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Effect of Watering Intervals (water stress) on Growth Performance of Okra Plants in Makurdi Benue State

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ABSTRACT

Background and Objective: *Okra (Abelmoschus esculentus) is a very popular vegetable in the world due to its acceptability in most markets. The effect of water stress on Okra plants under different water treatment conditions was investigated.* ***Materials and Methods:*** *Horticultural pots were filled with about 6000grams of soil. Two varieties of okra namely raining season and Clemson spineless were sown in the soils and were watered constantly for a period of 14 days after which watering intervals of 3, 5, and 7days were imposed. The experiment was arranged in a 2x4 factorial scheme fitted into a completely randomized design. Data were analyzed using Analysis of Variance and the Fisher's least significant difference was used to separate means at 5% level of significance. Results: Significantly higher height for Clemson spineless variety (15.48) compared to raining season variety (12.89). Higher number of leaves, number of shed leaves and days to flowering were recorded for raining season variety (8.60, 0.48 and 16.83) compared to Clemson spineless (8.52, 0.46 and 16.50). Significantly higher height, number of leaves and fewer days to first flowering were recorded for control (16.50, 9.38, and 16.46) compared to 3days (14.47, 9.04 and 16.50), 5days (13.35, 8.67 and 16.75) and 7days (12.44, 7.17 and 16.96) respectively. Higher number of shed leaves were recorded for 7days (0.92) compared to 3days (0.29) 5days (0.46) and control (0.21). Interaction between Clemson spineless variety and control produced significantly higher height (18.22) compared to all other interactions except interaction between Clemson spineless variety and 3 days watering interval (16.02). Number of leaves was significantly higher for interactions between raining season variety and control (9.58) compared to the other interactions. Interaction between raining season variety at 3days watering interval and interaction of Clemson spineless and control each produced significantly lower number of shed leaves (0.25) than the other treatment interactions. Interaction between Clemson spineless and the control produced significantly lower number of days to flowering (16.33) compared to other treatment combinations.* ***Conclusion:*** *Crops watered daily resulted in better growth than those subjected to water stress. Okra plants should be provided with adequate water supply so as to ensure their effective growth and development.*

1. Introduction

The okra (*Abelmoschus esculentus*) plant is an annual vegetable crop belonging to the family Malvaceae. It is a very popular vegetable in the world due to its acceptability in most markets. Okra pods contain carbohydrates, proteins and vitamins. It has the same comparable amount of essential and non-essential amino acids like soybean (Udoh *et al.,* 2005). It is greatly recognized for the important role it plays in human nutrition (Araujo *et al.,* 2018).

Okra has long been considered as a marginal crop. It procures very nutritional and dietary capsules and has been used in traditional cooking particularly in rural areas; but is currently finding great usage in the dietary habits of urban dwellers. Okra is used in many dishes because of their binding power and also because they compete in quantity and especially as a more balanced diet. Its mineral, protein and Vitamin A and C contents are significant. The young tender pods of Okra are cooked in curries, stewed and

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roasted and used as substitute for coffee. It is an important leaf vegetable in South West Nigeria, which is propagated by seed and is commonly cooked as soup (Sawadogo *et al.,* 2009).

Okra originated in tropical Africa and was grown in Mediterranean region. It is now grown in all parts of the tropics and during summer in the warmer parts of the temperature region where it is classified as semi-tolerant vegetable crop. It is very popular in the USA and in European Union Countries with about 637,837 tons available in their markets. World production of okra is estimated at 600,000 tons per year while overall production in West Africa is estimated to be above 500,000 tons per year. It constitutes about 4.6 percent of the total staple food production in Nigeria in the years 1970 to 2003.

Among various abiotic stresses, water stress is one of the most dynamic and worse stresses that hinder plant growth and development, and limit crop productivity more than any other ecological component depending on the genotype, duration, intensity, and developmental stage of the plants (Anjum *et al.,* 2011). Water stress has a potential to decrease crop yield and profitability by altering the plant growth and development, and inducing deterring effects on plant physiological and biochemical processes. Plants experience water stress either when the water supply to roots gets to be troublesome or when the transpiration rate turns out to be high. These two conditions regularly co-occur under arid and semi-arid climates (Anjum *et al.,* 2011). Therefore, this study evaluates the effect and response of okra plants to water stress.

2.0 Materials and Methods

2.1 Study Location

The study was carried out in Benue State University, Makurdi. Makurdi is located in North Central Nigeria along the Benue River, on Latitude 07°43'N and longitude 08°35'E. It is 104m above sea level and lies in the tropical Guinea -Savannah of West Africa where temperature range between 21.7-24.0°C and 29.0-33.7°C. It is an ectone belt that separates the Forested south from the true Savannah of the North. As such, vegetation is an assortment of tree and grasses. The study area also experiences a typical climate with two distinct seasons; the wet and dry seasons. The wet season lasts from April to October while dry season begins in November and ends in April (Nigerian Metrological Association; NIMET, 2017).

2.2 Collection of Okra seed samples

Two varieties of okra seeds namely; Clemson spineless an improved variety was obtained from premier seed Nigeria Ltd, Zaria, Kaduna state and raining season variety from Wurukum market, Makurdi were taken to the Botany laboratory of the Benue State University for further studies.

2.3 Planting procedures

Horticultural pots measuring 50 x 17cm (diameter and height respectively) with perforated bottom to enable drainage and aeration were filled with 6000grams of sandy loam soil leaving about 5cm to the brim to conveniently permit watering. The soil was mixed with 100grams of poultry dropping after which three seeds of the okra were sown at depth of about 2.5cm. Thinning was done to a plant per pot two weeks (14days) after planting.

2.4 Watering regimes (stress levels)

Four watering regimes (stress levels) were imposed in the study. These include; unstressed or (daily watering), 3 days, 5days, and 7 days watering intervals.

The unstressed or control treatments received constant watering (watering everyday) throughout the period of the research. Stressed plants were subjected to drought by gradually varying the interval of days to watering. For 3days, (4th day after the last day of watering), 5 days (6th day after the last day of watering, 7 days (8th day after the last day of watering) for each treatment.

Experimental design

Factors in the experiment

1. Two (2) varieties of okra (Clemson spineless and Raining season)

2. Four watering regimes/levels (Control, 3 days, 5 days, 7 days)

Experimental design is 4 x 2 factorial in a completely randomized design

Treatment combinations; 4 x 2 =8

Replications = 3

Total number of units/lots = 24

Data collected

Data were collected weekly for four (4) weeks. They include:

i. Plant height

This was determined using a graduated measuring tape. The measuring tape was stretched from the ground level to the top of the plant and the reading on the graduated measuring tape was recorded.

ii. Number of leaves

The numbers of leaves were obtained by counting the leaves and taking readings

iii. Number of shed leaves

These were determined by counting the number of leaves that were detached from the main stem of the Okra plant.

iv. Days to first flowering

This was obtained by calculating the days between sowing and anthesis of first flower of each plant.

Data Analysis

The data obtained were subjected to Analysis of variance (ANOVA). Means were separated using Fisher's least significant difference (FLSD) at 5% level of significance.

3.0 Results

3.1 Main and interaction effect of Variety and watering intervals on height of Okra plants

The main and interaction effect of variety and watering intervals on height of Okra Plant were statistically significant on weeks 1, 2, 3 and 4 ($P<0.05$) as shown in Tables 1 and 2. Results revealed that Clemson spineless variety produced significantly higher heights on weeks 1 2, 3 and 4 (10.82cm, 13.62cm, 16.77cm and 20.73cm respectively) compared to Raining season variety (9.38cm, 11.39cm, 14.15cm and 16.66cm respectively). Greater heights were recorded for control plants on weeks 1, 2, 3 and 4 (11.58cm, 14.32cm, 17.92cm, and 22.17cm respectively) and this was significantly higher than plants watered at 3 days interval (9.98cm, 12.53cm, 15.72cm and 19.63cm), 5days watering interval (9.72cm, 12.05cm, 14.65cm and 15.98cm) and 7days watering interval (9.10cm, 11.12cm, 13.57cm and 15.98cm respectively). Furthermore, interaction between Clemson Spineless variety and control produced significantly greater height (12.47cm 15.93cm, 19.67 and 24.80cm respectively) on weeks 1 2, 3and 4. This was significantly higher than all other treatment combinations involving 3days watering interval (10.73cm, 13.80cm, 17.33cm and 22.20cm respectively), 5 and 7 days watering intervals (10.30cm, 13.07cm, 16.07cm, 18.87cm and 9.77cm, 11.67cm, 14.03cm, 17.03cm respectively). Also, the interaction effect of the control with the raining season variety produced significantly higher height on weeks 1 - 4 (10.70cm, 12.70cm, 16.17cm, and 19.53cm) respectively than all the treatment combinations at 3 days watering interval (9.23cm, 11.27cm, 14.10 and 17.07cm respectively) 5 and 7 days watering intervals (9.23cm, 11.03cm, 13.10cm and 14.93cm) and 8.43cm, 10.57cm, 13.10cm, 14.93cm) respectively.

Table 1: Main effect of Variety and watering interval on the height of Okra plants

Variety	Height (cm)			
	1	2	3	4 (Weeks)
Clemson spineless	10.82	13.62	16.77	20.73
Raining season	9.38	11.39	14.15	16.66
LSD(0.05)	**1.27**	**1.28**	**1.35**	**1.56**
Watering intervals				
3 days	9.98	12.53	15.72	19.63
5 days	9.72	12.05	14.65	15.98
7 days	9.10	11.12	13.57	15.98
Control	11.58	14.32	17.92	22.17
LSD(0.05)	**1.79**	**1.81**	**1.91**	**2.21**

Table 2: Interaction effect of variety and watering interval on the height of okra plants

VARIETY	WATERING INTERVALS	HEIGHT(CM)			
		1	2	3	4 (WEEKS)
CLEMSON SPINELESS	3 DAYS	10.73	13.80	17.33	22.20
	5 DAYS	10.30	13.07	16.07	18.87
	7 DAYS	9.77	11.67	14.03	17.03
	CONTROL	12.47	15.93	19.67	24.80
RAINING SEASON	3 DAYS	9.23	11.27	14.10	17.07
	5 DAYS	9.13	11.03	13.23	15.10
	7 DAYS	8.43	10.57	13.10	14.93
	CONTROL	10.70	12.70	16.17	19.53
LSD (0.05)		**2.54**	**2.57**	**2.70**	**3.13**

3.2 Main and interaction effect of Variety and watering intervals on number of leaves of Okra plants

The main and interaction effect of variety and watering intervals on number of leaves of Okra were statistically significant on weeks 1, 2, 3 and 4 ($P<0.05$) as shown in Tables 3 and 4. Significantly higher number of leaves were recorded for Raining season variety on weeks 1 and 2 (5.83 and 7.75 respectively) compared to Clemson spineless variety (5.58 and 7.75 respectively). Significantly, higher number of leaves were however obtained for Clemson spineless variety on weeks 3 and 4 (9.58 and 11.33 respectively) compared to Raining season variety (9.48 and 11.25 respectively). Higher number of leaves were recorded for control plants on weeks 1, 2, 3 and 4 (6.17, 8.33, 10.50 and 12.50 respectively), compared to okra plants placed on 3 days watering interval (6.00, 8.00, 10.17, and 12.00 respectively), 5 days watering interval (5.67, 7.67, 9.67 and 11.67 respectively) and 7days watering interval (5.00, 6.67, 8.00 and 9.00 respectively) as shown in Table 5.

The interaction effect of Raining season variety and control recorded significantly higher number of leaves on weeks 1, 2, 3 and 4 (6.33, 8.67, 10.67 and 12.67) respectively compared to Okra plants subjected to 3days watering (6.33, 8.33, 10.67 and 12.33) respectively, 5days watering interval with (5.33, 7.33, 9.33 and 11.33) respectively and 7days watering intervals (5.33, 6.67, 7.67 and 8.67 respectively). Also, the interaction of Clemson spineless variety and control resulted in significantly higher number of leaves on weeks 1,2, 3 and 4 (6.00, 8.00, 10.33, and 12.33) respectively compared to okra plants watered at 3 days interval (5.67, 7.67, 9.67, 11.67), 5 days(6.00, 8.00, 10.00, 12.00) and 7 days (4.67, 6.67, 8.33, 9.33) (Table 4).

3.3 Main and interaction effect of variety and watering interval on number of Shed leaves of Okra plants

The main and interaction effect of variety and watering interval on number of shed leaves of Okra plants were statistically significant on weeks 1, 2, 3 and 4 ($P<0.05$) as shown in Tables 5 and 6. Significantly higher number of shed leaves were obtained for Clemson spineless variety

on weeks 1 and 4 (0.50, and 0.75 respectively) compared to Raining season variety (0.17and 0.50 respectively) however, on weeks 2 and 3, significantly higher number of shed leaves were recorded for Raining season (0.42 and 0.83 respectively) compared to Clemson spineless (0.25 and 0.33 respectively). Also, Okra Plants watered at 7days watering interval produced significantly higher number of shed leaves on weeks 1, 2, 3 and 4 (0.67, 0.67, 0.83 and 1.50 respectively) compared to 3days watering interval (0.17, 0.00, 0.83 and 0.17), 5days watering interval (0.50, 0.50, 0.50 and 0.33 respectively) and control (0.00, 0.17, 0.17 and 0.50 respectively).

Table 3: Main effect of Variety and watering interval on the number of leaves of Okra plants

Variety	Number of leaves (n)			
	1	2	3	4 (Weeks)
Clemson spineless	5.58	7.58	9.58	11.33
Raining season	5.83	7.75	9.48	11.25
LSD(0.05)	**0.61**	**0.74**	**0.88**	**0.82**
Watering intervals				
3 days	6.00	8.00	10.17	12.00
5 days	5.67	7.67	9.67	11.67
7 days	5.00	6.67	8.00	9.00
Control	6.17	8.33	10.50	12.50
LSD(0.05)	**0.86**	**1.06**	**1.24**	**1.17**

Table 4: Interaction effect of Variety and watering interval on number of leaves of Okra plants

Variety	Watering intervals	Number of leaves (n)			
		1	2	3	4 (weeks)
Clemson spineless	**3 days**	5.67	7.67	9.67	11.67
	5 days	6.00	8.00	10.00	12.00
	7 days	4.67	6.67	8.33	9.33
	Control	6.00	8.00	10.33	12.33
Raining season	**3 days**	6.33	8.33	10.67	12.33
	5 days	5.33	7.33	9.33	11.33
	7 days	5.33	6.67	7.67	8.67
	Control	6.33	8.67	10.67	12.67
LSD(0.05)		**1.22**	**1.49**	**7.76**	**1.65**

The interaction effect of Raining season variety and 7 days watering interval produced significantly higher number of shed leaves on Week 4 (1.67) compared to other treatment combinations with 5days watering interval (0.00), 3days watering interval (0.00) and control (0.33). The interaction of Clemson spineless at 3days and Raining variety at 7days interval respectively produced significantly higher number of shed leaves on week 3 (0.67 and 1.33 respectively). Significantly higher numbers of shed leaves were recorded for Clemson spineless at 7 days watering interval (1.00) on week 1 and for raining season variety (1.00) at 5days watering interval respectively and this was higher than other watering interval interactions (Table 6).

Table 5: Main effect of Variety and watering interval on the number of shed leaves of Okra plants

Variety	Number of shed leaves (n)			
	1	2	3	4 (Weeks)
Clemson spineless	0.50	0.25	0.33	0.75
Raining season	0.17	0.42	0.83	0.50
LSD(0.05)	**0.46**	**0.30**	**0.53**	**0.53**
Watering intervals				
3 days	0.17	0.00	0.83	0.17
5 days	0.50	0.50	0.50	0.33
7 days	0.67	0.67	0.83	1.50
Control	0.00	0.17	0.17	0.50
LSD(0.05)	**0.66**	**0.43**	**0.74**	**0.74**

Table 6: Interaction effect of Variety and watering interval on Number of shed leaves of Okra plants

Variety	watering intervals	Number of shed leaves (n)			
		1	2	3	4 (weeks)
Clemson spineless	**3 days**	0.33	0.00	0.67	0.33
	5 days	0.67	0.00	0.33	0.67
	7 days	1.00	0.67	0.33	1.33
	Control	0.00	0.33	0.00	0.67
Raining season	**3 days**	0.00	0.00	1.00	0.00
	5 days	0.33	1.00	0.67	0.00
	7 days	0.33	0.67	1.33	1.67
	Control	0.00	0.00	0.33	0.33
LSD(0.05)		**0.93**	**0.61**	**1.06**	**1.06**

3.4 Main and interaction effect of variety and watering intervals on days to first flowering of Okra plants

The main and interaction effect of variety and watering intervals on days to first flowering of Okra plants were statistically not significant on weeks 1, 2 and 3 ($P>0.05$) but was significant on week 4 ($P<0.05$) as shown in Tables 7 and 8. Significantly higher days to first flowering was obtained for Raining season variety on week 4 (25.33) compared to Clemson spineless (24.00). Also, Okra Plants under control produced significantly lower number of days to first flowering on week 4 (22.38) compared to 3days watering interval (24.00), 5days watering interval (25.00) and 7days watering interval (25.83).

The interaction effect of Raining season variety and 7 days watering interval produced significantly higher days to first flowering on Week 4 (26.67) compared to other treatment combinations with 3days watering interval (24.33), 5days watering interval (26.00) and control (24.33).The interaction effect of Clemson spineless variety and 7days watering interval produced significantly higher days to first flowering on week 4(25.00) compared to other treatment combination with 3days watering interval (24.00) and control (24.33). The interaction effect of Clemson spineless variety with the control produced least number of days to flowering (23.33) on week 4 compared to other treatment combinations.

Table 7: Main effect of Variety and watering interval on days to first flowering of Okra plants

Variety	Days to first flowering (n)			
	1	2	3	4 (Weeks)
Clemson spineless	7.00	14.00	21.00	24.00
Raining season	7.00	14.00	21.00	25.33
LSD(0.05)	**NS**	**NS**	**NS**	**0.72**
Watering intervals				
3 days	7.00	14.00	21.00	24.00
5 days	7.00	14.00	21.00	25.00
7 days	7.00	14.00	21.00	25.83
Control	7.00	14.00	21.00	22.38
LSD(0.05)	**NS**	**NS**	**NS**	**1.03**

Table 8: Interaction effect of Variety and watering interval on Days to first flowering of Okra plants

Variety	watering intervals	Days to first flowering (n)			
		1	2	3	4 (weeks)
Clemson spineless	**3 days**	7.00	14.00	21.00	23.67
	5 days	7.00	14.00	21.00	24.00
	7 days	7.00	14.00	21.00	25.00
	Control	7.00	14.00	21.00	23.33
Raining season	**3 days**	7.00	14.00	21.00	24.33
	5 days	7.00	14.00	21.00	26.00
	7 days	7.00	14.00	21.00	26.67
	Control	7.00	14.00	21.00	24.33
LSD(0.05)		**NS**	**NS**	**NS**	**1.45**

3.5 Overall main and interaction effect of variety and watering interval on vegetative parameters of Okra plants

The overall main and interaction effect of variety and watering Intervals on quality parameters of Okra plants were significant for height, number of leaves, number of shed leaves and days to first flowering. Significantly higher height was recorded for Clemson spineless variety (15.48) compared to Raining season variety (12.89). Also, higher number of leaves, number of shed leaves and days to first flowering were recorded for Raining season (8.60, 0.48 and 16.83 respectively) and this was significantly higher than Clemson spineless (8.52, 0.46 and 16.50 respectively). Okra plants under control produced significantly higher height and number of leaves (16.50 and 9.38 respectively) compared to plants watered at 3days watering interval (14.47 and 9.04 respectively) 5days watering interval (13.35 and 8.67 respectively) and 7days watering interval (12.44 and 7.17 respectively). However, Okra plants watered at 7days watering interval produced significantly higher number of shed leaves and days to first flowering (0.92 and 16.96 respectively compared to other treatment interactions involving 3days watering interval (0.29 and 16.50 respectively), 5days watering interval (0.46 and 16.75 respectively) and control (0.21 and 16.46 respectively) (Table 8).

Table 9: Overall main effect of Variety and watering interval on vegetative parameters of Okra plants

Variety	Vegetative parameters			
	Height	Number of leaves	Number of shed leaves	Days to first flowering
Clemson spineless	15.48	8.52	0.46	16.50
Raining season	12.89	8.60	0.48	16.83
LSD(0.05)	**1.33**	**0.75**	**0.14**	**0.18**
Watering intervals				
3 days	14.47	9.04	0.29	16.50
5 days	13.35	8.67	0.46	16.75
7 days	12.44	7.17	0.92	16.96
Control	16.50	9.38	0.21	16.46
LSD(0.05)	**1.88**	**1.06**	**0.19**	**0.25**

Table 10: Overall interaction effect of Variety and watering interval on quality parameters of Okra plants.

Variety	Watering intervals	Vegetative parameters			
		Height	Number of leaves	Number of shed leaves	Days to first flowering
Clemson spineless	**3 days**	16.02	8.67	0.33	16.42
	5 days	14.58	9.00	0.42	16.50
	7 days	13.12	7.25	0.83	16.75
	Control	18.22	9.17	0.25	16.33
Raining season	**3 days**	12.92	9.42	0.25	16.58
	5 days	12.13	8.33	0.50	17.00
	7 days	11.76	7.08	1.00	17.17
	Control	14.78	9.58	0.17	16.58
LSD (0.05)		**2.66**	**1.50**	**0.27**	**0.36**

The overall interaction effect of variety and watering intervals on quality parameters of Okra plants showed that higher height was recorded by Clemson spineless variety under control (18.22) compared to 3days watering interval (16.02), 5days watering interval (14.58) and 7 days watering interval (13.12). Interaction between raining season under control produced higher number of leaves (9.58) compared to 3days watering interval (9.42), 5days watering interval (8.33) and 7days watering interval (7.08). Clemson spineless variety watered at 7 days interval produced significantly higher number of shed leaves (0.83) compared to all other treatment combinations. Raining season watered at 7 days interval recorded significantly higher number days to first flowering (17.17) compared to all other treatment combinations involving 3days watering interval, 5days watering interval and control (Table 10).

4.0 Discussion

The effect of water stress on the growth of Okra (*Abelmoschus esculentus*) plants was investigated. Two varieties of Okra

investigated showed differences in their performance response to water stress. It was observed that Clemson spineless recorded higher height than Rainy season variety but the number of leaves, number of shed leaves and days to first flowering was lower than that of the Rainy season variety. These differences in the response of the varieties of Okra to water stress can be attributed to their genetic makeup which influences the response of one variety compared to the other. As such, raining season variety had more adaptive advantages than the Clemson in terms of responses to water stress. Similar findings were reported by Okeu *et al*. (2005) confirming the variation in response of different Wheat cultivars to water stress.

Watering interval significantly influenced the growth of the Okra plant on all weeks examined. The photosynthetic capacity of plants is usually enhanced by the presence of leaves. The lowered number of leaves due to water stress on Okra plants caused a poor development of the crops and hence their reduced growth. Okra plants with everyday watering recorded higher height compared to those watered at intervals. Plant height is a morphological characteristic associated with moving carbohydrates especially under stressed conditions. Water stress induces metabolic changes in plant accompanied with decrease in growth and photosynthesis. Thus, the lower plant height in stressed plants was primarily due to decreased cell expansion and elongation, increased leaf shedding and impaired mitosis under stress condition. This is in agreement with Medeiros and Aribido (2012) who reported that plant height is severely affected by water stress (drought) and is closely related to cell expansion and leaf senescence. Also Almeida *et al*. (2018) reported that plants under water stress exhibit reduced height compared to those which receive constant water.

It was observed that water stress resulted in decreased number of leaves than control plants which were not subjected to water stress. This is in agreement with Almeida *et al.* (2018) who reported that plants under water stress exhibit fewer leaf pairs than those from control plants. Water stress inhibits cell growth leading to a reduction in leaf development. Stressed Okra plants showed fewer leaves per vine and smaller leaf size. This reduction in tip activity under water stress conditions was likely due to modification in the relationship between inhibitors and stimulants for growth (Schultz, 2000).

During the study, it was observed that water stress increased the number of shed leaves compared to control plants which were not subjected to water stress. The regulation of leaves in plants during stress is a long term change which is important to improve the adaptability of a plant to water shortage in the environment (Maleki *et al.,* 2013). Also, Mantovani and Iglesias (2010) reported that drought stress (water stress) hasten leaf senescence and death rate of leaves and is considered an adaptive process of decrease water loss through transpiration. The process of shedding leaves during water stress is largely the result of increased synthesis and sensitivity to Abscisic acid in plants (Kabiri, 2010).

During the study, it was observed that water significantly influenced the days to first flowering. Okra plants watered daily (control plants) recorded a closer date to first flowering than the other okra plants under water stress. Water stress alters flower initiation as well as the duration. Moderate drought diminishes the length of time from flowering to anthesis; however, it might be increased under severe water stress condition. This effect was however dependent on the variety of the Okra plant and the watering regime utilized. This observation is in agreement with the report of Mehraban *et al.* (2018) who reported that although water stress affects most of the functions of plant, this effect depends on the level of water stress, the length of time to which the plant is subjected to water stress and other factors such as genotype of the crop.

5.0 Conclusion

Water stress affects the productivity of Okra plant as well as the rate of their growth. It also determines the extent to which the crop will produce and how effective the growth process will be. The nature of water stress imposed on crops also determines the final outcome of growth. For effectiveness, crops require daily watering especially at the developmental phases of their lifecycle so as to ensure that all the needed metabolic activities such as photosynthesis and respiration are effectively carried out.

6.0 Recommendations

Based on the findings of the study, the following recommendations are made:

i. Crops should be provided with adequate water supply to ensure their effective growth and development.

ii. Further studies should be conducted to evaluate the effect of water stress on other crops so as to provide wider literature to be reviewed for water stress effects on crops.

Significance Statement

Among various abiotic stresses, water stress is one of the most dynamic and worse stresses that hinder plant growth and development, and limit crop productivity more than any other ecological component. Water stress has a potential to decrease crop yield and profitability by altering the plant growth, development and inducing deterring effects on plant physiological and biochemical processes. Water stress affects the productivity of Okra plant as well as the rate of their growth. It also determines the extent to which the crop will produce and how effective the growth process will be.

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