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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 10 (17): 3023-3025, 2007
ISSN 1028-8880

Potential for Improving Crop Yields Through Better Water Management in Rainfed Regions

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Abstract: This study was conducted to determine the effect of water supply at critical growth stage of sorghum in Arid Zone Research Institute, D.I. Khan. The results indicated that the yield components and grain yield were significantly affected by water supply. Irrigation applied at heading stage of the crop significantly increased plant height, maturity period, fresh and dry weight of heads plot^{-1}, 1000 grain weight and grain yield of sorghum irrespective to cultivars. Maximum grain yield of 3319 kg ha^{-1} was obtained with irrigation as against 2206 kg ha^{-1} obtained from un-irrigated treatments. The plant height, fresh and dry weight of heads plot^{-1}, 1000 grain weight and grain yield of different cultivars were also different significantly irrespective to irrigation. Maximum grain yield of 2976 kg ha^{-1} was produced by the cultivar DS-2000 compared to 2550 kg ha^{-1} by DS-97 Yarik. The interaction between irrigation and cultivar as regards yield and yield components of sorghum was non significant. The findings of this study suggested that the grain yield of sorghum can be increased by 50% with irrigation applied at the heading of sorghum.

Key words: *Sorghum bicolor* L., cultivars, irrigation, grain yield, Pakistan

INTRODUCTION

In Pakistan, sorghum (*sorghum bicolor* L.) grown in summer produced very low yield than the actual potential mainly because of poor management of irrigation water available for cropping. The optimum water requirement for sorghum is 344-442 mm (Shah, 1981-1986). He observed decreased grain yield of sorghum by the increase of moisture stress level. Irrigation frequency entirely depends on weather and soil condition where in crop is grown but the crop growth stage and timely application of irrigation are the fundamental management factor to get maximum yield of test crop particularly where availability of irrigation water is scarce in the area. In hot dry areas, rising evaporation and falling soil water content often lead to water stress during blooming and grain formation stage of crop which ultimately reduces the yields. Denmead and Shaw (1960) found that moisture stress prior to silking, at silking and after silking reduced the grain yield by 50, 21 and 25 %, respectively. Sen (1952) recorded highest wheat yields from irrigation and recommended irrigation at the tillering and flowering stages. According to Robinson (1971), sunflower responds to irrigation, and yield increases exceeding 100% are common on drought affected soils. Khaliq and Cheema (2005) indicated that highest achene yields in sunflower were recorded with the irrigation applied at head visible, at floral initiation, at floral completion and during grain development. Nadia (2005) found significant increase in shoot length, No. of leaves/plant, total leaf area/plant and dry weight of shoot and root f sorghum plants irrigated with sewage waste water.

Singh *et al.* (1994) reported that the increase in seed yield by mustard would be due to the increase in leaf water potential and stomatal conductance and decrease in canopy temperature with irrigation. Connor *et al.* (1995) have reported the reduction in total dry matter yield when sunflower was grown under dry land conditions without supplemental irrigation. Similarly, Majid and Simpisan (1999) observed 57, 49 and 19% increase in seed yield of *Brassica junecea* with full, medium and minimum irrigation treatments over the dry treatment, respectively. Bajwa *et al.* (1987) observed positive correlation between grain yield of maize and irrigation and that of fertilization. Corn responded well to high frequency irrigations as observed by increased dry matter accumulation and grain yield of corn. The present study aimed to determine the effect of irrigation at heading of sorghum under hot dry climatic condition of D.I. Khan.

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MATERIALS AND METHODS

An experiment to study the feasibility of irrigation at heading stage of sorghum was undertaken at the Arid Zone Research Institute, D.I. Khan during Kharif, 2004. In this trial two different cultivars of sorghum (DS-97-Yarik and DS-2000) were tested with and without irrigation in Randomized Complete Block Design with split plot arrangement in three replications. The plot size maintained was 5×3.60 m with six rows plot^{-1}. The cultivars were put in main plot and irrigation in sub-plots. Pre-sowing irrigation was applied to whole of the experimental block to obtain optimum germination in all the treatments.

Pre-planting soil sample from the depth of 0-15 cm were collected for determination of soil characteristics of the area. The soil of the site was clayey in texture and found deficient in organic matter (0.89%), P_2O_5 (2 ppm), K (100 ppm) with pH (8.2) of the site. A uniform dose of 90-60 kg NP ha^{-1} was applied to all the treatments at the time of land preparation. The crop was sown on July 18, 2004. All the cultural practices like weeding and insecticides application were kept constant. Irrigation was applied at critical stage of heading of the crop according to the plan of study. The air temperature and rainfall data recorded during the growing period of crop has given in (Table 1). On physiological maturity of the crop, samples from all the treatments were harvested and tied into bundles for drying. The sun-dried samples were threshed manually and weighing was done on electric balance to collect the grain yield data. The data recorded on yield components and grain yield was computed and analyzed through computer M-STATC programme (1988).

Table 1: Air temperature and rainfall data recorded during the growing period of crop

	Air temperature (°C)		
Month	Maximum	Minimum	Rainfall (mm)
July, 2004	28	27	46
August, 2004	36	25	43
September, 2004	36	24	50
October, 2004	30	19	Nil

Source: Arid Zone Research Institute PARC Dera Ismail Khan

RESULTS AND DISCUSSION

The data recorded on plant growth, yield components and grain yield of sorghum (Table 2) showed that irrigation at heading of the crop had significantly affected the physiological characters of the crop. The plant height (254 cm) obtained with irrigation was significantly more than the plant height (140 cm) of un-irrigated treatments. The plants of DS-97 Yarik cultivar were significantly taller (208 cm) than the plants of DS-2000 attaining plant height of 185 cm. An application of irrigation delayed the maturity of the crop. Treatment received irrigation took 115 days to physiological maturity compared to 109 days of the control treatment. The difference in days taken to maturity by the different cultivars irrespective to irrigation was non-significant.

The number of heads plot^{-1} harvested was non-significant in either case of irrigation and cultivar. However, the fresh and dry weight of heads plot^{-1} was significantly affected by the irrigation as well as cultivars. The fresh weight of heads plot^{-1} was significantly more the treatments of irrigation than un-irrigated plots. Irrigation increased the fresh weight of heads from 875 to 1197 g plot^{-1}. The data also indicated that the fresh weight of heads plot^{-1} (1125 g) obtained from cultivar DS-2000 was significantly more than the DS-97 Yarik having (947 g). Similarly, the heads dry weight (998 g) in the treatments of irrigation was significantly more than the head dry weight (756 g) of control plots. The heads dry weight (969 g) of cultivar DS-2000 was significantly more than the weight (786 g) of DS-97 Yarik. The interaction between irrigation and cultivar was non-significant in either case of study.

The data on 1000 grain weight and grain yield was also significantly affected by the application of irrigation and cultivars as depicted in (Fig. 1 and 2). The 1000 grain weight 27.7 g in the treatment of irrigation was significantly more than the grain weight (24.3 g) of un-irrigated plots. The 1000 grain weight (27.8 g) of cultivar DS-2000 was significantly more than the 1000 grain weight (24.1 g) of DS-97 Yarik. The grain yield of sorghum

Table 2: Data on the yield components and grain yield of sorghum cultivars as affected by irrigation in D.I. Khan

	Plant height (cm)			Days to maturity			No. of heads (1.8 m^2)			Head fresh weight (g)			Head dry weight (g)			1000 seed weight (g)			Grain yield (kg ha^{-1})		
Treatments	DS-97 Yarik	DS 2000	Mean	DS-97 Yarik	DS 2000	Mean	DS-97 Yarik	DS 2000	Mean	DS-97 Yarik	DS 2000	Mean	DS-97 Yarik	DS 2000	Mean	DS-97 Yarik	DS 2000	Mean	DS-97 Yarik	DS 2000	Mean
Control	156	123	140b	111	106	109b	30.3	30.0	30.2a	783	967	875b	675	897	756b	22.5	26.0	24.3b	2081	2331	2206b
Irrigated	260	247	254a	114	116	115b	29.7	29.7	29.7a	967	1111	1197a	837	1100	998a	25.7	29.6	27.7a	3019	3620	3319a
Mean	208a	185 b	--	113a	111a	--	30.0a	5.8b	--	947b	1125a	--	786b	969a	--	24.1b	27.8a	---	2550b	2976a	---
LSD	14.23	--	13.44	NS	--	0.46	NS	--	NS	131..8	--	69.34	80.27	--	47.36	0.62	--	0.45	205.94	--	239.6

Means followed by same letter (s) do not differ significantly at p = 0.05; NS = Non significant

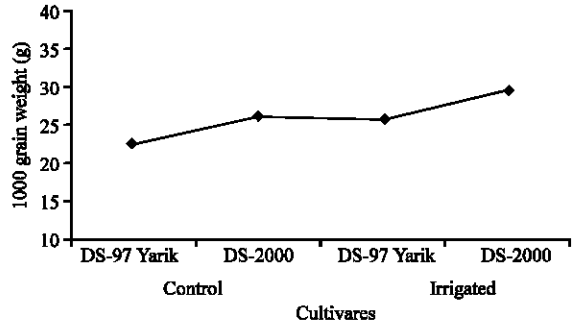

Fig. 1: One thousand grain weight of sorghum cultivars as affected by different irrigation regimes

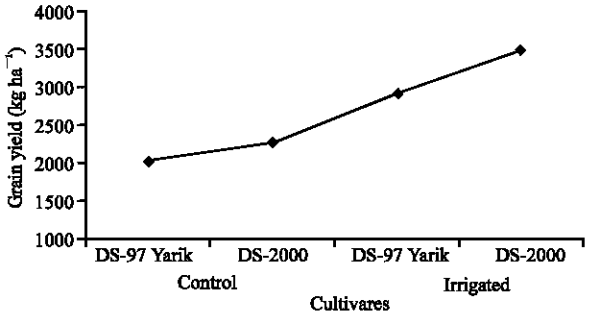

Fig. 2: Grain yield of sorghum cultivars as affected by different irrigation regimes

irrespective to cultivar was significantly increased by irrigation from 2206 to 3319 kg ha^{-1}. In terms of percentage this increase in grain yield of sorghum obtained with single application of irrigation at heading of the crop was 50% compared to un-irrigated plots. These results were in accordance with the findings of Sen (1952) and Majid and Simpson (1999). The grain yield (2976 kg ha^{-1}) of DS-2000 cultivar irrespective to irrigation was significantly higher than the grain yield (2550 kg ha^{-1}) of DS-97 Yarik.

CONCLUSION

The findings of this study suggested that in case of limited water supply, irrigation at heading stage of the crop should be applied to obtain maximum yield of sorghum in dry areas of D.I. Khan.

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