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RESPONSE OF LEAF AREA INDEX, VEGETATIVE AND REPRODUCTIVE PHASES OF TWO COTTON (*GOSSYPIUM HIRSUTUM* L.) CULTIVARS AT DIFFERENT REGIMES OF IRRIGATION SCHEDULING

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ABSTRACT. The experiment was conducted to investigate the effects of different regimes of irrigation schedule on various vegetative and reproductive stages of cotton crop. The results showed that irrigation effect was non significant for number of plants m^{-2}, while I_4 treatment produced maximum number of monopodial branches 2.18, but statistically it was at par with I_3, I_5. I_4 treatment showed maximum number of sympodial branches (20.43), followed by I_3 (18.63). F.H-900 showed statistically higher sympodial branches (18.34) than the F.H-901 (17.08). Maximum number of flowers per plant was formed in the I_4 treatment (101.00), followed by I_3 (96.31) and 1_5 (92.23). Significantly higher number of flowers and boll drops was recorded in treatment $I_{1,}$ followed by I_2. Flowers and boll drop per plant decrease with increase in irrigations applied to crop. Minimum number of flowers (60.45) and bolls (16.98) dropped per plant were in I_4 and 1_3 (65.0 and 22.72, respectively).

Key words: Growth; Bolls; Monopodial; Sympodial; Yield.

INTRODUCTION

Cotton, the ‘White gold’, plays an important role in agricultural, industrial and economic development (1.8% in GDP) of Pakistan. The area under cotton crop was 2835 thousand hectares with production of 13595 thousand bales, and average yield was 695 kg ha^{-1} during the year 2011-‘12 (GOP, 2012).

Use of irrigation water is of vital importance to crop growth under irrigated conditions. Water is an important constituent of the cell. Different physiological and metabolically functions taking place within the plant body are also controlled by the water contents of the plant. Water is essential for cell turgidity, which is related to photosynthesis, growth of cells,

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tissues and organs (Reddi and Reddi, 1995). Excess or shortage of water may affect the plant performance adversely. It is, therefore, imperative to determine suitable timing or proper stage of crop for water application. Over irrigation of cotton cal lead to excessive vegetative growth and it can also cause leaching of nutrients out of the root zone, increasing fertilizer costs and contaminating ground water supply. On the other hand, insufficient water supply can lead to moisture stress plants with a reduced number of fruiting positions, fruit loss and poor boll development, therefore optimum level of water application is most important. Any application less than this critical level decreased yields. Reducing the water application by 5% below the critical level caused about a 4.6% reduction in yield (Detar, 2008).

Shafiq (2002) reported that irrigation treatment showed a significant difference for light interception which ranged from 1683.09 MJ m^{-2} in six irrigation levels and 1503.43 MJ m^{-2} for four irrigation levels. He further reported that irrigation treatment also showed the significant effect on RUE for TDM. Mean value of RUE for TDM was 0.45 g MJ^{-1} and 0.103 g MJ^{-1} for seed cotton yield. The present study was undertaken to examine the response of vegetative and reproductive stages of two cotton cultivars under variable irrigation schedules under Faisalabad conditions.

MATERIALS AND METHODS

The experiment was laid out in a randomized complete block design (RCBD) with split plot arrangement. There were three replicates having a plot size of 1.5 m x 6 m. Experiment treatments were consisting of six levels of irrigation scheduling viz.; 1) irrigation at vegetative growth; 2) irrigation at vegetative growth + start of flowering; 3) irrigation at vegetative growth + start of flowering + start of boll formation; 4) irrigation throughout the season (control); 5) irrigation when potential soil moisture deficit (D) = 50 mm; 6) irrigation when potential soil moisture deficit (D) = 100 mm and two cotton cultivars viz. FH-900 and FH-901. The crop was sown with a single row hand drill. Nitrogen and phosphorus was applied @ 145 kg ha^{-1} and 58 kg ha^{-1} in the form of urea and diammonium phosphate, respectively. All other practices such as hoeing, weeding and plant protection, etc. were kept uniform for all the treatments.

Following data was recorded by taking sub sample of ten plants from each plot, randomly; number of monopodial branches $plant^{-1}$, number of sympodial branches $plant^{-1}$, number of flowers $plant^{-1}$, number of flowers shedded $plant^{-1}$, number of unopened bolls $plant^{-1}$, number of matured bolls $plant^{-1}$. All the weather data for the growing season of the crop was obtained from agro-meteorology Cell, Department of Crop Physiology, University of Agriculture, Faisalabad. Data recorded were statistically analyzed by using the Fisher's analysis of variance technique and least significance difference (LSD) test at 5% probability was applied to compare the significance of treatment means (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Germination count (m^{-2})

Non-significant differences were noted in germination counts recorded peer unit area. This is probably due to favorable conditions for seed germination. Moreover, the effect of irrigation treatments and cultivars could not be realized at this stage.

Leaf area index (LAI)

LAI is the main physiological determinant of crop yield. *Fig. 1* represents LAI development during the season as influenced by cultivars as well as irrigation levels. Non-significant differences were observed between cultivars at different samplings except at 118 and 149 days after sowing (DAS) with FH-900 producing more LAI than FH-901. LAI varied during the season among different irrigation regimes. Maximum value of LAI in all the treatments was recorded at 118 DAS with peak value in I_4 treatment (3.16). After that, LAI declined upto harvest and reached to values of 1.80, 1.43, 1.24, 1.00 and 0.97 in case of I_4, I_3, I_5, I_2 and I_6, respectively. Lowest value was recorded in I_1 i.e. 0.87. These results are supported by Shafiq (2002) who found that leaf area index was greater in irrigated than water stressed plants.

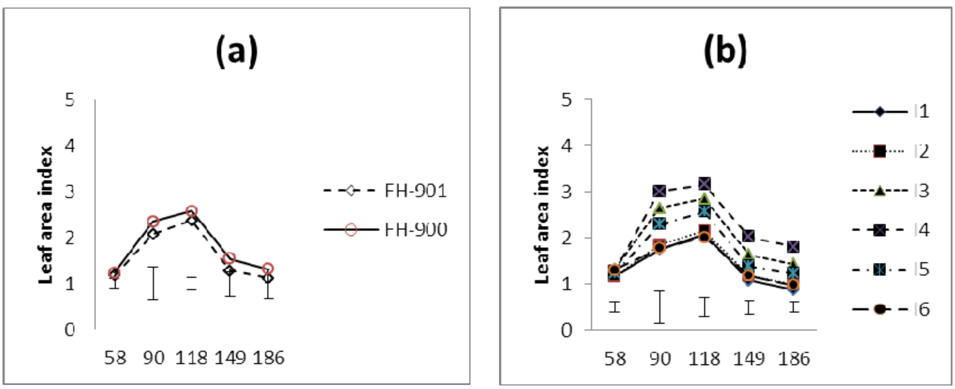

Figure 1 - Effect of different (a) cultivars and (b) irrigation levels on leaf area index; bars represent LSD at 5% level of probability.

Number of monopodial branches plant^{-1}

The data regarding number of monopodial branches plant^{-1} are given in *Table 1* The data reveals that cultivars and their interaction with irrigation levels were non-significant. Among irrigation treatment I_4 (irrigation though out the season) and I_3 (irrigation up to boll formation) produce maximum number of monopodial branches (2.18) and 1.85), respectively, but statistically these treatments were similar and significantly different from the treatments namely, I_1 (irrigation at vegetative growth), I_2 (irrigation up to flowering), I_5 (irrigation when soil moisture deficit D max = 50 mm) and I_6 (irrigation when soil moisture deficit D max = 100 mm) which were also statistically at par. These results indicate that water is essential for the growth of cotton right from its interception till maturity. These results are in line with those of El-Shahway *et al.* (1999) they reported that increasing frequencies of irrigation to cotton increased number of monopodial branches per plant.

Number of sympodial branches plant^{-1}

The higher number of sympodial branches plant^{-1} in cotton indicates the potential towards increased production of cotton. Statistical analysis of the data on number of sympodial branches plant^{-1} of two cotton cultivars as affected by different irrigation treatments are presented in *Table 1*. It is clear that varieties and irrigations significantly affected the number of sympodial branches plant^{-1} while their interaction was non-significant. FH-900 produced significantly the highest number of sympodial branches plant^{-1} (18.43) than FH-901 (17.08). Data show that the treatment I_4 (irrigation throughout the season) produced maximum number of sympodial branches plant^{-1} (20.43) followed by I_3 (irrigation up to boll formation) (18.63), I_5 (irrigation when potential soil moisture deficit D max = 50 mm), I_2 (irrigation up to flowering) (17.03) and I_6 (irrigation when soil moisture deficit D max = 100 mm) (16.23), I_1 (irrigation at vegetative growth) produced the lowest number of sympodial branches (16.20). Treatments (I_1, I_6, I_2 and I_5) were statistically similar. The results indicate that the stress of water at different plant growth stages in cotton is not helpful in obtaining greater number of sympodial branches per plant. This further reveals that normal plant growth is mainly dependent upon normal supply of water. The effect of cultivars and their interactions with irrigation levels on number of sympodial branches per plant was non-significant. These results are similar to the findings reported El-Shahway *et al.* (1999), Silva *et al.* (1999) and Soomro *et al.* (2001). They reported that irrigation at 14 days interval increase the number of sympodial branches per plant.

Number of flowers plant^{-1}

The effect of cultivars and irrigation levels on number of flowers per plant is presented in *Table 1*. It is evident that irrigation levels have a significant effect on the number of flowers per plant. The figures in this table show that I_4 (irrigation through out the season) produce highest number of flowers per plant (101.00), followed by I_3 (irrigation up to boll formation) (96.31) and I_5 (irrigation when soil moisture deficit D max = 50 mm) (92.23). Irrigation at I_1 (irrigation at vegetative growth), I_2 (irrigation up to flowering) and I_6 (irrigation when soil moisture deficit D max = 100 mm) were statistically similar having values 86.70, 87.67 and 84.83, respectively. Low number of flowers per plant was recorded in I_6

(irrigation when soil moisture deficit D max = 100 mm) treatment. The effect of cultivars and their interaction with irrigation levels was non-significant. These results are in line with Ungar *et al*. (1989) and Anace *et al*. (1999), who revealed that lowes flowering percentage (42%) in cotton resulted from sever and relatively late water stress.

Number of flowers shedded plant^{-1}

Number of flowers shedded per plant affects the number of bolls formed per plant and ultimately final yield of the plant. Data regarding flowers shedded per plant is given in *Table 1*, which clearly shows that number of flowers shedded per plant was significantly affected by irrigation treatments. The flower drop was significantly low in I_4 (irrigation throughout the season), followed by I_5 (irrigation when soil moisture deficit D max = 50 mm). The highest number of flowers shedded per plant was recorded in I_1 (irrigation at vegetative growth) (68.13). Flowers drop per plant decreased with increase in irrigation applied to the crop. The effect of cultivars and their interaction with irrigation levels was non-significant. These results are in line with those of Shah *et al*. (1999) and Shafiq (2002) that found that flower shedding increased in low irrigation treatments.

Number of unopened bolls plant^{-1}

Data regarding the number of unopened bolls per plant are given in *Table 1*. From table it is clear that irrigation treatments significantly affected this parameter. Among the irrigation treatments, it was revealed that boll drop was significantly higher in I_1 (irrigation at vegetative growth) treatment i.e. (28.72%) that was significantly at par with I_2 (irrigation upto flowering) and I_6 (irrigation when soil moisture deficit D max = 100 mm). Statistically, minimum number of unopened bolls were recorded in I_4 (irrigation throughout the season) i.e. (16.98%). The effect of cultivars and their interaction with irrigation levels on number of unopened bolls per plant was non-significant. These results are in line to the findings of Orgaz *et al*. (1991) and Shah *et al*. (1999), they reported that boll shedding increased in low irrigation treatments.

Number of bolls matured plant^{-1}

Number of bolls matured per plant is an important yield component; it contributes directly to the final seed cotton yield. Data in *Table 1* presents the number of bolls matured per plant. The analysis of data on number of bolls matured per plant indicates that I_4 c (25.53), was significantly higher than all other treatments. Lowest number of bolls matured per plant was in I_1 (irrigation at vegetative growth) treatment. Treatments (I_1, I_2 and $I_{6)}$ were statistically similar with each other. While (I_3) and (I_5) were statistically similar having values 24.33 and 23.67, respectively. The increased number of bolls matured per plant in I_4 treatment may be attributed to essentially meeting the water requirement of crop at all stages. The effect of cultivars on the number of bolls matured per plant was non-significant. These results are supported by the findings Orgaz *et al* (1991) and Soomro *et al*. (2001), Zwart and Bastiaanssen, (2004), they found that the final number of bolls was inversely to the amount of water applied.

Table 1 - Effect of cultivars and irrigation schedules on vegetative and reproductive stages of cotton crop

Treatments	Number of monopodial branches plant $^{-1}$	Number of sympodial branches plant $^{-1}$	Number of flowers plant $^{-1}$	Number of flowers shedded plant^{-1}	Number of unopened bolls plant^{-1}	Number of matured bolls plant^{-1}
Cultivars						
V1=F.H.901	1.44	17.08 b	92.96	64.53	23.2	23.14
V2= F.H.900	1.62	18.34 a	89.96	65.38	25.07	23.62
LSD 5 %	0.47	0.87	5.67	3.01	4.08	0.54
Significance	NS	*	NS	NS	NS	NS
Irrigation schedule						
I_1	1.27 b	16.20 d	86.70 d	68.13 a	28.72 a	21.73 c
I_2	1.40 b	17.03 c	87.67 d	67.27 ab	26.30 ab	22.60 c
I_3	1.85 a	18.63 b	96.31 b	65.00 bc	22.72 c	24.33 b
I_4	2.18 a	20.43 a	101.00 a	60.45 d	16.98 d	25.53 a
I_5	1.30 b	17.73 c	92.23 c	63.67 c	23.76 bc	23.67 b
I_6	1.17 b	16.23 d	84.83 d	65.23 bc	26.36 ab	22.10 c
LSD 5 %	0.39	0.77	3.88	2.32	2.85	1.04
Significance	**	**	**	**	**	**
Interaction	NS	NS	NS	NS	NS	NS
Mean	1.53	17.71	91.46	64.96	24.14	23.38

Means having different letters differ significantly from each other by LSD (P = 0.05).
*, ** = significant, highly significant. NS = Non significant
I_1= irrigation at vegetative growth;
I_2= irrigation at vegetative + start of flowering;
I_3= irrigation at vegetative + flowering + start of boll formation;
I_4= irrigation throughout the season (control);
I_5 =irrigation when potential soil moisture deficit (D) = 50 mm;
I_6= irrigation when potential soil moisture deficit (D) = 100 mm.

CONCLUSIONS

The general conclusion for this study is that the seed cotton yield among various treatments was related to their photosynthetic activity. The improvement to seed cotton yield through changes in LAI may perhaps contribute in this regard. LAI decreased from September 25 harvest onward throughout the whole period of growth. The data suggest that there is considerable scope to exploit the yield potential of cotton with different management practices, depending upon the prevailing climatic conditions. It may also be concluded that six irrigations (irrigation through out the season) are the most suitable for obtaining the higher seed cotton yield under the agro-ecological conditions of Faisalabad, Pakistan.

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