of okra (Abelmoschus esculentus L. Moench) in Mubi Adamawa State, Northern Guinea Savannah, grown at the Tree Crop Plantation (TCP) Farm, school of Agriculture, Federal polytechnic, Mubi, during 2022 and 2023 rain cropping season. Mubi is located in the North-eastern part of Adamawa State laid between Latitude 9^0 26′ and10^0 10′N and Longitude 13^0 10′ and 13^0 44′E. at an Altitude of 696m above sea level. The experiments were laid out in Split Plot Design with four (4) treatments: No weeding (W_1), 1 Weeding at 3 weeks after sowing (WAS) (W_2), 2 weeding at 3, and 6 WAS (W_3) and 3 weeding at 3, 6 and 9 WAS (W_4), replicated 3 times. Data were collected on plant height, Number of leaves, stem diameter, days to 50 % flowering, fruit length, fruit diameter, fresh fruit yield per plot, fresh fruit yield per hectare and dried fruit yield per hectare. The data on growth and yield parameters were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS), (SAS, 2000) and means that showed significant differences were separated by F-test using Duncan Multiple Range Test (DMRT). The results revealed that weeding regimes significantly influenced plant height, number of leaves, stem diameter, at 3, 6 and 9 WAS. On the response of phonological traits and yield components of okra, to weeding regimes and significant influence were observed in days to 50 % flowering, fruit length, fruit diameter, fresh fruit yield per plot, fresh fruit yield per hectare and dried fruit yield per hectare, accordingly. Treatment W_4 performed significantly higher than the other treatments. The study therefore recommends 3 times weeding at an interval of 3 WAS to okra farmers in Mubi and its environs for optimum fruit yield.

Keywords: Growth, Affected, Okra, Weeding Regime, Yield.

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) originated from Ethiopia in Africa (Khalid *et al.*, 2005) and was first cultivated by Egyptians in the 12^{th} century (Thompson and Kelley 1970) but nowadays widely cultivated throughout the tropics, sub-tropics and warmer parts of the temperate regions of the world (Echo, 2003; Khalid *et al.*, 2005; Farinde, *et al.*, 2007). It is a flowering plant and a member in malvaceae family, a polyploidy crop with chromosome number as: 2 n = 130, National Research Council (NRC. 2006). It is a stout, erect, herbaceous annual, stem is green with or without reddish tinge growing to the height of 2 m. Leaves are 10 – 20 cm long and broad, palmately lobed with 5 – 7 lobes. The flowers are solitary 4 -

8 cm in diameter axillary having epicalyx (up to 10) and calyx 5. There are 5 yellow petals and numerous stamens, the stigma is 5 – 9 lobed and fruit is capsules containing numerous seeds and basically, a self-pollinated crop (Bijendra, 2007; Shagufta, 2011). It is grown commercially in many countries such as India, China, Japan, Turkey, Iran, West Africa etc. (Banjawan, *et al*. 2007; Qhurehi, 2007: FAOSTAT, 2008). Distribution of West African okra is restricted to humid and per humid climates in Africa, between 12° N and 12° S. It is grown from Guinea to Nigeria in West Africa, Cameroon, Gabon and DR Congo in Central Africa and Uganda, in East Africa (Dhaliwal, 2017).
Okra grows well on a maximum average temperature of 35 °C with a minimum average above 18 °C. Optimal temperature for germination, growth and fruit setting is between 25 °C and 30 °C. No germination occurs below 16 °C and monthly average temperature range of 20 °C to 30 °C is considered favorable for growth, flowering and fruit development. Okra is slightly tolerant to acidity and thrives best at an optimum pH range from 6.6 – 8.0 (Shujat *et al*., 2006; Dhaliwal, 2017). Most of the okra species are well adapted to cultivate in up to 500 mm and above (Chadha, 2002 and Shagufta, 2011).
Okra is one of the priority vegetable crops in Nigeria and ranks above other vegetables including cabbage, Amaranthus, and Lettuce (Babatunde *et al.*, 2007). It is a vegetable who's essential and non-essential amino acids are comparable to those of soybean, which makes it important in the human diet (Law-Oqbomo *et al*., 2013). The fruit are consumed immature and can be used in salads, soups and stews fresh or dried, fried or cooked (Gemede *et al*., 2013). Fresh okra fruits are the most important vegetable source of viscous fiber, an important dietary component to lower cholesterol (Arapirtsas, 2008). Seed protein is rich in tryptophan (94 mg/g N) and also contains adequate amounts of sulfur-containing amino acid (189 mg 1 g N) a rare combination that makes okra seeds exceptionally useful in reducing human malnutrition (Chadha, 2002). The oil content of the seed is quite high (18 – 20%) and the oil yield from the okra crop is 794 kg ha^{-1} while its mucilage is used for medicinal purposes Industrially, okra mucilage which is extracted from root, fruit and stem of the plant is usually used for paper production, confectionary products and also used for cleaning the cane juice from which jiggery or brown sugar is produced (Onyishi, 2011). FAO (2004) reported that, okra fruit contain vitamin B_6, calcium and folic acid which could help in good vision, bone formation, growth and proper circulation of blood, and digestion. It soluble fibre also plays a vital role in lowering serum cholesterol, reducing heart disease and cancer, especially colorectal cancer.
These are some of the most attractive benefits that made okra unique among other vegetables. However, weeds dominate and become one of the major important limiting factors responsible for low productivity in okra production. They compete with the crop for light, nutrients, moisture and space leading serious reduction in the total fruit yields, thus their control become imperative (Hassan *et al*., 2003). Weeds are found everywhere causing several billions of dollars' worth of crop losses annually, with the global cost of control running amounting to billions of dollars (Abouziena and Haggag, 2016).

An earlier study by Edet, and Etim, (2010) and Larbi, *et al.*, (2013) revealed that, damage from insect pests; diseases and rodents were less compared to the level of damage from weeds. The effect of weed competition is reflected in poor crop establishment, reduced leaf number and size, yellowing of leaves and reduced leaf longevity, retarded growth and delay maturity (Awaar *et al*., 1992). Studies indicated that yield reduction in okra fruits due to weeds interference in the range of 40 – 90 % was reported by (Akobundu, 1987). Annual average (30 - 45 %) losses of the total production due to improper management and policy of weeds control were recorded by (Usoroh, 1995). Similarly, Ayegbe (2004), Ahmed *et al*. (2009) in their findings recorded yield losses between 50 – 60 % in okra.
Early weeding is advisable to prevent weeds from setting seeds. One year seedling means seven years weeding (Thierfelder and Wall, 2018). The longer the weeds are left uncontrolled the harder there control becomes, leading to high cost of production and yield reduction. Moreover, weed scientists / researchers find it difficult to agree on a particular timing and weeding interval due to varietal differences of okra species, Hence, the study is aimed to evaluate the effect of weeding regimes on the growth and yield of okra and make possible recommendations to farmers in order to increase production level and maximize profit.

Materials and Methods

Description of the Study Area and Climatic Condition

The two-year experiments were conducted at the Tree Crop Plantation (/TCP) Farm, School of Agriculture Federal polytechnic, Mubi, Adamawa State Nigeria, situated between Latitude 9° 26' and 10° 10'N and Longitude 13° 10' and13° 44'E at an altitude of 696 m above sea level in June 2022 raining season. The area has a bimodal rainfall with annual mean rainfall of 900 mm and the minimum temperature of 18 °C during the harmattan period and 40 °C maximum in April (Adebayo and Tukur (2000) and Muhammad, *et* al., 2009). There are two seasons: the wet season lasted from April – October and dry season from November – Match with a characteristics of cold dry dust laden wind especially in January and February.

Description of Experimental Materials

Source of seeds: The okra seeds variety, locally known as "Yar-kwadam" was collected from a certified local seed vendor in Mubi main market. To ensure uniform germination and protection against soil borne pests, seeds were treated with Apron Star WS (*Thia-methoxan + difenocanazole*) at the rate of 1 sachet (10 g) per 1 kg okra seeds properly mixed 5 hour prior to planting on the field.

Fertilizer source: Nitrogen fertilizer in the form of Urea was obtained from the farmer's cooperative society in Mubi North and then incorporated with the experimental soil at the rate of 100 kg ha^{-1}. After incorporation, the experimental field was abandon for 2 weeks to undergo proper decomposition.

Treatments and Experimental Design

The treatments consisted of three weeding regimes: No weeding (W_1), Weeding once at 3 weeks after sowing (WAS) (W_2), weeding twice at 3, and 6 WAS (W_3) and weeding thrice 3, 6 and 9 WAS (W_4). The experiment was laid out in a split-plot design and replicated three times.

Experimental Procedures and Crop Management

After selecting the experimental site, it was marked and demarcated. Some shrubs and plant residues from the last harvest present field were collected by one site of the farm, fire set on them and finally burned to ash. The field was then ploughed with the aid of tractor mounted implement and subsequently larger lobe soils were further broken down to create fine tilt soil conditions. This was done manually using simple farm tools such as rake and hoe. Then, individual plot in accordance with the layout plan was manually constructed. The total land area of the experimental site were 441.45 m^2 with gross plot size of 3 × 2.1 (6.3 m^2) and the net plot size of 2.25 x 1.8 m^2 (4.05 m^2). The experimental field was divided into 3 blocks and each block consisted of 16 plots that gave the total of 48 plots. A path way of 0.5 m between plots and 1 m between replications to allow easy passage for regular data collection was crated. Nitrogen fertilizer at the rate of 100 kg ha^{-1} were applied to the soil, mixed properly and allowed for proper decomposition for 2 weeks before sowing.
Sowings were done on the 10^{th} July, 2022 and 2023 accordingly. Healthy seeds were manually placed in a hole at the moist soil condition at the rate of 2 – 3 seeds / hole, 2 - 3 cm depth and later thinned down to 1 seedling / stand at 2 weeks after sowing. Seeds were sown at the distance of 75 x 30 cm both between crop row and stand systematically. Weeding being the major determining factor, was undertaken in the following sequence during the study period: No weeding at all (W_1), 1 Weeding at 3 weeks after sowing (WAS)(W_2), 2 weeding at 3, and 6 WAS (W_3) and 3 weeding at 3, 6 and 9 WAS (W_4) accordingly.

Soil Sampling and Analysis

Prior to sowing in both years, 5 core soil samples, randomly collected from 0 – 30 cm depth – soil using soil auger were mixed to form a composite sample. The composite soil sample was air – dried, ground, and passed through a 2 mm sieve mesh and subsequently subjected for analysis to determine the soil textural classes, chemical properties and. exchangeable bases of soil using standard laboratory procedures. The soil pH was determined glass electrode pH meter, total nitrogen (N) content was by micro-kjedahl method designed by (Bremner and Mulvaney, 1982), and total Phosphorus (P) was by Bray 1 method (Bray and Kurzt, 1945) while calcium (Ca) and magnesium (Mg) were determined by the Atomic Absorption Spectrophotometer (AAS) idea of (Perkin-Elmer Corp, 1969). Sodium (Na) determined using flame emission photometry profound by (Doll and Lucas, 1975). Determination of organic carbon (C) content was achieved according to Walker- Black wet oxidation method (Walkey – Black, 1934). The soil has the following characteristics: pH (6.41); organic carbon (3.70 %); total N (0.73 %); extractable P (6.67 mg kg); Ca (1.93); Na

0.38 and Mg (0.47) in cmol kg^{-1} accordingly. Soil particle size distribution was sandy 54.2 %; clay 14.2 %and silt 31.6 %. The soil was classified as sandy ultisol (Ibe ,2005). The soils have low mineral reserves and are therefore of low fertility, (Table 1).

Data Collection

Growth characters

Plant height (cm): The heights of 5 sampled plants selected from the center of each plot were measured from the base of the plant to the terminal bud at 3, 6 and 9 WAS, using graduated meter rule and their averages taken and recorded.

Number of leaves per plant: The fully open green leaves were physically counted on each sample plant at 3, 6, and 9 WAS. The number of such leaf per plant was found, average computed and recorded.

Stem diameter per plant (mm): The stem diameter on each of the 5 sampled plants was measured using a digital vernire caliper graduating in millimeters at 3, 6 and 9 WAS, their average taken and computed.

Crop phenology

Days to 50% flowering: The days to which half of the total number of plants in each plot produced flower were determined by daily observation, data taken and recorded.

Fruit length and fruit diameter (cm)

Out of the fruits produced by the sampled plants, 5 fresh fruits at harvest were randomly selected from each plot. Length and diameters of each fruit were measured using a digital vernire caliper graduating in millimeters. This process repeated for 5 consecutive harvests, values summed up together and average taken and calculated.

Yield characters

Fresh fruits yield per plot (g): Total produce obtained from the net plot was calculated separately in each bed and fruit collected were weighed using electrical weighing machine and average taken and data recorded.

Fresh fruit yield per hectare (g): From the recorded data of fruits yield per plot, fruits yields were computed per hectare by multiplying the yield per plot by conversion factor ($10{,}000 m^2$) and the values recorded. Below is the formula:

$$\text{Fruit Yield (kg ha)} = \frac{\text{Fruits per plot (kg)}}{\text{Net plot size } (m^2)} \times 10{,}000\ m^2$$

Dried fruit yield per hectare (g): Ten fully dried fruits were randomly selected (once at harvest) from the total number of fruits produced by the sample plants in each plot. The samples were weighed in the laboratory using electronic weighing machine and means taken and recorded.

Data Analysis

The data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS), (SAS, 2000) and means showing significant difference were separated by F-test using Duncan Multiple Range Test (DMRT) at a probability of 5 % according to Gomez and Gomez, (1984).

Results and Discussions

Soil characteristics: The physico-chemical properties of soil of the experimental site before cropping are presented in Table 1. The soil of the study site was sandy-loam, with the pH of 6.41 (2022) and 6.62 (2023) which were acidic in nature. The organic carbon content 3.70 2022 and 3.93 %) fall under the category of very high in accordance with the rating of Tadese (1991) who classified soil organic percentages as: < 1.0, 1.0 – 1.71, 1.72 - 3. 31 – 4.29 and > 4.3 as very low, low, medium high and very high respectively. The soil of the experimental site are considered as medium with total nitrogen 0.73(2022) as well as 0.19 %) content also in accordance with the rating of London (1991) who classified soils having total nitrogen of greater than 1.0 % as very low, 0.5 - 1 % high, 0.2 – 0.5 % medium, 0.1 – 0.2 % low and less than 0.1 % as very low in total nitrogen content. Available phosphorus of 6.67 (2022) and 6.83ppm (2023) were fairly low according to the classification of Olsen *et al*. (1954) Who also classified Available P < 5 ppm were classified as: very high, high, medium, low and very low accordingly. The experimental site has Carbon Exchange Capacity (CEC) of 3.25 (2022) and 3.44 meg/100 (2023) which may be interpreted as low, hence in congruent with the rating of the London (1991) who classified soils having CEC of > 40, 25 – 40, 15 – 25, 5 - 15 < 5 meg/100 g as very high, high, medium, low and very low.

Table 1: Physico-chemical properties of the experimental site before cropping

S/No.	Particular	2022	2023
	Physical properties		
A.	**Particle size distribution (%**		
	Clay	13.2	13.3
	Silt	21.6	23.0
	Sand	38.2	43.7
B.	**Textural Class**	Sandy-loam	Sandy-loam
C.	**Chemical properties**		
	pH (1 – 2 soils: water solution)	6.41	6.62
	Organic carbon (kg^{-1})	3.60	3.83
	Carbon exchange capacity (c mol (+) kg^{-1})	3.25	3.44
	Available nitrogen (g N kg^{-1})	0.73	0.19
	Available phosphorus (mg P kg^{-1})	6.67	6.83
	Available magnesium (c mol (+) kg^{-1})	0.47	0.48
	Available sodium (c mol (+) kg^{-1})	0.38	0.36
	Available calcium (c mol (+) kg^{-1})	1.93	1.95

Source: Laboratory Experiment, 2022 and 2023

Growth characters

Plant height (cm): The effect of weeding regimes on plant height in 2022, 2023 cropping season and their combine analysis were presented in Table 2. The mean values indicated that weeding regimes had significant (P ≤ 0.001) influence on the okra Plant height at 3, 6 and 9 weeks after sowing (WAS). At 3 WAS, W_4 treatment recorded the tallest plant with the height of: 9.438(2022) and 10.022 cm (combine). While in 2023 the longest okra plant having reached 10.659 cm height was obtained from W_3 treatment. However, the lowest plant height: 7.688 (2022), (9.423) and 8.555 cm (combine) were observed fromW_1 treatments. At 6 and 9 WAS significant variations among the treatment means square were equally observed. Okra with the maximum height as: 21.439, 22.778, 22.108 cm (6 WAS) and 36.567, 44.275, 40.466 cm (9 WAS) were generated from N_4. The minimum mean values: 14.702, 17.695 and 16.198 cm (6 WAS) and 26.039, 33.715, 29.877 cm (9 WAS) being the least figures were obtained from the control treatment (W_1) accordingly. The significant increase in plant height at all the growth stages (3, 6, and 9 WAS) under the varying weeding regimes recorded in this study was absolutely in accordance with the earlier findings of Mahmoud *et al*. (2013) who reported significant increase in plant height as a result of variation in weeding period. The consistent increase in plant height might be attributed to the increase in the number of weeding which was confirmed by Gogoi *et al.* (1997); Okezie (2000) and Tunku, (2006) who reported that the more the weeding regimes, the more the performances of crop as the rate of weeding will determine the overall performances of the crop in terms of growth and yield characters.

Table 2: Effect of weeding Regimes on plant height (cm) and number of leaves per plant in 2022, 2023 cropping season and combine

Treatments	3 WAS			6 WAS			9 WAS		
	2022	**2023**	**combine**	**2022**	**2023**	**Combine**	**2022**	**2023**	**Combine**
W_1	7.688^d	9.423^b	8.555	14.70^d	17.698^d	16.198^d	26.039^d	33.715^c	29.877^d
W_1	8.248^c	10.280^a	9.260	16.19^c	19.905^c	18.048^c	29.421^c	35.653^c	32.537^c
W_1	8.898^b	10.659^a	9.779	17.98^b	20.803^b	19.395^b	35.125^b	39.527^b	37.326^b
W_1	9.438^a	10.608^a	10.022	21.43^a	22.778^a	22.108^a	36.567^a	44.275^a	40.466^a
SE ±	0.110	0.337	0.096	0.403	0.337	0.263	0.318	0.618	0.376
Level of Sig.	***	***	***	***	***	***	***	***	

Mean with the same letter(s) in each treatment group are not significantly different at 5 % level of probability using Duncan's Multiple Range Test (DMRT)

Key: WAS= Week after Sowing, W_1= Zero weeding, W_2= Weeded once, W_3= Weeded twice, W_4= Weeded thrice, SE=Standard Error, ***=Significant at 0.001%

Number of leaves per plant: Variations in weeding regimes significant (P ≤ 0.001) influenced the number of leaves in okra at 3, 6 and 9 WAS during the 2022, 2023 cropping season and in the combine analysis (Table 2). The mean squares of the analysis of variance indicated that, the greatest number of 6.708, 9.183, 7.946 (3 WAS), 9.383, 15.566, 12.475 (6

WAS) and 23.323, 20.593, 21.958 leaves (9 WAS) were observed from W_4 treatment whereas, the control treatments (W_1) produced okra with the lowest number of 5.258, 7.125, 6.192 (3 WAS), 7.150, 10.378, 8.764 (6 WAS) and 12.369, 14.947, 13.658 leaves (9 WAS) respectively. Significant effect of weeding regimes on the number of leaves per plant observed under the varying weeding regimes in this experiment might probably be attributed to the time interval required for the treatment effect to become evident on the okra crop. This is in line with the earlier observations by Uko *et al.* (2018) who attributed the linear significant increase in the number of leaves to frequent weeding. This was earlier confirmed by Mahmoud *et al*. (2013) who reported significant linear increase in number of leaves as a result of variation in weeding.

Table 3: Effect of weeding Regimes on number of leaves per plant in 2022, 2023 cropping season and combine

Treatments	3 WAS			6 WAS			9 WAS		
	2022	2023	combine	2022	2023	Combine	2022	2023	Combine
W_1	5.258^d	7.125^d	6.192^d	7.150^b	10.378^b	8.764^c	12.369^c	14.947^c	13.658^d
W_1	5.592^c	7.850^c	6.721^c	8.433^b	14.270^a	11.203^b	15.272^b	16.299^c	15.785^c
W_1	5.975^b	8.208^b	7.092^b	8.650^b	13.755^a	11.352^b	17.329^b	18.123^b	17.726^b
W_1	6.708^a	9.183^a	7.946^a	9.383^a	15.566^a	12.475^a	23.323^a	20.593^a	21.956^a
SE ±	0.048	0.098	0.065	0.203	0.554	0.295	0.584	0.563	0.406
Level of Sig.	***	***	***	***	***	***	***	***	***

Mean with the same letter(s) in each treatment group are not significantly different at 5 % level of probability using Duncan's Multiple Range Test (DMRT)

Key: WAS= Week after Sowing, W_1= Zero weeding, W_2= Weeded once, W_3= Weeded twice, W_4= Weeded thrice, SE=Standard Error, ***=Significant at 0.001%

Stem diameter: The effect of Weeding regimes on stem diameter during the 2022, 2023 cropping seasons together with their combine analysis were evaluated (Table 3). The results indicated that, stem diameter had significantly ($P \leq 0.001$) influenced by weeding regimes with the highest responses observed from W_4 treatment having recorded: the thickest stem measured as: 2.816, 2.978, 2.897 (3 WAS), 6.717, 6.395, 6.556 (6 WAS) and 15.808, 14.983, 15.396 mm (9 WAS). Whereas, the thinness stem with the lowest means of: 2.152, 2.167, 2.159 (3 WAS), 4.778, 4.904, 4.841 (6 WAS) and 11.728, 10.799 and 11.263 mm (9 WAS) being the least performance were obtained from the control treatment (W_1) as well. Significant effect of weeding regimes on okra stem diameter have been reported by many authors including Yellamanda and Sankara (2013); Mahmoud *et al.* (2013) who equally reported significant increase in stem girth due to weeding intervals in okra field. This interesting result may be attributed to the early and subsequent weed removals which enhance the ability of okra plant to quickly utilize all the essential nutrients for its growth and development without any external competition.

Table 4: Effect of weeding Regimes on stem diameter (mm) in 2022, 2023 cropping season and combine

Treatments	3 WAS			6 WAS			9 WAS		
	2022	2023	combine	2022	2023	Combine	2022	2023	Combine
W_1	2.152^c	2.167^c	2.150^d	4.778^b	4.904^d	4.841^d	11.728^d	10.799^c	11.263^d
W_1	2.418^b	2.494^b	2.456^c	5.311^b	5.386^c	5.348^c	12.850^c	11.668^c	12.259^c
W_1	2.609^b	2.843^a	2.726^b	6.305^a	5.873^b	6.089^b	14.60^b	13.920^b	14.26^b
W_1	2.816^a	2.978^a	2.987^a	6.717^a	6.395^a	6.556^a	15.808^a	14.983^a	15.396^a
SE ±	0.055	0.039	0.033	0.155	0.076	0.087	0.262	0.347	0.218
Level of Sig.	***	***	***	***	***	***	***	***	***

Mean with the same letter(s) in each treatment group are not significantly different at 5 % level of probability using Duncan's Multiple Range Test (DMRT)

Key: WAS= Week after Sowing, W_1= Zero weeding, W_2= Weeded once, W_3= Weeded twice, W_4= Weeded thrice, SE=Standard Error, ***=Significant at 0.001%

Crop phenology

Days to 50 % flowering, fruit length, fruit diameter: were considered as crop phenology of okra. All these characters were significantly ($P \leq 0.001$) affected by weeding regimes during the 2022, 2023 cropping seasons and in their combine effect (Table 4).Days to 50% flowering decreased with the increase inthe number of weeding up to 3 times (W_4) which attained at the shortest: 54.583 (2022), 52.667 (2023) and 53.542 days (combine). However, the longest periods of 57.667 (2022), 56.417 (2023) and 57.042 days (combine) to attained 50% flowering were recorded from the control treatment (W_1) The significant decrease in days to 50 % flowering observed in this study goes in line with the previous findings of Smith and Ojo (2007) and Mahmoud *et al.* (2013) who equally reported significant reduction in days to 50 % flowering. Meanwhile, the lowest mean values recorded at the control treatment might be attributed to prolong period of crop-weeds competition in the field, Adeitan (2004) reported that, okra suffers severe competition with weeds leading to delay in flowering and fruit setting.

Significant ($P \leq 0.001$) response of fruit length due to weeding regimes was equally observed in these trials with the longest fruit measured as: 9.110 (2022), 9.492 (2023) and 9.301 cm (combine) recorded from W_4 treatment whereas, the shortest fruits with the least means of: 6.981 (2022), 7.575 (2023) and 7.278 cm (combine) were obtained from the control treatment (W_1). Weeding regimes had significant ($P \leq 0.001$) influence on fruit diameter as revealed in the 2022, 2023 cropping seasons and their combine analysis (Table 5), with W_4 treatment appeared superior having recorded the thickest okra with the fruit diameters of: 10.189 (2022), 10.171 (2023), and 10.180 cm for the combine analysis, while the least mean values of: 8.160 (2022), 8.477 (2023) and 8.318 cm (combine) were generated from the control treatment (W_1) accordingly. The observed pattern of significant progressive increase in both fruit length and diameter at the various weeding intervals in this trial for both seasons is similar to the previous findings of Bamipe (2007); Osundare (2009); Mahmoud *et al.*, (2013) and Shah *et al.* (2017). They all reported significantly higher values of these phonological traits on different soil under the varying weeding intervals. Onunkan (2012) found that, okra plots infested by weeds throughout the crop's life recorded significantly lower fruit diameter as compared to plots weeds managed at different period. This result implied that, the time interval adopted for weed removal in this study was able to break the period required by various weed species to freely compete and cause substantial damage to the main crop and hence might have resulted to complete maintenance of the phenotypic traits by the okra. This assertion is supported by Ibrahim and Hamma (2012) who reported higher okra fruit length where weeds competition with host plants were low as compared to the plot weeded throughout the study periods.

Table 5: Effect of weeding regimes on some okra crop phonological traits in 2022, 2023 cropping season and combined

Treatments	Days to 50 % flowering			Fruit length			Fruit diameter		
	2022	**2023**	**combine**	**2022**	**2023**	**Combine**	**2022**	**2023**	**Combine**
W_1	57.667^a	56.667^a	57.042^a	6.981^c	7.575^c	7.278^d	8.160^d	8.477^c	8.318^d
W_1	53.583^b	55.583^b	54.875^b	7.697^b	8.354^b	8.025^c	8.791^c	9.273^b	9.032^c
W_1	55.583^b	55.583^b	54.625^b	8.731^a	8.868^b	8.800^b	9.583^b	9.874^a	9.729^b
W_1	54.417^b	54.417^d	53.542^c	9.110^a	9.492^a	9.301^a	10.189^a	10.171^a	10.180^a
SE ±	0.453	0.453	0.246	0.168	0.166	0.118	0.119	0.133	0.089
Level of Sig.	***	***	***	***	***	***	***	***	***

Mean with the same letter(s) in each treatment group are not significantly different at 5 % level of probability using Duncan's Multiple Range Test (DMRT)

Key: WAS= Week after Sowing, W_1= Zero weeding, W_2= Weeded once, W_3= Weeded twice, W_4= Weeded thrice, SE=Standard Error, ***=Significant at 0.001%

Yield character

Fresh fruit yield per plot and per hectare (g): Fresh fruit yield per plot and per hectare significantly ($P \leq 0.001$) influenced by weeding regimes in 2022, 2023 and in their combine analysis (Table 6). On the response of fresh fruit yield per plot to weeding regimes, treatment with the outstanding performance of: 954.25 (2022), 914.93 (2023) and 934.39 g (combine) fruit yield / plot was W_4 whereas, the least performing treatment which recorded the lowest means of: 468.89 (2022), 566.69 (2023) and 517.79 g (combine) fruit / plot with a wide margin when compared the values with the rest of the treatment means was the control (W_1).Data for the effect of weeding regimes on the okra fresh fruit yield per hectare as experimented during the study period was highly significant (Table 6). The maximum fruit yield: 1514.69 (2022), 1427.13 (2023) and 1470.91 (combine) g ha^{-1}recorded where weeding was done more frequently (W_4) compared to the minimum yield of: 766.90 (2022), 899.51 (2023) and 833.21 g ha^{-1}(combine) as observed from the control treatments (W_1).

The highest significant mean values of fresh fruit yield per plot and per hectare consistently recorded under W_4treatment in both the parameters could be attributed to less competition between weeds and the crops which resulted in higher performances of the crop in all the plots under this treatment. While the lower mean values observed under the control treatment (W_1) might be due to higher competition level which led to lower photosynthetic ability and hence lower mean values of fruit yield per plot/hectare produced. This finding is in line with the work by Mahmoud *et* al. (2013) and Shah*et al*. (2017) who reported significant mean variations of okra fruit yield at the highest level of weeding regimes. Increase in fresh fruit yields of okra due to weeding regimes were equally reported by Iyagba and Ibe (2013). Similarly, Dada and Fayinminnu (2007) recorded higher okra fruit yield (t/ha^{-1}) when weeding was done 3 - 6 weeks after the crops were established. It was therefore concluded that, the lower the infestation of weeds in a crop, the higher the performances of the crop in terms of growth and yield. However, the higher the infestation of the crop by weeds, the lower the performances of crop in terms of growth and yield attributes (Shippers, 2000; Tijjani-Eniola *et al*. 2006; Rodenburg and Johnson, 2009).

Dried fruit yield per hectare(g): Dried fruit yield per hectare responded significantly ($P \leq 0.001$) higher to the variations in weeding periods as observed in 2022, 2023 and in combine (Table 6), with the greatest fruit yield of: 709.80, (2022), 698.34 (2023) and 704.07 g ha^{-1} (combine) recorded from(W_4) treatment. The control treatment (W_1) continued to remain the least, with the mean values measured as lower as 365.14 (2022), 384.74 (2023) and 374.94 g ha^{-1}(combine) accordingly. The significant pattern of increase in dried fruit yield per hectare due to the variations in weeding periods observed in this study implied that, timely weeding after seedling establishment indispensable to determine the yield in okra. The highest mean values recorded at W_4treatment were sufficiently enough to reduce the incidence of crop-weed competition for growth resources. This was confirmed by Iyagba *et al.*(2013) who stated that, better weed control will reduce competition from the weeds leading to higher fruit yield.

Table 6: Effect of weeding regimes on some okra yield attributes in 2022, 2023 cropping season and combine

Treatments	Fresh fruit yield per plot (g)			Fresh fruit yield per hectare (g)			Dried fruit yield per hectare (g)		
	2022	**2023**	**combine**	**2022**	**2023**	**Combine**	**2022**	**2023**	**Combine**
W_1	468.89^d	566.69^d	517.79^d	766.90^d	899.51^c	833.21^d	365.14^d	384.74^c	374.94^d
W_1	621.91^c	715.52^c	668.72^c	989.04^c	1138.26^b	1062.65^c	464.24^c	526.34^b	495.29^c
W_1	787.24^b	814.90^b	814.57^b	1249.58^b	1336.36^a	1470.91^b	635.54^b	663.01^a	649.29^b
W_1	954.25^a	914.93^a	934.39^a	1514.69^a	1427.13^a	1470.91^a	709.80^a	698.34^a	704.07^a
SE ±	0.110	16.203	12.883	27.568	25.703	25.703	10.869	13.860	8.807
Level of Sig.	***	***	***	***	***	***	***	***	***

Mean with the same letter(s) in each treatment group are not significantly different at 5 % level of probability using Duncan's Multiple Range Test (DMRT)

Key: WAS= Week after Sowing, W_1= Zero weeding, W_2= Weeded once, W_3= Weeded twice, W_4= Weeded thrice, SE=Standard Error, ***=Significant at 0.001%

Conclusion

The findings of the present study revealed that, there were significant variations in all the okra attributing characters experimented in this trial in that any increase in the number of weeding resulted to an appreciable increase in these parameters. Evidence of these variations were vividly seen with treatment W_4 (plot weeded at 3, 6, and 9 WAS) which resulted to higher mean values of plant height, number of leaves, stem diameter just to mention few as compared to the control treatment (W_1). Similar trends were observed in regard to crop phenology and yield attributing characters such as days to 50 % flowering, fruit length, fruit diameter. Fresh fruit yield per plot per hectare as well as dried fruit yield per hectare were all significantly superior over the rest of the treatments at the highest weeding intervals (W_4) accordingly.

Recommendations

Based on the study findings, the following recommendations were made:

i. Farmers in Mubi and its environments are encouraged to adopt 3 times weeding at an interval of 3 WAS for better growth and height fruit yields.
ii. Similar research should be conducted on other okra varieties in different locations within the region so as to create more options for yield comparison and also to access variety that may likely resist weed competition.

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