Research Article

Effect of Irrigation Intervals on the Yield and Fibre Characteristics of Cotton Genotypes

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Abstract | Cotton is a life line of Pakistan's economy. Drought stress is the major ecological factor that negatively impacts cotton yield and quality. A field experiment was conducted in 2016 at Cotton Research Station, Dera Ismail Khan, Pakistan to evaluate the effects of four moisture regimes on yield and fiber characteristics of two cotton genotypes. The experiment was laid out in split-plot within a randomized complete block design with three replications. Four irrigation intervals namely I_1 (10 days interval), I_2 (15 days interval), I_3 (20 days interval) and I_4 (25 days interval) were allotted to main plots while cotton genotypes (CIM-602 and CIM-616) were assigned to subplots having 10 m×3 m. Results revealed that cotton crop irrigated at 20 days interval showed greater bolls per plant; weight per boll; seed cotton yield and ginning out-turn (GOT %). The results further showed that the genotype CIM-602 gave optimum yield owing bolls per plant, weight per boll, GOT % plus higher staple length compared to CIM-616 at 20 days irrigation interval. Thus it was concluded that the genotype-CIM-602 irrigated at 20 days interval suited well to the study area and had the potential to optimize cotton yield and quality in Dera Ismail Khan, Pakistan.

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Introduction

Cotton (*Gossypium hirsutum* L.) plays a significant role in the economy of Pakistan (Ibrahim et al., 2007). It provides raw materials to the textile industry. It is called silver fiber, due to its unique fiber quality (Arshad and Anwar, 2007). Cotton is used for several products ranging from clothes to home furnishings and medical products. So, cotton is continuously in demand due to its diversified usages and is connected to the powers and weaknesses of the overall economy of Pakistan. Worldwide, Pakistan is the fifth largest producer but fourth largest consumer of cotton however, the largest exporter of cotton yarn (APTMA, 2015). In Pakistan, cotton area is about 3.20 million hectares having 2.15 million tons production (PCCC, 2015). Cotton contribution to GDP was 1.5%, 60 % to foreign exchange and 7.0 % to agriculture (Government of Pakistan, 2016). Low yield of cotton can be attributed to man factors such as use of low quality seed resulting in poor germination, low seed rate, low plant population, poor management practices, conventional sowing methods, insect pests attack, improper nutrition, water stress and use of inferior cotton genotypes. It indicated a vast scope for increasing the average seed cotton yield taking care for yield constraints. It requires maximum use the available agricultural and agronomic resources for greater benefits. Irrigation intervals management for different cotton genotypes are of vital importance in this regard. Optimum irrigation plays key role in yield potential; similarly, suitable genotype for a region is essential for optimum growth and development. For enhancing cotton yield in Pakistan, it is needed to study different cotton varieties under different environment for better use of sources accessible for successful crop production (McAlavy, 2004).Cotton production is fully dependent upon the accessibility of irrigation water either from canal or tube well. Irrigation water applied less or more than optimum badly affects cotton yield (Howell, 2001; Deng et al., 2004). Proper irrigation scheduling is essentially required which saves water and energy, boosts up cotton yield and quality. It is therefore, vital to decide appropriate time and amount of irrigation water. Irrigation of cotton crop affected canopy development water use efficiency (Bhattarai, 2005). Proper water management and enhanced water use is a probable selection standard for increasing cotton yield under water stress. Cotton crop wanted less amount of moisture per hectare than other crops (Hearn, 2000). Proficient use of irrigation saves rain and canal water as well. Efficient use of water to cotton is an important thought, because, rainfall is not sufficient for the crop (Ertek et al., 2001). Additionally, recent increases in energy prices have attracted attention of crop producers asking how to manage inputs to maximize efficiency of their water resources (Varlev et al., 2000). To benefit from irrigation scheduling we must have an efficient irrigation system. The prime consideration with reference to water need for the crop is to decide the time and amount of irrigation. Irrigation water, applied less or more than the optimum requirement of cotton crop, adversely affects the cotton yield. Water balance irrigation scheduling is the day-to-day accounting of the amounts of water coming into and going out of the effective root zone of a crop. It is based on estimating the soil water content in the crop root zone viewed as a system (Harris, 2005).

Keeping in view the importance of efficient use of irrigation water by proper scheduling for cotton production, the present study was carried out to investigate the effect of number of irrigations on the yield and fiber characteristics of cotton genotypes.

Materials and Methods

Experimental site, soil and climate

Research trial was conducted at Cotton Research Station, Dera Ismail Khan (31°49´N, 70°55´E, 165m above sea level), Pakistan. The site is comparatively flat with dominant clay characteristics. It is an arid to semi-arid region having limited rain fall (about 200 mm mean annual rainfall) which is not enough for growing crops. Experimental site is hyperthermic, and typic Torrifluvents (SSS, 2009).The detail physico-chemical Characteristics are given in Table 1. Weather data was monitored on Meteorological Station located near Cotton Research Station. Detailed air temperature and rainfall were presented in Table 2.

Table 1: *Physico-chemical properties of the experimental soil.*

Characteristics	Values
Sand	151 g kg^{-1}
Silt	450 g kg^{-1}
Clay	400 g kg^{-1}
Electrical conductivity (EC)	2.66 dSm^{-1}
Soil pH (1:1)	7.80
Organic Matter	0.89 %
NO_3-N	5.52 mg kg^{-1}
Available K (mg kg^{-1})	190 mg kg^{-1} soil
AB-DTPA extractable P	7.8 mg kg^{-1} soil
Total N	0.99 g kg^{-1} soil

Table 2: *Average air temperature and rainfall at Cotton Research Station, Dera Ismail Khan during 2016 growing season.*

Months	2016			
	Temperature ^{0}C			
	Max	Mini	Mean	Rainfall (mm)
April	38	6	22	-
May	45	7	26	17
June	45	12	29	6.0
July	45	18	32	126
August	41	20	31	43
Sept.	40	18	29	40.0
October	36	18	27	-
Nov.	31	10	21	-

Experimental procedure

The experiment was conducted in RCBD with split plot having three replications. Four moisture regimes namely I_1 (irrigation at10 days interval), I_2 (irrigation at 15 days interval), I_3 (irrigation at 20 days interval) and I_4 (irrigation at 25 days interval) were assigned to main plots while two cotton genotypes namely, CIM-602 and CIM-616 were included in subplots. Each subplot consisted of four rows of 10 m length and 0.75 m intra-row width. Genotypes selected for this research study were all Bt. transgenic improved cotton varieties. All subplots were treated equally regarding seed bed preparation, sowing method, insect/pests

Table 3: *Mean square values of boll number, weight per boll, seed cotton yield, ginning out turn and fibre length as affected by Irrigation intervals and genotypes.*

S.V	D.F	Bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	Ginning out-turn (%)	Fiber length (mm)
Replication	2	13.042	0.00218	81413	1.9781	0.03792
Irrigation intervals (I)	3	67.042**	0.28923**	649010**	19.5735**	0.00375^{ns}
Error a	6	4.375	0.01037	20849	0.6627	0.04292
Genotypes (G)	1	117.042**	0.10140**	628884**	16.0067**	0.51042*
I x G	3	6.042*	0.00237^{ns}	104883*	0.0393^{ns}	0.11375^{ns}
Error b	8	0.792	0.00280	11923	0.9660	0.04917

control and fertilization. The land was prepared with disk plough followed by tiller, rotavator and then bed furrows were made. The field was then leveled and divided into eight sub plots. Cotton seed were treated with Sulfuric Acid (1kg H_2SO_4 per10 kg cotton seed). Delinted cotton seed were dibbled manually on bed furrows. Cotton seeds were sown on May 4 and 1st irrigation was given 10 days after sowing. Thinning was done 20 days after sowing in the respective treatments. Nitrogen and phosphorus were applied as TSP and urea at 60 and 150 kg.ha^{-1}, respectively. All phosphorus was applied at sowing, while N was given in three splits namely 1/3rd at sowing, at flowing and at boll formation stage. Post emergence herbicide, Haloxyfop-R-methyl was sprayed to control weeds. Seed cotton was picked in the 2nd week of November. All cultural and protection practices were equally used.

Procedure for data recording

Data were recorded on bolls per plant^{-1}, weight per boll (g), yield of seed cotton (kg ha^{-1}), ginning out-turn (GOT %), fibre length (mm). Five representative plants were tagged in each treatment for the purpose of recording data. Boll number was recorded by counting bolls of five representative plants and converted to average number of bolls plant^{-1}. For recording boll weight, 50 bolls were randomly selected from already tagged plants in each plot. Total bolls weight was divided by 50 and mean boll weight was recorded in gram. Seed cotton yield was recorded by harvesting central 2 rows of each plot manually. Seed cotton samples were sundried and cleaned by removing inert matter from the samples. After drying and cleaning they were weighed and ginned separately by using electric ginning machine. GOT is the ratio of the lint weight to the total seed cotton weight. The lint of each sample was weighed and ginning out turn (GOT) was calculated by applying formula, GOT (%) = (lint yield/ seed cotton yield)*100 (Xian et al., 2014). For fiber length, representative samples of cotton lint were taken from each plot and mean length was obtained by using high volume instrument (HVI) system in Central Cotton Research Institute, Multan, Pakistan.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using a split-plot within a randomized complete block design accordance to procedures outlined by Steel and Torrie (1997). Least significant difference tests were applied where data were found statistically significant according to MSTATC software.

Results and Discussion

Bolls plant^{-1}

Bolls is the prime yield contributing element of cotton yield. Bolls per plant significantly respond to irrigation intervals, genotypes and their interaction (Table 3). Interaction results indicated that genotype-CIM-602 irrigated at 20 days interval produced maximum number bolls plant^{-1} (Figure 1).Too short (10 days) or long (25 days) irrigation intervals resulted in lower number of bolls for all genotypes. In longer irrigation interval, flowering coincided with high moisture stress that probably resulted in abortion of flowers and young bolls and thus there were lower boll retention per plant as reported by some researchers (Rajput, 2006; Onder et al., 2009). The flower initiation was also affected by less or more number of irrigation intervals. Improper irrigation water encouraged vegetative growth resulted in declined flowering (Onder et al., 2009). These results in agreement with that of (Ertek et al., 2001) who concluded that sufficient interval of irrigation to cotton produced more bolls per plant. The genotype CIM-602 is of bushy type, maintained 2-3 monopodia and more number of sympodia,

Table 4: *Boll number, boll weight, seed cotton yield, ginning out turn and fibre length as affected by irrigation intervals and genotypes.*

Irrigation intervals	Bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	GOT %	Fibre length (mm)
I1= 10 days interval	16.17 c	2.54 c	1773.5 c	36.59 bc	28.62
I2= 15 days interval	19.83 b	2.77 b	2206.0 b	37.61 b	28.65
I3= 20 days interval	24.17 a	2.98 a	2568.5 a	40.02 a	28.60
I4 = 25 days interval	18.67 bc	2.51 c	2081.5 b	35.91 c	28.65
LSD $_{0.05}$	2.96	0.1439	203.99	1.1501	NS
Genotypes (G)					
CIM-602	21.92 a	2.76 a	2319 a	38.35 a	28.78 a
CIM-616	17.50 b	2.63 b	1996 b	36.72 b	28.48 b
LSD $_{0.05}$	0.84	0.0498	102.80	0.9253	0.2087

Note: *Means followed by similar letters do not differ significantly at 5% level of probability;* **NS:** *Non-significant.*

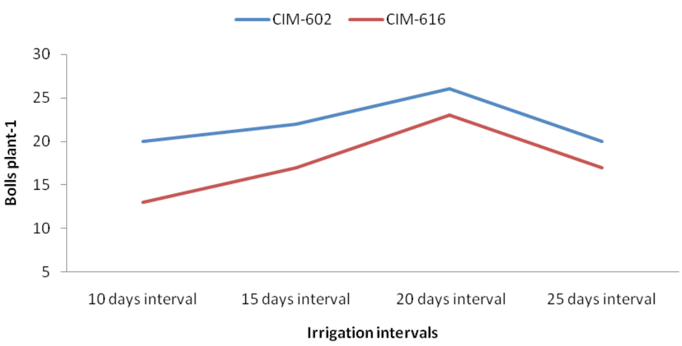

Figure 1: *Interactive effects of irrigation intervals and genotypes on bolls plant^{-1}.*

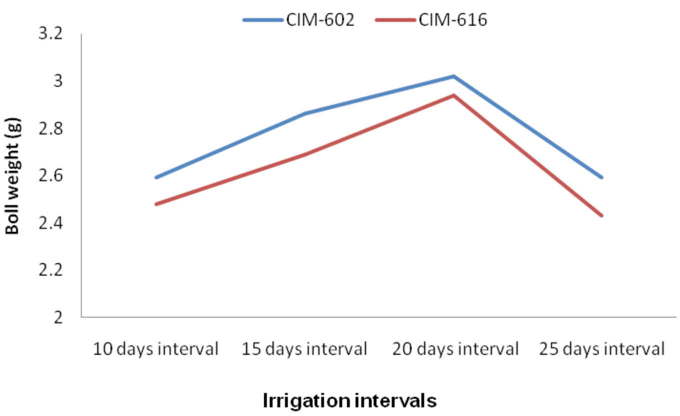

Figure 2: *Interactive effects of irrigation intervals and genotypes on boll weight (g).*

producing maximum number of bolls per plant under less frequencies of irrigation. Bolonhezi et al., (2000) reported analogous results who reported that different cotton cultivars were different in number of bolls due to differences in irrigation intervals.

Boll weight (g)

Weight per boll was influenced significantly by irrigation intervals and genotypes, however, interaction effects of irrigation intervals and genotypes were not significant. (Table 3). Heaviest boll weight was recorded in I_3 (irrigation at 20 days interval) compared to other irrigation intervals (Table 4). Contrary to this shorter irrigation interval had lower boll weight probably due to more attacks of insect pests. Moreover, crop at shorter irrigation interval is more prone to insect pests and diseases attack due to vigorous cotton plant growth. On the other hand, flowerings in too longer interval coincided with high moisture stress that also adversely affected boll growth and development (Yazar et al., 2002; Naveed, 2003). Among genotypes, CIM-602 produced highest boll weight. Our results are in line with those of (Wang et al., 2004) who stated that irrigation regimes significantly affected boll weight of different cotton cultivars.

Seed cotton yield (kg ha^{-1})

Seed cotton yield had significant response to irrigation intervals, genotypes and irrigations × genotypes interactions (Table 3). Interaction effects showed that CIM-602 produced highest seed cotton yield when irrigated at 20 days interval (Figure 3). The cotton yield was low in shorter irrigation interval, probably the more vegetative growth that resulted in lower seed cotton yield (El-Shahawy and Abd-El-Malik, 2005; Singh et al., 2010). Regarding the excess of water, several studies such as Wanjura et al. (2002) and Karam et al. (2006) showed that cotton productivity can be reduced due to water excess. Higher seed cotton yield may be ascribed of higher bolls and boll wt. Optimum irrigation intervals probably improved root growth and consequent nutrient and water uptake, resulted in higher seed cotton yield (Ertek et al., 2001). The results indicate that there were significant variations among cultivars for seed cotton yield under different irrigation intervals as also reported by Rajput, (2006).

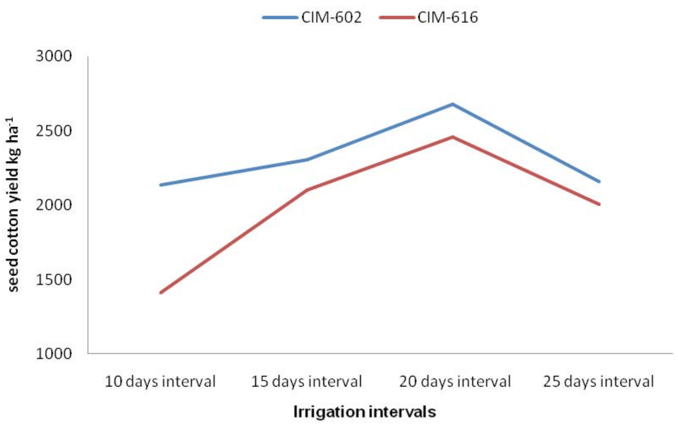

Figure 3: *Interactive effects of irrigation intervals and genotypes on seed cotton yield (kg ha^{-1}).*

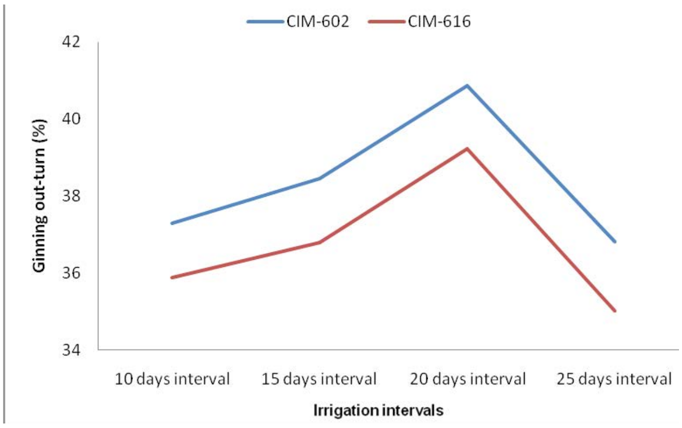

Figure 4: *Interactive effects of irrigation intervals and genotypes on ginning out turn (%).*

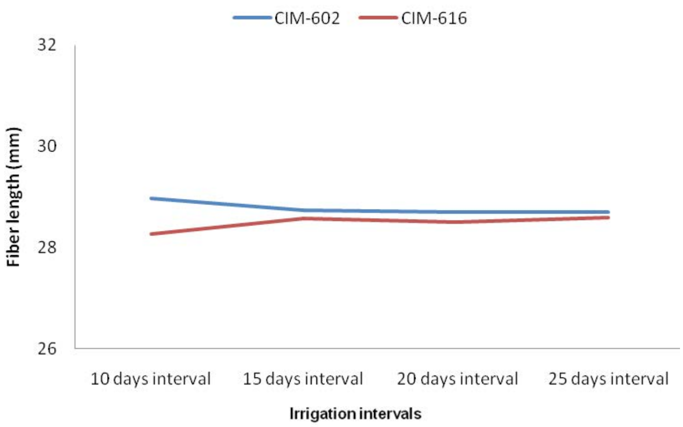

Figure 5: *Interactive effects of irrigation intervals and genotypes on fibre length (mm).*

Ginning out-turn (GOT %)

GOT had significant response to irrigation intervals and genotypes while their interactions were not significant (Table 3). Mean values for irrigation intervals revealed that GOT was highest when crop received irrigation at 20 days interval (I_3) (Table 4). All other irrigation intervals had lower values of GOT. CIM-602 gave highest GOT among the genotypes. The results suggested that $I_3$was higher yielding than I_4 or I_1 and I_2. Karam et al. (2006) reported that every fortnight delay in irrigation beyond I_3 resulted in a significant decrease in GOT /lint yield. Increased GOT might be associated with the physiological response to the culture under higher irrigation water (Cetin and Bilgel et al., 2002). In case of irrigation interval at 20 days the higher the water availability in the soil the greater the ability of the roots to absorb nutrients and the photosynthetic efficiency of the leaves. In case of irrigation interval at 20 days optimum water supply and higher nutrients absorption, contributed towards boll growth and boll filling that probably resulted in higher lint yield as confirmed by Rajput et al. (2006).

Fiber length (mm)

Fiber length showed significant response to genotypes, however, irrigation intervals and their interactions were not significant (Table 3). CIM-602 had higher fiber length during the growing season (Table 4). These results are in line with those of (El-Shahawy and Abd-El-Malik, 2005; Ashokkumar and Ravikesavan, 2011) who concluded that staple length was not influenced by irrigation frequencies, and this character is probably associated with the genetic makeup of a variety.

Conclusions

This study comprised of four irrigation intervals (10, 15, 20 and 25 days intervals) and two genotypes (CIM-602 and CIM-616). In conclusion, results of this study suggest that higher cotton yield and quality can be attained, under Dera Ismail Khan, Pakistan conditions, when cotton genotype CIM-602 is planted with 20 days irrigation interval.

Author's Contribution

Najeeb Ullah: As a principal author conducted the research
Abdul Aziz Khakwani: Supervised the study and provided technical input at every step
Niamat Ullah Khan: revised the manuscript
Muhammad Safdar Baloch: Analysed the lab work
Ejaz Ahmad Khan: Assisted in prepration of final draft.

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