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ASSESSMENT OF DROUGHT TOLERANT COTTON GENOTYPES THROUGH IRRIGATION INTERVALS

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ABSTRACT

The current research was conducted at the experimental field of Central Cotton Research Institute Sakrand during the cotton season 2018-19. Twelve genotypes were screened out under normal (15 days intervals), moderate (21 days intervals) and severe (29 days intervals) water stress conditions. Nevertheless, the significant difference was perceived in cotton genotypes at different irrigation intervals. The varieties, treatments and their interaction were also found significant for various traits under studied. It was noted that water stress condition caused substantial reduction in seed cotton yield and its contributing traits. Amongst the genotypes, CRIS-613 performed outstanding at all three treatments normal, moderate stress and in water deficit conditions and given higher seed cotton yield, while minimum shedding of fruiting structure. Thus it is suggested that CRIS-613 is drought tolerant variety and could be utilized in water deficit areas as well as cotton breeders may use the variety for breeding program to develop drought tolerant material. However, CRIS-552 and CRIS-533 also performed well under water stress conditions and given good yield, hence these genotypes also recommended for sowing in areas of drought condition.

Keywords: water deficit, drought, stress, a-biotic factors, irrigation interval, cotton

INTRODUCTION

Cotton is an ancient fiber crop of Pakistan and provides raw material to textile sector. Pakistan is 5th largest cotton producing country, 3rd biggest consumer worldwide. The area under cotton cultivated in Pakistan during year 2019-20 were 2.895 million hectares with the production of 12.72 million bales (Cotton Review, 2020). The yield of this crop is decreased since many years due to various factors, but abiotic factors effects particularly drought has significant effect on cotton production. Understanding crop response to water deficit is principal stage for breeding genotypes with improved drought tolerance (Joshi *et al.,* 2016). Cotton is now become challenging crop due to abiotic and biotic factors, which cause decline in yield (Choudhary *et al.,* 2017 and Nachimuthu *et al.,* 2017). Water deficit is critical issue in current scenario. The water stress affects depend on the harshness and length of the stresses, the growth and development stages at which water stress is imposed, and on plant genotype. Cotton crop shows higher tolerance to abiotic stresses than the other crops. Though, extreme environmental circumstances like drought affect cotton growth and development, its production, and fiber quality ultimately disturbs the whole equilibrium. In this relation to screen out and evolve the drought tolerant strains of the cotton crop is a challenging task for the cotton scientists. Karademir *et al.* (2011) and Jayalalitha *et al.* (2015) found that due to water stress the seed cotton yield could be reduced. Grimes *et al.* (1969), Gerik *et al.* (1996) and Wang *et al.* (2016) reported different response of cotton varieties at various irrigation levels.

MATERIAL AND METHODS

The present research was conducted to screen out drought tolerant cotton genotypes sown under different drought conditions during the year 2018-19 at experimental field of Central Cotton Research Institute, Sakrand. The layout of the experiment was split plot design with three replications. The water stresses were kept as main plot and genotypes as sub-plots. Three water stresses i.e., severe stress (29 days interval), moderate stress (21 days interval) and no stress (15 days interval), and twelve genotypes (CRIS-5A, CRIS-9, CRIS-129, CRIS-134, CRIS-342, CRIS-467, Bt.CRIS-508, CRIS-510, CRIS-533, CRIS-543, CRIS-552 and CRIS-613) were tested in this trial.

One bag of di-ammonium phosphate (DAP) fertilizer.acre^{-1} applied before sowing during the ridge making and three bags of nitrogenous (N) fertilizer (Urea) acre^{-1} were also applied in four split doses according to the growth and development. Cultural practices (weeding and inter-culturing) and timely plant protection measures were made as needed by the crop. The crop was irrigated according to the schedule. Plant height (cm), bolls and shedding fruiting parts plant^{-1} (buds, flowers and bolls) at different days after sowing were taken. At the maturity, the data

regarding boll weight (g), seed index (g) and seed cotton yield (Kg ha^{-1}) were also noted. The data was analyzed as ANOVA (analysis of variance) suggested by Gomez and Gomez (1984) by using factorial model and L.S.D at 5% and L.S.D at 1% probability was used to compare the means and calculated with statistical software Statistix-8.1. For analysis of variance and means were separated using Fisher's protected least significant difference (LSD) and the comparison of means were tested by Duncan Multiple Range Test (DRMT) at 5% and 1% using least significant difference (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The data presented in Table-1 mean square values for yield and its contributing traits, which indicated that the varieties (V) were highly significant at 5% and 1% probability for all the characters studied and suggested sufficient genetic diversity among the genotypes. Nevertheless, the significant difference was perceived in cotton genotypes at different irrigation intervals. The treatments (T) also found highly significant for plant height (cm), sympodial branches, bolls, shedding of fruiting $plant^{-1}$ and seed cotton yield, it suggested that irrigation intervals have positive effect on these traits. The treatments showed non-significant boll weight and seed index. However, the interaction of varieties (V) with treatments (T) was found significant for bolls $plant^{-1}$, seed index, shedding fruiting parts and seed cotton yield $acre^{-1}$. Whereas, non-significant plant height, sympodial branches and boll weight. It was noted that varieties have performed well in all the treatments. Similar findings documented by Bakhsh *et al.* (2019), Ullah *et al.* (2018) and Veesar *et al.* (2018) about significant variation of genotypes and irrigation innervations.

The performance of cotton genotypes as given in Table 2 indicated that at normal conditions in treatment-1(T1) when eight irrigations were applied with 15 days interval, the genotype CRIS-467 height was higher as compared with others and CRIS-342 formed maximum sympodial branches $plant^{-1}$. As regards with yield and its contributing traits, CRIS-613 performed well and formed maximum bolls $plant^{-1}$, given big boll and produced maximum seed cotton yield $acre^{-1}$. Whereas, the CRIS-552 was also second best genotypes which formed maximum bolls $plant^{-1}$ and given higher seed cotton yield $acre^{-1}$ as compared to other cotton genotypes. As regards with shedding fruiting parts $plant^{-1}$ (square, flower and bolls), the maximum shedding was noted in CRIS-467 which dropped maximum fruiting numbers viz. squares, flowers and bolls in normal conditions. While, minimum shedding fruiting parts were recorded in CRIS-613 that result of more number of boll formed and achieved maximum seed cotton yield. It is suggested that these two varieties CRIS-613 and CRIS-552 could prefer for sowing at normal conditions, where availability of proper irrigation. The results are in accord with Pettigrew (2004), Ullah *et al.* (2018), Veesar *et al.* (2018) and Bakhsh *et al.* (2019) who also reported that genotypes could perform better at optimum irrigations level.

Table 1. Analysis of Variance (ANOVA) mean square values for various traits of cotton.

Source of Variation	D.F	Plant Height (cm)	Sympodial Branches $Plant^{-1}$	Bolls $Plant^{-1}$	Boll Weight (g)	Seed Index (g)	Shedding fruiting $Plant^{-1}$	Seed cotton Yield (Kg $acre^{-1}$)
Replication (R)	2	2073.81	82.74	6.32	0.01	1.14	2303.74	3906
Varieties (V)	11	1251.29**	50.04**	213.31**	0.57**	1.49**	1298.23**	100185**
Error R x V	22	61.27	2.43	18.45	0.08	0.25	118.78	4912
Treatments (T)	2	612.45**	24.71**	1001.49**	0.01^{ns}	0.01^{ns}	1427.66**	243090**
V x T	22	61.71^{ns}	0.85^{ns}	28.13**	0.10^{ns}	0.62**	63.03**	12768**
Error R x V x T	48	21.71	2.38	28.46	0.06	0.17	117.25	9656
CV% (R x V)		6.14	6.12	10.25	11.58	6.34	12.01	7.23
CV% (R x V x T)		6.05	6.05	12.73	9.84	5.26	11.93	10.13

Similar letters are non-significant in each column according to Duncan Multiple Range Test at $p < 0.05$.

The data presented in Table 3 which exhibited average performance of varieties in in moderate stress treatment-2 (T2) when six irrigations were applied with 21 days interval, there was gradually reduction was observed in characters at moderate stress. The higher vegetative growth (plant height and sympodial branches) was recorded in CRIS-467 followed by CRIS-552. While lower height and less sympodial branches were recorded in CRIS-533. The maximum number of bolls $plant^{-1}$ was formed by CRIS-613 in moderate stress conditions. While minimum shedding of fruiting parts viz. squares, flowers and bolls was also counted in CRIS-613. Therefore, it was noted that in moderate stress conditions CRIS-613 dropped less fruiting parts and formed more number of bolls $plant^{-1}$.The CRIS-342 also formed 2nd higher number of bolls but also was top in shedding fruiting parts. The bigger boll was weight in CRIS-613 as compared with other varieties and maximum seed index was given by CRIS-510. The seed cotton

yield depends upon with the dual contribution of other traits bolls plant^{-1} and boll weight. The utmost seed cotton yield was also given by CRIS-613 due to higher number of boll formation and bigger boll weight. The CRIS-552 and CRIS-533 also performed better moderate stress and given higher seed cotton yield as compared with remaining varieties. Mert (2005) and Basal *et al.* (2009) reported similar findings that irrigation stresses reduced seed cotton yield, boll weight (g) and bolls plant^{-1}. Soomro *et al.* (2011) documented that genotypes performance is differ in optimum and under irrigation stress condition.

Table 2. Mean performance of varieties at T_1=8 Irrigations (15 days interval) normal condition.

Varieties	Plant Height (cm)	Sympodial Branches Plant^{-1}	Bolls Plant^{-1}	Shedding fruiting Plant^{-1}	Boll Weight (g)	Seed Index (g)	Seed cotton Yield (Kg acre^{-1})
CRIS-5A	141.3^{b}	27.8^{b-e}	37.0^{h}	96.3^{abc}	2.4^{b-e}	5.2^{d}	943^{ef}
CRIS-9	136.7^{bc}	27.3^{de}	37.5^{gh}	86.0^{cd}	2.6^{bcd}	7.2^{abc}	1016de
CRIS-129	118.4^{ef}	26.8^{de}	42.9^{ef}	85.4^{cd}	2.6^{bcd}	7.7^{abc}	1289^{b}
CRIS-134	137.3^{bc}	27.4^{de}	42.3^{ef}	89.3^{bcd}	2.3^{cde}	7.5^{abc}	1116^{cd}
CRIS-342	124.9^{def}	30.5^{a}	53.8^{b}	98.8^{ab}	2.2^{de}	6.9^{bc}	1089^{cd}
CRIS-467	157.3^{a}	29.9^{ab}	46.2^{de}	102.5^{a}	2.5^{bcd}	6.7^{bc}	843^{f}
CRIS-508	138.9^{bc}	27.7^{cde}	41.5^{fg}	86.8^{cd}	2.0^{e}	7.0^{bc}	943^{ef}
CRIS-510	119.9^{ef}	29.6^{abc}	52.1^{bc}	68.5^{ef}	2.8^{ab}	8.1^{ab}	1058^{cde}
CRIS-533	114.5^{f}	24.3^{f}	52.1^{bc}	60.7^{fg}	2.3^{cde}	6.5^{cd}	1168^{bc}
CRIS-543	127.8^{cde}	25.9^{ef}	48.0^{cd}	77.9^{de}	2.7^{bc}	7.0^{bc}	871^{f}
CRIS-552	128.3^{cde}	28.8^{a-d}	54.6^{b}	84.4^{d}	2.3^{cde}	7.3^{abc}	1261^{b}
CRIS-613	133.2^{bcd}	27.7^{cde}	59.2^{a}	54.1^{g}	3.2^{a}	8.5^{a}	1434^{a}
CD 5%	11.65	2.30	4.05	11.56	0.48	1.46	132.80
CD 1%	15.43	3.11	5.50	15.84	0.66	1.99	180.50
CV %	5.23	4.87	5.05	8.33	11.59	12.14	7.22

Similar letters are non-significant in each column according to Duncan Multiple Range Test at $p < 0.05$.

Table 3. Mean performance of varieties at T_2=6 Irrigations (21 days interval) moderate stress.

Varieties	Plant Height (cm)	Sympodial Branches Plant^{-1}	Bolls Plant^{-1}	Shedding fruiting Plant^{-1}	Boll Weight (g)	Seed Index (g)	Seed cotton Yield (Kg acre^{-1})
CRIS-5A	136.4^{bc}	26.3^{ab}	41.1^{bcd}	98.3^{bc}	2.8^{ab}	7.6^{abc}	944^{cd}
CRIS-9	132.6^{bcd}	26.0^{ab}	35.0^{e}	95.7^{bc}	2.8^{ab}	6.0^{def}	799^{ef}
CRIS-129	116.7^{ef}	25.1^{bc}	36.5^{de}	94.1^{cd}	2.5^{abc}	7.8^{abc}	1089^{b}
CRIS-134	125.3^{c-f}	26.1^{ab}	40.0^{cde}	97.0^{bc}	2.3^{bc}	5.8^{ef}	871^{def}
CRIS-342	120.3^{def}	27.7^{ab}	46.1^{ab}	111.9^{a}	2.3^{bc}	5.9^{def}	944^{cd}
CRIS-467	154.3^{a}	28.5^{a}	44.0^{abc}	103.3^{b}	2.8^{ab}	7.2^{a-d}	1016^{bc}
CRIS-508	141.5^{ab}	26.5^{ab}	38.9^{cde}	86.1^{de}	2.0^{c}	5.4^{f}	798^{f}
CRIS-510	114.1^{ef}	27.5^{ab}	44.5^{abc}	77.7^{f}	2.7^{ab}	8.5^{a}	943^{cde}
CRIS-533	111.5^{f}	22.7^{c}	39.1^{cde}	78.7^{ef}	1.9^{c}	6.6^{c-f}	1119^{b}
CRIS-543	139.7^{abc}	28.3^{a}	41.2^{bcd}	79.1^{ef}	2.8^{ab}	6.9^{b-e}	943^{cde}
CRIS-552	127.6^{b-e}	27.9^{ab}	44.5^{abc}	92.9^{cd}	2.5^{abc}	8.2^{ab}	1123^{b}
CRIS-613	128.4^{b-e}	26.7^{ab}	49.9^{a}	71.3^{f}	3.1^{a}	8.4^{a}	1371^{a}
CD 5%	14.62	2.87	5.93	8.01	0.64	1.31	144.41
CD 1%	19.88	3.91	8.06	10.87	0.88	1.78	196.28
CV %	6.69	6.39	8.39	5.22	15.07	11.07	8.56

Similar letters are non-significant in each column according to Duncan Multiple Range Test at $p < 0.05$.

Significant reduction was observed in various plant characters under water deficit conditions at treatment-3, when only four irrigations were applied with 29 days of interval (Table 4). Higher vegetative growth, height and sympodial branches was observed in CRIS-467 and CRIS-508 under water deficit conditions. While, these genotypes formed less bolls with higher shedding of fruiting parts, ultimately lowering seed cotton yield. The higher number of bolls, boll weight, seed index and maximum seed cotton yield was found in genotype CRIS-613 which

performed outstandingly under water deficit conditions when four irrigations were applied at 29 days interval. It was also noted that due to less irrigations, minimum fruiting parts were dropped by CRIS-613 and proved as drought tolerant variety as compared with other genotypes. The CRIS-552 and CRIS-533 were also found good varieties under water deficit conditions with 2nd higher yielding varieties. Above results were comparable with Bakhsh *et al.* (2018) and Veesar *et al.* (2018) that the reduction in traits take place under water deficit conditions. Gwathemy *et al.* (2011) documented that water stress increases shedding of buds and flowers and boll retention. Iqbal *et al.* (2010), *Baloch et al. (2011)* and Niu *et al.* (2013) who reported that water deficit tolerance varied with genotypes.

Table 4. Mean performance of varieties at T_3=4 Irrigations (29 days interval) water deficit.

Varieties	Plant Height (cm)	Sympodial Branches Plant^{-1}	Bolls Plant^{-1}	Shedding fruiting Plant^{-1}	Boll Weight (g)	Seed Index (g)	Seed cotton Yield (Kg acre^{-1})
CRIS-5A	125.3^{b-e}	25.0^{cd}	28.5^{f}	104.1^{bc}	2.5^{cde}	7.3^{bc}	799^{d}
CRIS-9	131.4^{bc}	24.8^{cd}	32.7^{de}	102.6^{bc}	2.2^{ef}	6.3^{d}	654^{e}
CRIS-129	113.7^{efg}	23.0^{e}	33.1^{de}	97.5^{c}	2.1^{f}	5.5^{e}	871^{cd}
CRIS-134	123.0^{b-f}	25.3^{bcd}	35.9^{cd}	100.9^{bc}	2.2^{ef}	6.1^{d}	944^{bc}
CRIS-342	116.9^{d-g}	26.3^{abc}	39.1^{bc}	122.9^{a}	2.4^{c-f}	7.3^{bc}	944^{bc}
CRIS-467	149.9^{a}	26.9^{ab}	31.5^{ef}	110.4^{b}	3.0^{ab}	7.9^{a}	799^{d}
CRIS-508	132.9^{b}	24.2^{de}	37.3^{bc}	104.1^{bc}	2.3^{def}	7.0^{c}	799^{d}
CRIS-510	110.6^{fg}	27.0^{ab}	37.4^{bc}	85.6^{de}	2.7^{bc}	8.3^{a}	871^{cd}
CRIS-533	104.5^{g}	20.6^{f}	33.2^{de}	82.3^{e}	2.3^{def}	6.0^{de}	1017^{b}
CRIS-543	121.6^{b-f}	27.4^{a}	35.8^{cd}	85.3^{de}	2.6^{cd}	8.0^{a}	871^{cd}
CRIS-552	119.2^{c-f}	26.5^{abc}	41.2^{ab}	95.7^{cd}	2.5^{cde}	7.8^{ab}	1017^{b}
CRIS-613	126.9^{bcd}	24.3^{de}	44.1^{a}	70.1^{f}	3.1a	8.2^{a}	1118^{a}
CD 5%	12.87	1.76	3.94	11.54	0.36	0.53	76.80
CD 1%	17.49	2.40	5.36	15.68	0.49	0.72	104.39
CV %	6.18	4.16	6.50	7.04	8.66	4.39	5.48

Similar letters are non-significant in each column according to Duncan Multiple Range Test at $p < 0.05$.

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