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Effects of Irrigation Intervals And Nitrogen Rates on Growth And Pod Yield of Okra *Abelmoschus Esculentus* (L) In Sokoto North-West Nigeria.

[1]Aliyu, [1]U., M. Bello,[2] A. Muhammad And [2]N.M.Kwaifa
[1] Department Of Crop Science, Usmanu Danfodiyo University, Sokoto.
[2] Department Of Crop Science, Kebbi State University Of Science And Technology, Aliero

Abstract: *Experiments were conducted during 2014/2015 and 2015/2016 dry seasons at the Fadama Teaching and Research Farm of Usmanu Danfodiyo University, Sokoto, located at latitude13^{o} N and longitude 20^{o}E The area was located in the Sudan Savanna zone of Nigeria.The experiment consisted of three irrigation intervals (5, 8 and 11days). and three levels of nitrogen Fertilizer (0kg/ha, 50kg/ha and 100kg/ha). The treatments were factorially combined and laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on the growth and yield parameters which included stand establishment count, Plant height, number of leaves per plant,* ***n****umber of branches per Plant, days to 50% flowering, number of pods per plant, pod length. Fresh pod weight and total pod yield. Results of the experiments revealed that 5 days irrigation interval recorded the highest values in all parameters under investigation. Similarly, 100kg N/ha recorded the highest values in most of the parameters measured. Therefore, it may be concluded that 5 days irrigation interval in combination with 100kgN ha^{-1} may be suitable for increased okra production in the study area.*

I. INTRODUCTION

Okra is a vegetable crop that belongs to the family Malvaceae, genus *Abelmoschus*, and has four main species*: Abelmoschus esculentus* (L) Moench (common okra). *Abelmoschus caillei* is West African okra (Kumar *et al*., 2010). Worldwide production of okra as fresh fruit vegetable is estimated at six million metric tons per year (FAOSTAT, 2012). In Africa, total annual production was put at 1.9 million tons per year. The leading producers are Nigeria, Sudan, Ivory Coast, Ghana, Benin and Egypt (FAO, 2010). The highest yield of the crop was recorded in Egypt (14.17t/ha) followed by Burkina Faso (10.0t/ha), Kenya (6.25t/ha) and Ghana (5.56t/ha) (FAOSTAT, 2010). The pods can be sliced, thinly and cooked for a long time, so the mucilage dissolves. (Chada, 2002). Okra contains carbohydrates, proteins and vitamin C in large quantities and also essential and non essential amino acids. The pods are among the very low calorie vegetables, containing no saturated fats or cholesterol. (Adeboye and Oputa, 1996) Okra provides an important source of protein (0.1mg), fat (0.2g), fiber (1.2g), moisture (89.6g), phosphorus (56mg), sodium (6.9mg), carbohydrates (6.4g), minerals (0.7g) potassium (103mg), vitamin C (13mg), magnesium (53mg) and other mineral matters which are often lacking in the diet of developing countries (Gopalan *et al*., 2007). The average yield from farmers in Nigeria is 3.2t/ha and this low compared to the African average yield. Low yield of Okra recorded by Nigerian farmers are due to inappropriate fertilizer application and prolong water stress condition (Adelana, 1995).. To obtain optimum yield, appropriate application of nitrogen fertilizer, good irrigation timing and adequate irrigation are necessary. This research was conducted with the view to determine the best irrigation interval and different rates of nitrogen fertilizer for optimum yield of okra.

II. MATERIALS AND METHOD

The experiment was conducted during 2014/2015 dry season at the Fadama Teaching and Research Farm of Usmanu Danfodiyo University, Sokoto, located at latitude 13^{o} N and longitude 20^{o}E between March and May 2015.The area was located in the Sudan Savanna zone of Nigeria, the site of the experiment is made up of sandy loam and the area was characterized by long dry season between October and early June. The experiment sisted of three irrigation intervals (5, 8 and 11days). and three levels of nitrogen Fertilizer (0kg/ha, 50kg/ha and 100kg/ha). The treatments were factorially combined and laid out in a Randomized Complete Block Design (RCBD) with three replications.

Seeds of Jokoso improved variety of okra was used for the study The variety is highly consumed; and has a thick flesh pods and short to medium in height. 3-5 seeds of okra were dibbled at an inter and intra- row spacing of 50cm and 30cm respectively. The seedlings were thinned to one per stand at 2WAS and missing stands were supplied immediately after germination. Nitrogen fertilizer in form of Urea was applied as per treatments in two split doses. The first dose was applied 2WAS while the second dose at 50% flowering. Okra was harvested while tender and immature at 2 to 3 days interval. Data were collected on the growth and yield parameters which included stand establishment count, Plant height, leaf number, Number of Branches per Plant, Days to 50% Flowering, Number of Pods per Plant, Pod Length. Fresh Pod Weight and total Pod Yield. The data collected was analyzed statistically using analysis of variance (ANOVA) using statistical analysis system (SAS, 2003). Where "F" test shows significant differences between treatments, Duncan Multiple Range Test (DMRT) was used to separate the means (Gomez and Gomez, 1984).

III. RESULTS AND DISCUSION

Establishment count

Effects of irrigation interval and nitrogen levels on establishment count of okra are shown in (Table 1). Generally, irrigation interval and nitrogen application had no significant effect on establishment count. This may be due to the fact that, at that stage it was too early for the effects of the treatments to manifest their effects on establishment count.

Plant height (cm)

Results on the effect of irrigation interval and nitrogen on plant height is shown on (Table 2) there was significant effect of irrigation interval on plant height of okra at 2, 4 and 6 WAS. The results also showed that at 4WAS, plots that were irrigated at 5 days interval produced taller plants which were statistically not different from those irrigated at 8 days interval. However, at 6WAS, the result showed that taller plants were recorded with 8 days intervals which were higher than what was obtained with 11 days interval The results revealed that plant height decreased with increase in irrigation interval. This reduction might probably have been due to increase in moisture stress condition with increase in irrigation interval which in turn reduced the rate of cell enlargement and plant growth. Abd El-Kader *et al*. (2010) also observed that height and stem diameter of okra increases by enhancement of water availability. They reported decrease in morphological characters like plant height to have occurred by increasing the irrigation interval. John (1993) reported that increasing water stress was found to restrict photosynthesis partly as a result of stomata closure and partly because of increased mesophyll resistance. A similar observation was reported by Kurup *et al.* (1997). Nitrogen level was also observed to have significant effect on plant height of okra at both 2, 4 and 6WAS, that is to say all nitrogen levels of 50 and100 kg/ha produced plants that are statistically taller than the plants obtained with 0 kg N/ha. The significance of nitrogen on the height of okra plant may be due to the fact that higher nitrogen levels enhances photosynthetic efficiency of the plant there by giving room for rapid increase in plant size hence taller plants.

Number of Leaves per plant

The results indicated that irrigation interval had no significant effect on the number of leaves of okra at 2 and 4 WAS (Table 3). However, 5 and 8 days irrigation intervals resulted to significantly higher number of leaves of okra at 6 WAS than the 11 days interval. This may be due to prolonged water stress experienced by the plants with 11 days interval, because moisture is necessary for the physiological development, translocation and nutrient uptake of okra. Anant *et al*. (2009) reported similar results. They maintained that the highest okra fruit yield was accompanied by high leaf water potential, leaf relative water content, photosynthetic activity, stomatal conductance and leaf area index. Also Abd El-Kader *et al*. (2010) reported that number of leaves and stems per okra plant decreased when subjected to stress conditions, so that the highest number of leaves and stems per plant were obtained at the shortest irrigation interval

The results showed significant effect of nitrogen fertilizer on the number of leaves of okra was significant at both 4 and 6 WAS but not at 2 WAS. The highest number of leaves were obtained with 50 and 100 kg /ha.

Days to 50% flowering

Results on the effects of irrigation intervals and nitrogen levels on days to 50% flowering of okra are presented in (Table 1). There was significant effect of irrigation interval on days to 50% flowering. Five (5) days and 8 days intervals recorded fewer number of days to attain 5% flowering which was statistically different from what was recorded for 11days irrigation. This means that shorter irrigation intervals gave plants chance to grow and attain flowering stage within fewer days.

Number of Branches

There was significant effect of irrigation interval on number of branches produced by okra plants (Table 1) . Results showed that 5 and 8 days irrigation intervals produced significantly higher number of branches than the 11days irrigation interval. The higher number of branches produced the plants with short intervals may be as result of benefits derived from sufficient provision of moisture which enable them to utilize resources efficiently. Also, results revealed that number of branches was significantly affected by different levels of nitrogen fertilizer, the 100kgN ha^{-1} produced significantly higher number of branches than 0 and 50kgN ha^{-1}. This is because application of high nitrogen level enhances plant growth hence higher number of branches.

Number of pods per plant

Numbers of pods per plant were significantly affected by irrigation interval (Table 4). Results showed that 5 and 8 days irrigation intervals produced significantly high number of pods per plant than the 11days irrigation interval. This is may be due to the prolonged moisture stress experienced by plants irrigated at 11 days interval hence, less productivity. It was observed that nitrogen was highly significant on the number of pods per plants. The highest number of pods per plant (15.744) were produced by the plants that received 100kgN ha^{-1} and the lowest (6.344) was obtained from 0kgN ha^{-1}. Ahmad *et al*. (1999) also found higher number of fruits per plant with application of 120 kg N/ha. Singh (1985) observed that application of N at 90-100 kg/ha gave the higher number of pods per plant of okra.

Pod Weight

The effects of irrigation intervals on pod weight was found to be significant (Table: 4). The results indicated that 5 and 8 days irrigation intervals resulted to significantly higher pod weight than irrigating at 11days interval. The higher pod weight recorded from 5 and 8 days irrigation intervals could be as a result of availability of moisture for photosynthesis and translocation of photosynthates for pod development which is limited at 11 days interval. West (2004) also reported that frequent irrigation increases size and weight of fruit.

The results also revealed that pod weight was significantly affected by different levels of nitrogen fertilizer, 100kgN ha^{-1} was significantly higher in weight than the 0kgN ha^{-1}. The results however showed that 100kgN ha^{-1} and 50kgN ha^{-1} were found to be statistically the same. This result is similar to the finding of Kurup *et al.* (1997) who reported that N rates up to 100 kg /ha could increase pod weigh of okra.

Pod length

The effect of irrigation intervals on pod length is presented on (Table 4). The results showed that there was significant effect of irrigation intervals on pod length of okra ($P<0.05$). Five (5) and 8days irrigation intervals resulted to significantly longer pods than the 11days irrigation interval, This may be due to the moisture stress in plants that were irrigated at 11 days interval which lead to reduction on the pod length. This finding is in conformity with that of Boland *et al.* (2000) who reported that the leaves of plants will respond to water stress by the closure of their stomata and this inhibit photosynthesis. West (2004) also reported that irrigation increases size and weight of fruit. The low utilization of water deficient crops has poor carbohydrate utilization and therefore fruit decrease in size (Viets, 1999). Similarly, the result showed that pod length was significantly affected by various levels of nitrogen. Longest pods were recorded with 100kgN ha^{-1} and shortest pods were recorded in control plots (0kgN ha^{-1}). Pod length is a tone character for economic yield which depends upon various factors such as genetic makeup of the cultivars and their response to prevailing environmental conditions. This reflects that the more the nitrogen fertilizer dose the better will be pod length as reported by (Anjum & Amjad, 1999). The results agrees to those of Arora *et al*., (1991) who reported that pod length in okra was significantly improved by application of nitrogen. The results showed that there was significant interaction effect between irrigation interval and nitrogen on pod length of okra (Table 5). Longest pods (5.1cm) were recorded in plot having the combination of 5 days interval and 100kgN ha^{-1}. While shortest pods (2.8cm) were there in plot that combines 11 days interval and 0kgN ha^{-1}.

Total Pod yield

Results from Table 4 showed the effect of irrigation interval on total pod yield of okra. The results indicated that there was significant effect ($p<0.05$) of irrigation interval. Five (5) and 8 days irrigation interval produced significantly higher pod yield per hectare than the 11days irrigation interval. Total yield of okra per hectare significantly decreased with increased in irrigation interval, this indicated negative effect of water stress caused by irrigation at high intervals which reduced okra total yield per hectare by accelerating leaf senescence. The significant reduction of yield with increase in irrigation interval may also be due to overall effects of water on okra development at vegetative and reproductive phases. Thus, drought stress has been reported to reduce translocation of assimilate from the leaves to the fruits. Reduction in total yield with increasing irrigation interval may also be due to corresponding effect of irrigation interval on yield component such as number of pod per plant, number of branches, plant height which all responded in the same manner. Bauder (2001) reported reduction in okra yield with increased water stress. Similarly, there was significant influence of nitrogen on fruit yield of okra. The highest yield (5.73 t/ha) was obtained from 100 kg N/ha. The differences of yield among three nitrogen levels are attributable to the difference in the number of pods per plant and weight of pods. As the number and weight of pods were higher in the plant from 100 kg N/ha, the ultimate fruit yield was higher in those plants. This result is similar to the finding of Kurup *et al.* (1997) who reported that N rates up to 100 kg /ha could increase pod yield of okra. Also Sultana (2000) recorded highest yield of okra with 100 kg N/ha. The pod yield per hectare was significantly affected by the interaction between irrigation and nitrogen (Table 6). From the results indicated that the highest yield of okra (5.335t/h) was recorded in the plot that combined 5 days irrigation interval and 100kgN ha^{-1}. While the lowest yield of okra (1.116t/h) was recorded in plot combining 11 days irrigation interval and 0kgN ha^{-}.

IV. CONCLUSION

From the study, it could be concluded that the use of 5 days irrigation interval in combination with 100kgN ha^{-1} may be recommended for increased okra production in the study area.

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Table 1: Effect of Irrigation interval and Nitrogen fertilizer on Establishment count, days to 50% flowering and number of leaves of Okra at UDU Teaching and Research fadama Farm at sokoto

Treatment	**Establishment count**	**Days to 50% flowering**	**Number Of Branches**
Irrigation interval (days)			
5	97.678	44.778[a]	4.222[a]
8	94.433	46.444[b]	4.467[a]
11	94.900	48.111[c]	3.200[b]
SE+	1.458	0.066	0.261
Significance	NS	*	*
Nitrogen kg/ha			
0	94.289	46.667[a]	2.689[c]
50	96.444	40.077[a]	3.289[b]
100	96.578	40.556[a]	4.911[a]
SE+	1.521	082	0.120
Significance	NS	*	*
Interaction			
IXN	NS	**NS**	NS

Means in a column followed by same letter(s) do not differ significantly according to DMRT at 5% level of probability. WAS= weeks after sowing okra. NS= Not significant. *= Significance at 5% level of probability

Table 2: Effect of Irrigation interval and Nitrogen fertilizer on plant height of okra at 2, 4 & 6 WAS at UDU Fadama Teaching and Research Farmt Sokoto

		Plant Height (cm)	
		Weeks After Sowing	
Treatments	**2**	**4**	**6**
Irrigation interval (days)			
5	27.133	38.911[a]	45.978[a]
8	26.578	33.800[b]	38.367[b]
11	26.778	29.222[c]	33.889[c]
SE±	0.673	0.695	0.968
Significance	NS	*	*
Nitrogen Level (kgha^{-1})			
0	26.444	30.867c	33.900[c]
50	26.267	38.400[b]	39.222[b]
100	27.778	41.667[a]	47.111[a]
SE±	0.654	0.371	0.087
Significance	NS	*	*
Interaction			
I X N	NS	NS	NS

Means in a column followed by same letter(s) do not differ significantly according to DMRT at 5% level of probability. WAS= weeks after sowing okra. NS= Not significant. *= Significance at 5% level of probability

Table 3: Effect of Irrigation interval and Nitrogen fertilizer on number of leaves of okra at 2, 4 & 6 WAS at UDU Teaching and Research fadama Farm during 2014/2015 dry Season at sokoto

	Number of leaves		
	Weeks After Sowing		
Treatment	**2**	**4**	**6**
Irrigation interval (days)			
5	7.467	10.400^{a}	17.000^{a}
8	7.822	11.222^{a}	16.089^{a}
11	8.244	9.600^{a}	12.922^{b}
SE$^{\pm}$	0.256	0.276	0.722
Significance	NS	*	*
Nitrogen Level (kg ha^{-1})			
0	7.778	9.067^{c}	15.389^{b}
50	7.833	10.678^{b}	19.267^{a}
100	7.922	11.622^{a}	19.356^{a}
SE$^{\pm}$	0.281	0.225	0.314
Significance	NS	*	*
Interaction			
I X N	NS	NS	NS

Means in a column followed by same letter(s) do not differ significantly according to DMRT at 5% level of probability. WAS= weeks after sowing okra. NS= Not significant. *= Significance at 5% level of probability

Table 4: Effect of Irrigation interval and Nitrogen fertilizer on number of pod per plant and pod weight per plant of Okra at UDU Teaching and Research fadama Farm Sokoto.

Treatment	**Number of pods per plant**	**Pod weight (grams)**	**Pod length (cm)**	**Pod yield t/ha**
Irrigation interval (days)				
5	15.744^{a}	34.440^{a}	4.633^{a}	4.305^{a}
8	10.667^{b}	27.393^{b}	5.011^{a}	3.424^{a}
11	6.344^{c}	13.298^{c}	3.811^{b}	1.662^{b}
SE$^{\pm}$	2.064	284	0.211	0.321
significance	*	*	*	*
Nitrogen kg/ha				
0	10.667^{c}	17.140^{b}	3.611^{b}	2.668^{c}
50	13.611^{a}	28.642^{a}	4.511^{a}	3.480^{b}
100	15.478^{a}	29.349^{a}	4.633^{a}	4.142^{a}
SE$^{\pm}$	2.084	2.903	0.269	0.442
Significance	*	*	*	*
Interaction				
IXN	Ns	*	*	*

Means in a column followed by same letter(s) do not differ significantly according to DMRT at 5% level of probability. WAS= weeks after sowing okra. NS= Not significant. *= Significance at 5% level of probability

Table 5: Interaction between irrigation intervals and nitrogen levels on pod length per plot of Okra at UDU Teaching and Research fadama Farm during 2014/2015 dry Season

		Nitrogen Level (kgN ha^{-1})	
Irrigation interval (days)	**0**	**50**	**100**
5	4.200^{c}	4.767^{a}	5.100^{a}
8	4.967^{a}	4.933^{a}	4.967^{a}
11	2.800^{d}	3.967^{c}	4.667^{b}
SE±		**0.282**	

Means in a column followed by same letter(s) do not differ significantly according to DMRT at 5% level of probability. WAS= weeks after sowing okra. NS= Not significant. *= Significance at 5% level of probability

Table 6: Interaction between irrigation intervals and nitrogen levels on total pod yield per hectare of Okra at UDU Teaching and Research fadama Farm during 2014/2015 dry Season at sokoto

		Nitrogen Level (kgN ha^{-1})	
Irrigation interval (days)	**0**	**50**	**100**
5	2.526^{c}	4.053b	5.335^{a}
8	2.784^{c}	3.737^{b} 1.669^{d}	3.752^{b}
11	1.116^{d}		2.201^{cd}
SE±		**0.351**	

Means in a column followed by same letter(s) do not differ significantly according to DMRT at 5% level of probability. WAS= weeks after sowing okra. NS= Not significant. *= Significance at 5% level of probability