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CHARACTERIZATION AND PERFORMANCE OF CRIS-543: HIGH YIELDING AND HEAT TOLERANT COTTON VARIETY

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ABSTRACT

CRIS-543 is newly developed high yielding and heat tolerant cotton variety (cv) that combat with climate change situation like high temperature and shortage of irrigation waters. cv. CRIS-543 was developed through hybridization conventional breeding method. The cross was attempted between cv. FH-945 and cv. CRIS-134 in 2002-03. The performance of cv. CRIS-543 was outstanding over the series of trials i.e. Varietal Trials, Varietal Trials, Zonal Varietal Trials and National Coordinated Varietal Trials with significant higher seed cotton yield and with wider adaptability than the standard varieties. Cv. CRIS-543 is heat tolerant variety which given higher yield in hot places at different ecological zones and it also proved best in heat tolerant and water stress trials. Therefore, it is strongly recommended for general cultivation in those areas, where fruiting parts shedding problems happed due to high temperature and shortage of irrigation water. It also possesses high GOT and longer staple length along with other fiber traits. Variety is non Bt. tolerant to sucking insect pests and diseases; the optimum sowing period of this variety is 15th April to 15th May. It attained higher yield on 150 kg N ha^{-1} at 30 cm spacing. The variety salient features were presented in technical expert subcommittee and after recommendation of committee, the proposal was submitted and present in Sindh Seed Council (SSC). Keeping in view the performance and salient features of cv. CRIS-543 SCC approved for general cultivation in Sindh during the year 2020.

Keywords: high yielding, heat tolerant, cotton variety, cv. CRIS-543, characterization.

INTRODUCTION

Cotton is a main fiber crop; it has significant importance globally with high commercial value. It is being grown in temperate and tropical regions of more than 70 countries; where climatic conditions suit the natural growth requirements of cotton. This includes periods of hot and dry weather and adequate moisture obtained through irrigation. Pakistan is 5th largest cotton producing country in cotton growing countries; it is 3rd major consumer globally. The cotton area of Pakistan in 2019-20 was 2.895 million hectares, with the production of 12.72 million bales. In Sindh cotton was grown on 0.640 million hectares and produced 4.60 million bales. While, in Punjab province it was cultivated on 2.145 million hectares and achieved production 7.90 million bales (Soomro, 2020). It is cultivated on nearly at 3 million hectare along the Indus Valley and supported directly up to 26% farming community (Sial *et al.*, 2014). Majeedano *et al.* (2014) found superiority of newly genotypes over the standard check variety in different experiments. Ahsan *et al.* (2017) developed high yield and heat tolerant variety followed by conventional breeding method and duly tested in through various trials. In major cotton growing areas of Pakistan facing issue of high temperature, it was exceeding from 45^{o}C and considered as hot climatic conditions. So, heat is the only one major factor which directly affecting the cotton crop and ultimately decrease in seed cotton yield (Raza, 2009). For enhancing seed cotton yield the synergistic synchronization of the reproductive stress and vegetative stress under abiotic stressful environment (Abbas *et al.*, 2016 and Rashid *et al.*, 2016).

Development of new varieties with high yielding and better fiber quality is primary objective of the cotton breeders. It is the prime object that new cultivar should high yielding; possess better fiber traits, tolerant to biotic and a-biotic factors and with wider adaptability in agro ecological zone of farming community. Therefore, the present research was conducted in keeping in mind to evolve high yielding variety with particular attention tolerate to heat and water stress conditions in Pakistan. CCRI-Sakrand developed cotton variety CRIS-543 through conventional breeding method that is high yielding and heat tolerant.

MATERIAL AND METHODS

The CRIS-543 was developed through hybridization conventional breeding approach. The cross was attempted between two inbred genotypes FH-945 and CRIS-134at Central Cotton Research Institute Sakrand, Sindh Province

during 2002-03.The F_1 were raised in 2003-04. The F_2 segregating population was raised in 2004-05 and selection of superior desired plants according to characteristics need basis through pedigree selection method. F_3, F_4, $F_5$and F_6generations was raised from single plant progenies in 2005-06, 2006-07, 2007-08 and 2008-09, respectively. The selected single plants progenies were raised at experimental farm and desirable single plants with required characteristics were identified and selection for further testing in yield trials. CRIS-543 was tested in varietal trials (1 & 2) in 2009-10 and 2010-11. In micro yield trials (1 & 2) it was tested in 2011-12 and 2012-13. CRIS-543 was tested in zonal varietal trials (1 & 2) in 2013-14 and 2014-15. It was also tested in outstation zonal varietal trial at the environmental conditions of lower Sindh (Mirpurkhas), middle Sindh (Sakrand) and upper Sindh (Ghotki) during 2013-14 and 2014-15 to test the wider adaptability. CRIS-543 was tested in National Coordinated Varietal Trial (NCVT) nationally during two consecutive years 2015-16 and 2016-17.

The CRIS-543variety trials was tested in varietal trials, micro yield trials, zonal varietal trial and national coordinated in randomized complete block design with three replications. The row to row space was 75cm and plant to plant space was 30cm. The recommended doses of fertilizer were applied as per need in split doses. The plant protection measures were also applied as per need, whenever required. The 10 plants were tagged from each replication during every year collection of data. Data collected on different parameters were analyzed statistically by using statistics 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).

Table 1. Breeding history of high yield, early maturing and heat tolerant variety CRIS-543.

Sr. No.	Year	Development stages of CRIS-543
1	2002-03	Hybridization between FH-945 and CRIS-134
2	2003-04	F_1 was grown in field condition
3	2004-05	F_2 generation was grown in field and single plants were selected
4	2005-06	F_3 generation was grown in filed and superior plants were selected
5	2006-07	F_4 single plant progeny rows were studied
6	2007-08	F_5 single plant uniform progeny rows were studied
7	2008-09	F_6superior progeny rows were studied and bulked
8	2009-10	Varietal Trial 1
9	2010-11	Varietal Trial2
10	2011-12	Micro Yield Trial 1
11	2012-13	Micro Yield Trial 2
12	2013-14	Zonal Varietal Trial 1
13	2014-15	Zonal Varietal Trial 1
14	2015-16	National Coordinated Varietal Trial 1st year
15	2016-17	National Coordinated Varietal Trial 2nd year

RESULTS AND DISCUSSION

Characterization

The growth habit is indeterminate. Main stem is erect, semi-hairy with medium pigmentation. The sympodial branches are medium in length with medium internodes length that made the plant look open canopy. The number of sympodia ranges from 25-29 per plant. The leaves are medium green with mostly 5 lobes and 1-3 nectaries per leaf. Flowers, petals and pollen are creamy, spotless with mostly 3 nactaries per flower. The boll is almost round, medium size with normal gossypol glands; there is tendency of twin boll formation at sympodial branches. The seed is fuzzy, dusky white, medium sized, coat color brown and seed index ranging from7.4 to 8.4.

Varietal Trial

The newly developed strain CRIS-543 was tested in Varietal Trials at the experimental field of Central Cotton Research Institute Sakrand during 2009-10 and 2010-11. Table 2 exhibited that during 1st year 2009-10, CRIS-543 produced maximum seed cotton yield over the standard check variety, which increase over 21.89%. While, 2nd year 2010-11 it also showed good performance and attained higher seed cotton yield increased 19.76% over the standard CRIS-134.

Micro Yield Trial

New strain was tested in Micro Yield Trial in two consecutive years 2011-12 and 2012-13. Data presented in table 3 revealed that CRIS-543 gave higher seed cotton yield with increased 18.33% over the standard check variety in 2011-12. During 2012-13 it also proven best and showed higher yield with increased 29.02% over the standard variety CRIS-342.

Table 2. Performance of CRIS-543 in varietal trials during 2009-10 and 2010-11.

Year	Trial	Variety	Seed Cotton Yield (kg ha^{-1})	(%) increase over standard check
2009-10	Varietal Trial 1	CRIS-543	4198	21.89%
		CRIS-134 (std.)	3444	
2010-11	Varietal Trial 2	CRIS-543	4012	19.76%
		CRIS-134 (std.)	3350	

Table 3. Yield performance of CRIS-543 in micro yield trials during 2011-12 and 2012-13.

Year	Trial	Variety	Seed Cotton Yield (kg ha^{-1})	(%) increase over standard check
2011-12	Micro Yield Trial 1	CRIS-543	3763	18.33%
		CRIS-342 (std.)	3180	
2012-13	Micro Yield Trial 2	CRIS-543	4308	29.02%
		CRIS-342 (std.)	3339	

Zonal Varietal Trial

Zonal Varietal Trial was conducted in 2013-14 and 2014-15, CRIS-543 was tested at three ecological zones (lower, middle and upper) in Sindh. The data exhibited in table 4 shown that CRIS-543 produced maximum seed cotton yield compared with standard variety. At the Mirpur Khas zone yield of CRIS-543 was increased 10.61% over the standard and 44.44% yield was also increased at Sakrand. However, at the environmental conditions of Sakrand newly strain given 21.25% higher yield over the standard variety CRIS-342.It was noted that at two higher temperature zones Sakrand and Ghotki, CRIS-543 yield was increase that is the indication of adaptable in hot region or heat tolerant.

Table 4.Adaptability of CRIS-543 in outstation zonal varietal trial during 2013-14.

Sr. No.	Locations	Variety	Seed Cotton Yield (kg ha^{-1})	(%) increase over standard check
1	Cotton Research Station MirpurKhas	CRIS-543	4213	10.61%
		CRIS-342 (std.)	3809	
2	Central Cotton Research Institute Sakrand	CRIS-543	4664	44.44%
		CRIS-342 (std.)	3229	
3	Cotton Research Station Ghotki	CRIS-543	3857	21.25%
		CRIS-342 (std.)	3181	

CRIS-543 is highly acceptable and high yielding variety, during the 2nd year 2014-15 in Zonal Varietal Trial (table 5); it again performed better and contributed with higher seed cotton yield at Mirpur Khas 11.55% increase over standard variety and in Sakrand zone17.05% increase over the standard. While, at Ghotki it was given 19.31% more yield than the standard check variety CRIS-342. Similarly it again performed as heat tolerant variety as attained high yield in hot zones. Therefore, it is highly recommended for general cultivation in hot areas of middle and upper Sindh.

Table 5. Adaptability of CRIS-543 in outstation zonal varietal trial during 2014-15.

Sr. No.	Locations	Variety	Seed Cotton Yield (kg ha^{-1})	(%) increase over standard check
1	Cotton Research Station Mirpur Khas	CRIS-543	4278	11.55%
		CRIS-342 (std.)	3835	
2	Central Cotton Research Institute Sakrand	CRIS-543	4531	17.05%
		CRIS-342 (std.)	3871	
3	Cotton Research Station Ghotki	CRIS-543	4195	19.31%
		CRIS-342 (std.)	3516	

CRIS-543 was tested at grower field in 9 districts of Sindh, the objective of conducting such trial; for evaluating varietal yield potential and adaptability in different environmental conditions of Sindh. Table 6 displayed that on an average of per district newly developed strain CRIS-543 gave higher seed cotton yield over the standard check CRIS-342; in Umar Kot 7.2%, TandoAllahyar 9.7%, Matiari 11%, Sanghar 10%, Benazir Abad 11.4%, Naushehro Feroze 13.3%, Dadu 13%, Sukkur 16.6% and in Ghotik 11.6%.On average of 23 locations of all the districts, CRIS-543 produced 11.53% more yield that will be 444 kg ha^{-1}.Data proved that CRIS-543 has wider adaptability and heat tolerant variety as it given higher yield in high temperature areas as compared with standard check variety.

Table 6. Multi location trials of CRIS-543 at grower field of various districts in 2013-14.

Sr. No.	District	Locations	Seed Cotton Yield (kg ha^{-1})		(%) increase over standard check
			CRIS-543	CRIS-342 (std.)	
1	Umar Kot	1	4324	4032	7.2%
2	TandoAllahyar	2	4235	3861	9.7%
3	Matiari	4	4246	3825	11%
4	Sanghar	6	4268	3880	10%
5	Benazir Abad	5	4232	3800	11.4%
6	NaushehroFeroze	1	4258	3758	13.3%
7	Dadu	2	4440	3929	13%
8	Sukkur	1	4368	3746	16.6%
9	Ghotki	1	4376	3920	11.6%

National Coordinated Varietal Trial

The CRIS-543 was included in National Coordinated Varietal Trial for two years 2015-16 and 2016-17. It was tested in various environmental conditions regionally in all the four provinces. Table 6 indicated that in 1st year NCVT results showed that CRIS-543 performed outstand and stood 1st in Sindh province which given highest seed cotton yield compared with other candidate lines. It was also 10.66% increase over the standard variety CRIS-129.

Table 7. CRIS-543 yield results of national coordinated varietal trail stood 1st in Sindh.

Year	Trial	Variety	Seed Cotton Yield (kg ha^{-1})	(%) increase over standard check
2015-16	National Coordinated Varietal Trial	CRIS-543	2822	10.66%
		CRIS-129 (std.)	2550	

During 2nd year testing in NCVT (Table 7) revealed that CRIS-543 also given outstanding performance produced highest seed cotton yield and stood 1st in Pakistan during 2016-17, 11.51% yield increased over the standard check varieties CRIS-129 and CIM-473. It was noted that in NCVT trial, it was sown on hot ecological zones of Pakistan i.e. Sakrand, Ghotki, Sibbi, Multan, RaheemYar Khan etc. data supported that CRIS-543has a potential to perform in hot areas and proven as heat tolerant cotton variety.

Table 8. CRIS-543 yield results of national coordinated varietal trail stood 1st in Pakistan.

Year	Trial	Variety	Seed Cotton Yield (kg ha^{-1})	(%) increase over standard check
2016-17	National Coordinated Varietal Trial	CRIS-543	2752	11.51%
		CRIS-129/ CIM-473 (std.)	2468	

Summary of Fiber Traits

The fiber characteristics data depicted in table 9, the replicated lint samples were tested from Central Cotton Research Institute Multan by using HVI (high volume instrument). Data suggested that CRIS-543 ginned higher highest ginning outturn 41.3%, longest staple length (28.5 mm) and prime micronaire value 4.4 µg $inch^{-1}$ that is better than commercial variety CRIS-342.

Heat Tolerant

Physiological traits having consequence to heat tolerance were noted in the strains are presented in Table 10. Strain CRIS-543 maintain the highest anther dehiscence (78%) during hot months (June and July) compared to standard variety CRIS-129 and excelled in heat tolerance considering sympodial node number bearing 1stsympodial node number, 1stsympodial node height (cm), and sympodial node number bearing 1st effective boll. The data further proved that newly developed genotype is heat tolerant.

Table 9. Summary of fiber characters of variety CRIS-543.

Varieties	**GOT (%)**	**Staple Length (mm)**	**Fibre Strength (g tex^{-1})**	**Micronaire value (µg inch^{-1})**	**Uniformity Index (%)**
CRIS-543	41.3	28.5	31.6	4.4	81.1
CRIS-342 (std.)	37.6	27.4	30.2	4.6	82.8

Table 10. Physiological traits for determining heat tolerance of CRIS-543.

Physiological Parameters	**CRIS-543**	**CRIS-129 (Std.)**
Anthar Dehiscence (%)	78	63
1stSympodial node Number	6.8	11.3
1stSympodial node height (cm)	16.2	21.1
Sympodial node number bearing 1st effective boll	9.2	13.8
Sympodial node height bearing 1st effective boll (cm)	17.5	25.8

Irrigation Intervals

Irrigation trial conducted for testing under water stressconditions in 2015-16 (Table 11). The results revealed that in water stress situation at CRIS-543 performed well and produced higher seed cotton yield over the standard variety CRIS-342. In T_1 and T_2 when 4 and 6 irrigations were applied, its yield increased over the standard which was 39.88%and 35.40% respectively. The results confirmed that CRIS-543 is heat tolerant that have the potential to perform in water stress conditions with less shedding of fruits and given good yield. Therefore, it is recommended to that area, who suffering in water shortages or longer intervals.

Table 11. Performance of CRIS-543 at various levels of irrigations.

Irrigations	**Strains**	**Seed cotton yield (kg ha^{-1})**	**(%) increase over standard check**
T_1 (4 irrigations)	CRIS-543	4255	39.88%
	CRIS-342 (std.)	3042	
T_2 (5 irrigations)	CRIS-543	4353	35.40%
	CRIS-342 (std.)	3215	
T_3 (7 irrigations)	CRIS-543	4416	14.20%
	CRIS-342 (std.)	3867	

Entomological Study

Host plant resistance studies help cotton breeders to develop/screen varieties which have natural resistance against insect pests. The natural resistance of a variety in turn reduces frequency of pesticide sprays to some extent and consequently saves resources available with the growers. Host plant resistance trials were conducted to evaluate CRIS-543 for its natural resistance to insect pests during 2013-14 and 2014-15 crop seasons at CCRI- Sakrand in unsprayed blocks. Data presented in Table-12 indicated that, on an average of two years, CRIS-543 showed a slight natural tolerance against thrips, jassid, whitefly and bollworm damage as compared to commercial variety CRIS-342.

Pathological Study

The Pathological studies on CRIS-543 relating to seedling rot, boll rot and Cotton Leaf Curl Virus disease were conducted at Central Cotton Research Institute, Sakrand during 2013-14 and 2014-15 crop season. The average of two years data expressed in Table-13 shown that, incidence of seedling rot and boll rot were found 2.8% and 2.5%

in CRIS-543 compared to 3.2 % and 2.3% of CRIS-342 respectively. The incidence of CLCuV in CRIS-543 was 1.3% compared to 2.5% of CRIS-342 under Sakrand conditions.

Table 12. Host Plant Resistance Studies of CRIS-543 for sucking pests and bollworm.

Varieties	Average pest population/leaf			Bollworm damage (%)
	Thrips	Jassid	Whitefly	
2013-14				
CRIS-543	3.34	0.37	0.48	1.70
CRIS-342 (Std.)	3.67	0.48	0.46	1.87
2014-15				
CRIS-543	5.46	0.43	0.54	1.87
CRIS-342 (Std.)	5.94	0.50	0.55	1.81

Table 13.Pathological study for disease resistance of CRIS-543.

Variety	Seedling rot (%)	Boll rot (%)	CLCuV Incidence%
CRIS-543	2.8	2.5	1.3
CRIS-342 (std.)	3.2	2.3	2.5

Agronomic Study

Sowing Date Trial

In order to determine optimum sowing time, CRIS-543 was tested in four sowing dates viz; 15thApril, 1st May, 15th May and 1st June during 2014-15 and 2015-16 cotton seasons at CCRI-Sakrand. The data illustrated in Table-14indicated that, CRIS-543 produced higher seed cotton yield in both the years (2014-15 and 2015-16) on 15th April sowing. On an average of two years, maximum seed cotton yield (4000 kg ha-1) was obtained when the variety was sown on 15thApril followed by 3760 kg ha^{-1} of 1st May, 2740 kg ha^{-1} of 15th May and 3136 kg ha^{-1} of 1stJune sowing. Therefore, it can be concluded that the optimum sowing period of this variety is 15thApril to 15thMay for central or middle Sindh. CRIS-543 may also strongly be recommended for sowing in other zones having similar climatic conditions

Table 14. Sowing date study of CRIS-543 during 2014-15 and 2015-16.

Sowing Date	Seed cotton yield (kg ha^{-1})			
	Strains	2014-15	2015-16	Average
S_1 (15th April)	CRIS-543	3915	4085	4000
	CRIS-342 (std.)	3615	3388	3501
S_2 (1st May)	CRIS-543	3680	3840	3760
	CRIS-342 (std.)	3450	3320	3385
S_3 (15th May)	CRIS-543	3071	3214	3142
	CRIS-342 (std.)	2670	2810	2740
S_4 (1st June)	CRIS-543	3161	3112	3136
	CRIS-342 (std.)	2733	2655	2694

Table 15.Effect of nitrogen fertilizer and plant spacing on seed cotton yield of CRIS-543.

Treatment	Nitrogen Dose	Spacing		
		15cm	23cm	30cm
T_1	50 kg ha^{-1}	2845	3065	3215
T_2	100 kg ha^{-1}	2911	3180	3410
T_3	150 kg ha^{-1}	3012	3233	3945
T_4	200 kg ha^{-1}	3070	3274	3987

Nitrogen cum Spacing Trial

The data presented in Table-19 showed that the maximum seed cotton yield (3987 kg ha^{-1}) was obtained at 30 cm spacing under 200 kg Nitrogen per hectare at par to application of 150 kg N ha^{-1}(3945 kg ha^{-1}), 100 kg N ha^{-1} (3410 kg ha^{-1}) and 50 kg N ha^{-1} (3215 kg ha^{-1}). The data indicates that CRIS-543 has the potential to provide higher

yield on 150 kg N ha^{-1} at 30 cm spacing and this variety does not need a very high input which is difficult to manage by a common grower.

Seed Availability

The BNS, Pre-Basic and Basic seed of CRIS-543 will be maintained under the supervision plant breeders (cotton breeders) of Central Cotton Research Institute Sakrand. Institute may provide genetically pure seed to public and private sector on their request. However, it large scale multiplication will be held at public and private seed sector of Pakistan.

Conclusion

CRIS-543 is newly developed high yielding and heat tolerant cotton variety that combat with climate change situation i.e. high temperature and shortage of irrigation waters. The performance of CRIS-543 was outstanding over the series of trials i.e. Varietal Trials, Varietal Trials, Zonal Varietal Trials and National Coordinated Varietal Trials with higher seed cotton yield and wider adaptability than the standard variety.CRIS-543 is heat tolerant variety which given higher yield in hot places at different ecological zones and it also proved best in heat tolerant and water stress trials. Therefore, it is strongly recommended for general cultivation in those areas, where fruiting parts shedding problems happed due to high temperature and shortage of irrigation water.

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