ISSN - 2277 - 2755

Journal of Agricultural Science and Environment

YIELD AND YIELD CHARACTERS OF SORGHUM (*Sorghum bicolor L*. Moench)VARIETIES AS INFLUENCED BY IRRIGATION INTERVAL AND PLANT DENSITY AT KADAWA IN THE SUDAN SAVANNAH

***[1]Y. HUSSAINI, [1]A.M. FALAKI, [1]H.J. JANTAR AND [2]U.S. ABDULLAHI**

[1]Department of Agronomy and [2]Plant Science, Institute for Agricultural Research, Ahmadu Bello University Zaria, Nigeria
***Corresponding author:** yusufhuss2006@yahoo.com **Tel: +**2347064881498

ABSTRACT

A two-years field experiment was conducted during 2008 and 2009 dry seasons at Irrigation Research Station Kadawa in the Sudan savannah to study the yield and yield characters of sorghum (*Sorghum bicolor L*. Moench) varieties as influenced by irrigation intervals and plant densities. The treatments consisted of factorial combination of three sorghum varieties (KSV-4, KL-2 and NR 71168), three irrigation intervals (7, 14 and 21 days) and three plant densities (66,666, 53,333 and 44,444 ha^{-1}). Split plot design was used in the experiment and replicated three times with irrigation interval and variety assigned to main plots and plant density allocated to the sub plots. The sub plots size was 4m x 3m ($12m^2$), while the net plot was $6m^2$. Significantly longer panicles were found in KSV4 and KL-2 at 14 days interval in 2008 and at 21 days interval in 2009. Higher grain weight per panicle was recorded in NR 71168 at 21 days irrigation interval in both years. NR 71168 variety out yielded other two varieties in both years when irrigation interval was extended from 7 to 14 days. No significant response was recorded due to varying plant densities although, 66,666 gave higher grains output compared to other plant densities studied. From this study it is concluded that NR 71168 variety at 14 days irrigation interval and 66,666 ha^{-1} plant density under irrigation could be used at Kadawa in the Sudan savannah agro ecological zone of Nigeria.

Key words: Irrigation interval, plant density and variety, sorghum.

INTRODUCTION

Sorghum (*Sorghum bicolor L*. Moench*)* which is of African origin is an important food and feed crop of the semi arid tropics. Semi -arid tropics of Asia and sub-Saharan Africa grow about 60% of the sorghum (Dogget, 1970 and Andrews, 1975) and it ranks fifth in importance after wheat, rice, maize and barley. It is cultivated among peasant and large scale farmers in Nigeria during rainy season cropping (Ila, 1989 and ICRISAT, 1990) . Sudan savannah provides the most suitable production environment for sorghum where different varieties from local strains (KL 2) and improved varieties (KSV 4 and NR 71168) are commonly cultivated under rainfed condition. The conditions include higher solar radiation, predominant sandy loam soil and lower incidence of pests and diseases.

Grain sorghum can endure limited, short term water stress thus making the cultivation of the crop possible in the drier regions of Nigeria with supplementary irrigation or as irrigated crop. It responds rapidly to additional water especially during flag leaf and booting growth stages when the number of seeds per head is set. On the other hand, less moisture is required during grain filling period, but important to maintain seed weight and production potential (Anon., 2004). However, according to Bammeke (1987), sorghum water requirement is higher during flowering and grains filling periods therefore making scheduling irrigation during these periods important for efficient growth and higher yield as well as to ensure maximum return on irrigation inputs. Likewise, environmental factors of temperature, humidity, wind, soil moisture, evaporation and transpiration are all driving factors in determining yield (Anons., 2006). Therefore, cultivation of sorghum may be possible under irrigation to supplement rainfed production system thereby increasing food and feed supply for ever increasing consumer population and livestock. The major constraint during this period is the incidence of birds infestation at maturity stage that drastically the reduced the yield and sometimes lead to total failure. In addition plant density determines the absorption rate of solar radiation and the rate of evapo - transpiration of the soil and the crop canopy and hence affecting photosynthetic processes that determine crop growth and its ultimate yield.

This study was therefore conceived with the objective of finding an appropriate variety, irrigation interval and plant density for good growth and yield of sorghum under irrigation at Kadawa in the Sudan savannah agro ecological zone of Nigeria.

MATERIALS AND METHODS

The experiment was conducted during 2008 and 2009 dry seasons at Irrigation Research Station, Institute of Agricultural Research Kadawa (11^0 39'; 08^0 02'E, 500 m above sea level) in the Sudan savannah. The treatments consisted of factorial combination of three sorghum varieties (KSV-4, KL-2 and NR 71168), three irrigation intervals (7, 14 and 21 days) and three plant densities (66,666, 53,333 and 44, 444 plants ha^{-1}). Split- plot design was used in the experiment and replicated three times with irrigation interval and variety assigned to main plots and plant density allocated to the sub plots. The plot was ploughed and harrowed and later made into ridges at 75cm apart. The sub plots size was 4m x 3m ($12m^2$) containing four ridges where the two central ridges served as the net plot ($6m^2$). Two to three seeds were sown at the specified spacing of 20 cm x 75 cm, 25 cm x 75 cm and 30 cm x 75 cm and irrigated immediately. Subsequent irrigations were done at weekly intervals. At four weeks after sowing (WAS) the plants were irrigated as per treatment at 7, 14 and 21 days intervals. First and second weeding were done using hoe at three and five weeks after transplanting (WAS), respectively. The plants were thinned to one plant per stand during first weedings. Recommended dose of fertilizer were applied immediately after first and second weeding. Result of soil analysis and record of meteorological data of the experimental site are recorded and presented on Tables 1 and 2, respectively.

The data were collected on panicle length and grains weight and the grain yield which was later converted on per hectare basis. The data were subjected to analysis of variance as described by Snedecor and Cochran (1967).

Table 1: Physical and chemical properties of the experimental site at 0-30cm

Soil properties	Soil depth at 0-30cm	
	2007	2008
Physical Composition (%)		
Sandy	50.0	52.0
Silt	28.2	230.2
Clay	29.0	28.0
Textural class	Sandy loam	Sandy loam
Chemical composition		
pH in water	7.2	6.4
pH (0.0 $CaCl_2$)	6.3	6.0
Organic carbon(g/kg)	0.72	0.73
Available phosphorus (mg/kg)	24.3	25.3
Total nitrogen (g/kg)	0.22	0.30
Exchangeable bases (cmol/kg)		
Ca++	1.80	1.70
Mg++	1.20	1.30
K+	0.07	0.08
Na++	0.25	0.24
Exchangeable acidity	0.09	0.09
CEC	7.11	7.20

Source: Analyzed at Department of Soil Science IAR/ABU, Zaria

Table 2: Meteorological data (means) of the trial location at Kadawa in the Sudan savannah during 2008 and 2009 dry seasons

Month	Max. temp (0^0c)	Min. temp (0^0c)	Rel. humidity (%) 10.0am	Rel. humidity (%) 4.0am	Wind direction
2008					
Jan	30	12	37	13	SE
Feb	33	19	50	37	SE
Mar	32	19	51	16	NE
Apr	42	24	68	28	SW
2009					
Jan	33	13	36	13	SE
Feb	31	20	48	37	SE
Mar	35	21	53	19	NE
Apr	42	24	66	30	SW

Source: Metrological Unit, Irrigation Research Station Kadawa IAR/ABU Kano-Nigeria

Means were separated using Duncan Multiple Range Test DMRT (Duncan, 1955) at $p \geq 0.05$ level of probability.

RESULT

Table 3 shows the effects of irrigation interval, variety and plant density and their interaction on panicle length of irrigated sorghum during 2008 and 2009 dry seasons at Kadawa. The result indicated that 21 days irrigation interval produced the longest panicle while 7 and 14 days interval gave statistically similar results in both years. Statistically similar panicle length was observed between KSV 4 and KL 2 while NR 71168 gave the shorter panicles during the periods under review. The effect of density and interaction among treatments was not significant in the both years and the combined means.

The effect of treatments on grains weight per panicle is presented on Table 3. The result indicated that both 7 and 14 days irrigation intervals gave lower grains weight per plant in both years compared to 21 days interval which gave the highest grains weight per plant during the periods under review. NR 71168 varieties gave the highest weight while the other two varieties gave statistically similar but lower weights in both years means. The effects of density and interaction among treatments were not significant in both years.

The effect of treatments on grains yield per hectare is presented on Table 3. In 2008, there was no significant difference in yield when irrigation interval was extended from 7 to 14 days; however, increasing the irrigation interval from 14 to 21 days resulted in significant increase in yield. Similarly, in 2009 increasing irrigation interval from 7 to 14 days did not result in any significant increase in grains yields. However, when the irrigation period was extended to 21 days, a significant increase on grains yields was recorded. A significant effect was observed due to varietal differences in both years where NR 71168 variety out-yielded KSV4 and KL2 that gave statistically similar lower yield.

There was no significant effect of density on grain yield in both years. A significant response was obtained on grains yields due to interaction between variety and irrigation interval in both years.

Table 4 shows the interaction between variety and irrigation interval on grains yield during 2008 dry season at Kadawa. Increasing irrigation interval in KSV 4 and KL-2 varieties from 7 to 14 days resulted in lower grains yield. However, when the interval was increased from 14 to 21 days a significant yield increase was recorded. NR 71168 out yielded other varieties at 7 and 14 days irrigation interval whereas no significant yield difference was observed among the varieties at 21 days irrigation period.

Table 5 shows the significant interaction between variety and irrigation interval on grains yield of sorghum during 2009 dry season. Holding the variety constant at a varying irrigation interval revealed that irrigation periods from 7 to 14 days gave statistically similar but lower yields in KSV 4 and KL 2 varieties. Higher yield was observed when the irrigation interval was extended to 21 days interval whereas; no significant response was observed in NR 71168. Conversely, at a fixed irrigation period, 7 days irrigation intervals gave the highest yields in NR 71168, while the other two varieties gave similar but lower yields. Similar result was obtained at 14 days irrigation

Table 3: Effects of irrigation interval, variety, and plant density on panicle length (cm), grain weight (kg) and grain yield (kgha-1) of irrigated sorghum during 2008 and 2009 at Kadawa

Treatment	Panicle length		Grain weight		Grain yield	
	2008	2009	2008	2009	2008	2009
Irr. Interval (I) (Days)						
7	22.8b	22.8b	0.6b	0.7b	1111.0ab	1154.3b
14	23.9ab	23.9b	0.6b	0.6b	1018.5b	1038.3b
21	24.2a	24.5a	0.8a	0.8a	1271.6a	1389.5a
SE+	0.43	0.42	0.04	0.04	77.43	62.52
Variety (V)						
KSV-4	22.3a	22.3a	0.6b	0.7b	1018.5b	1104.9b
KL-2	25.2a	25.3a	0.6b	0.7b	987.6b	1087.6b
NR 71168	23.3b	23.6b	0.8a	0.8a	1395.0a	1389.5a
SE+	0.43	0.42	0.04	0.04	77.43	62.52
Density (D)						
44,444	23.8	24.0	0.6	0.7	1074.0	1172.8
53,333	23.3	23.3	0.7	0.7	1148.1	1143.2
66,666	23.9	23.9	0.7	0.8	1264.7	1266.1
SE+	0.43	0.42	0.04	0.04	77.43	62.52
Interaction						
V X I	NS	NS	NS	NS	*	*
D X I	NS	NS	NS	NS	NS	NS
D X V	NS	NS	NS	NS	NS	NS
D X V X I	NS	NS	NS	NS	NS	NS

Means followed by the same letter in the same column within the same treatment group are statistically similar at 5% level of probability using DMRT. Where NS= not significant

* = Significant at 5% level of probability
** = Significant at 1% level of probability

Table 4: Interaction between variety and irrigation interval on grain yield of irrigated sorghum during 2008 dry season cropping at Kadawa

Treatment	Irrigation interval		
	7 days	14 days	21 days
Variety			
KSV 4	962.9c	851.8d	1240.7ab
KL 2	944.3d	704.0e	1314.8ab
NR 711186	1425.9a	1500.0a	1259.3ab
SE+	134.12		

Means followed by the same letter within the same row or column are statistically similar at $p \geq 0.05$

Table 5: Interaction between variety and irrigation interval on grain yield per hectare of irrigated sorghum during 2009 dry season cropping at Kadawa

Treatment	Irrigation interval		
	7 days	14 days	21 days
Variety			
KSV 4	10373c	777.8c	1500.0a
KL 2	1037.4c	818.5c	1407.4ab
NR 711186	1388.9ab	1518.5a	1261.1ab
SE+	108.28		

Means followed by the same letter within the same row or column are statistically similar at $p \geq 0.05$

interval. However, at 21 days irrigation interval a statistically higher yield was found in KSV 4 which was at par with other varieties tested.

DISCUSSION

The soil water requirement decreases with frequency of irrigation while the plant water needs increase at vegetative stage of growth and decrease at later stage of growth as indicated on panicle length and grains weight. This was attributed to the need of frequent irrigation at 7 days' interval when the plant was well established due to higher rate of vegetative development and at moderate frequency at later period for grains production irrespective of the variety. Similarly, it was reported that during dry season, the soil air is dry accompanied with greater evaporation rates, heavy wind, low relative humidity and less or no ground cover. Therefore, during this period efficient and timely application of water is important to meet the field capacity for efficient and profitable dry season cropping (Anons., 2004). Grain yield increased at wider irrigation interval in KSV 4 and KL 2 compared to NR 71168 variety. This could be attributed to moisture and environmental requirement of the crop varieties at their various stages of growth. This supported earlier report that sorghum can endure limited, short term water stress and the crop water requirement is less during grain filling stage, but remains important to maintain seed weight and higher yield potential (Anons., 2004). However, extended moisture stress slows plant development during vegetative growth and this has an adverse effect on grains formation at later reproductive stage.

According to Bammeke (1987), plant density at sub optimal level is responsible for lower yield of most crops in the tropic; this was simply attributed to the lower number of plants per unit area. However, the non significant response of grains yield to plant density in this study could be attributed to the environmental factors such as higher solar radiation, lower night temperature, lower incidence of pests and diseases and ease of drying, that favour the growth of the plant in respective of the plant density used.

According to ICRISAT (1990), different sorghum cultivars are doing well in the Savannah area under rainfed condition, despite the mid season drought experienced during the late August and September, good yields, of over 5 tones ha^{-1} were recorded from short duration cultivars while severe lodging were observed in other lines. Therefore, irrigated sorghum production is possible where water supply is available even at wider irrigation interval of 21 days in the Savannah area. In addition, the production of sorghum which was hitherto restricted during rainy season cropping in the area can be practicable under irrigation during dry season, this is because dry season provides a better production environment as indicated in Table 1. The non significant effect of plant density on grains yield could be attributed to the above reasons as the season advanced that hastens the growth of all the varieties at the varying densities.

Similar result was recorded by Otaza, (1987) and Postiglione and Basso (1980). However, Ila (1989) observed that due to need of more effective space to intercept sunlight and the need to reduce competition among plant, a significant response was recorded due to various plant densities. Similarly, closer spacing promotes shading of the soil surface and hence reduces evaporation and suppressed weeds growth.

The higher moisture requirement of NR 71168 variety throughout growth period might be due to its higher moisture requirement compared to the other varieties. In addition, KSV 4 and KL 2 are more adapted to the environment compared to NR 71168 as they are commonly grown during rainy season in the area.

CONCLUSION

From this study it is found that NR 71168 gave higher yield compared to other varieties tested at a plant density of 66,666 ha^{-1} and 14 days irrigation interval.

ACKNOWLEDGMENT

The authors sincerely thank the Director of Institute for Agricultural Research, Ahmadu Bello University Zaria for financing the study and for permission to publish the article.

REFERENCES

Andrews, D.J. 1975. Sorghum varieties for late season in Nigeria. *Tropical Agriculture Abstract,* 1(5): 75.

Anonymous, 2004. Texas Cooperative Extension at: http://texasextension.tamu.edu

Anonymous, 2006. Irrigation Management in Sorghumat:http://pursehouserural.com.au

Bammeke, M.L 1987. *The effect of nitrogen and plant density on the agronomic performance of sorghum hybrid*. Unpublished M.Sc. Thesis submitted to Postgraduate School, Ahmadu Bello University, and Zaria. 87 P.

Dogget, H. 1970. Sorghum. Longman greens and co. Ltd. London.

Duncan, D.B. 1955. *Multiple Range and Multiple F test Biometrics,* 11: 1-42.

International Crops Research Institute for Semi-Arid Tropics 1990. Annual Report Patancheru, AP 502324 India. 10 p.

Ila, M.L. 1989. *Effect of sowing date and time of nitrogen fertilizer application on components of sorghum (Sorghum bicolor L. Moench) varieties*. Unpublished MSc. Thesis submitted to Postgraduate School , Ahmadu Bello University, Zaria. 75 P.

International Crops Research Institute for Semi-Arid Tropics 1990. Annual Report. Patancheru, AP 502324 India. 10 P.

Otaza, E.R. 1987. Effect of different population densities and nitrogen levels on yield and yield components of sorghum. *Tropical Agriculture Abstract,* 8(8): 69.

Postioglione, L., Basso, F. 1980. The sorghum crop in the southern areas; hybrids and sowing density in Brasillica hills. *Imformative Agrerio*, 36(46): 12967.

Snecdector, G.W., Chochran W.G. 1967. *Statistical methods 6th edition*. Iowa State University Press. U.S.A. 456pp.

(Manuscript received: 18th May, 2010; accepted: 29th December, 2010).