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The Performance of Multi-Parental Cotton (*Gossypium hirsutum* L.) Hybrid Genotypes

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ABSTRACT

We aimed to evaluate the possibilities of increasing the ginning out-turn in multi-parent hybrid populations of cotton. Two genotypes with high ginning out-turn were crossed with seven F_3 populations obtained from double crosses, and then fourteen F_1 populations were created in 2020. The F_1 populations, their grandparents, and two parents, a total of 23 genotypes, were compared by Randomized Complete Block Design with three replications in 2021. Significant differences were detected among genotypes, including crosses and parents for seed cotton yield per plant, ginning out-turn, fiber fineness, and fiber strength. The orthogonal contrasts indicated that the average performance of hybrids was significantly higher than that of parents for ginning out-turn, seed cotton yield per plant, and fiber fineness. Standard heterosis was between -11.19% and 20.54% for seed cotton yield per plant; 4.71% and 16.03% for ginning out-turn. [(ST-468 × Claudia) × (Gloria × Carisma)] × Esperia should be transferred to further generations. Multi-parent hybrids could be used to create the required variance and maintain dominance for the improvement of yield and ginning out-turn.

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Çok Ebeveynli Pamuk (*Gossypium hirsutum* L.) Melez Genotiplerinin Performansı

ÖZET

Çok ebeveynli melez pamuk popülasyonlarında çırçır randımanını artırma olanakları değerlendirilmiştir. Sekiz adet çift melez F_3 melez popülasyonu ile yüksek çırçır randımanına sahip iki genotip melezlenmiş ve 14 farklı F_1 melez popülasyonu elde edilmiştir. Melezlerden ve ebeveynlerden oluşan genotipik farklılık tek bitki kütlü pamuk verimi, çırçır randımanı, lif inceliği ve lif dayanıklılığı yönünden önemli bulunmuştur. Ortogonal karşılaştırmalar melezlerin ortalama performansının çırçır randımanı, tek bitki kütlü pamuk verimi ve lif inceliği yönünden ebeveyn ortalamasından önemli düzeyde farklı olduğunu göstermiştir. Standart heterosis tek bitki kütlü pamuk için %-11.19 ile %20.54; çırçır randımanı için %4.71 ile %16.03 arasında değişmiştir. [(ST-468 × Claudia) × (Gloria × Carisma)] × Esperya melez kombinasyonunun ileri generasyonlara aktarılması gerektiği saptanmıştır. Çırçır randımanı ve kütlü pamuk verimini artırmayı amaçlayan ıslah çalışmalarında dominantlığı sürdürmek ve varyasyonu oluşturmak için çok ebeveynli melezlerin kullanılabileceği sonucuna varılmıştır.

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INTRODUCTION

Cotton, grown in tropical, semi-tropical, and semi-arid areas of the world, is included in the genus Gossypium. Cotton fiber and seed provide raw materials to the textile and edible oil industries, respectively (Shahzad et al., 2019; Tarazi et al., 2020). In Türkiye, the pricing of cotton by cooperatives and private buyers is primarily based on the ginning out-turn (GOT). In addition, GOT is one of the most important yield components, and genotypic performance for high GOT has been extensively used in cotton breeding (Desalegn, 2016). The quantitative characteristics such as seed cotton yield and ginning out-turn exhibited polygenic heritage and broad variations in segregating generation of cotton (Memon et al., 2017; Monicashree et al., 2017; Premalatha et al., 2020; Balci et al., 2021b). Therefore, cotton breeders concentrate on optimizing the high ginning out-turn and seed cotton yield with fiber characteristics within commercial limits (Akbar et al., 2009; Ahuja et al., 2018). The results of simple correlation and path analysis demonstrated that ginning out-turn is one of the attributes most to seed cotton yield (Zhou, 1986; Choudhari et al., 1988; Ahmad ve Azhar, 2000; Salahuddin et al., 2010; Erande et al., 2014).

Ibragimov (1989) announced that higher seed cotton yield and ginning out-turn brought with coarse fiber in cotton genotypes. The significant and negative association between seed cotton yield and ginning out-turn (Dinakaran et al., 2012; Parmar et al., 2015) and ginning out-turn with seed weight, boll weight, fiber length, and fiber fineness (Karademir et al., 2010) were underlined. The presence of a negative genetic correlation among ginning out-turn, seed cotton yield, and fiber quality characters can often limit the success of breeding (Yu et al., 2013), and this negative association needs to be broken by the different methods (Islam et al., 2016). A multiparent advanced generation inter-cross (MAGIC) population can be a good method to eliminate the mentioned negative linkage compared with bi-parental populations having low allelic diversity (Jenkins et al., 2008). MAGIC populations can result from cycles of recurrent selection aimed at combining favorable alleles.

In another study, F_4 and F_5 cotton plants were crossed with opposite and diverse testers to determine the performances of heterotic groups and the combining abilities of testers (Girish et al., 2019). To compare the heterotic populations and to predict the double cross performance, the robust and compact cotton types were crossed in Line × Tester mating design, and it was concluded that crosses involving between group genotypes (interplant type) are highly heterotic (Ranganatha et al., 2013).

Heterobeltiosis and standard heterosis are the performance of F_1 over the better parent and over the standard check to identify the best cross combination (Shashibhushan & Patel, 2019; Kumbhalkar et al., 2021; Chapara & Madugula, 2021).

The previous studies on double cross population assessed the hybrid performance in terms of yield, yield components, and fiber quality characteristics (Yehia et al., 2009; El-Hashash, 2013; Ekinci et al., 2016). In this study, seven F_3 populations of double crosses obtained from recurrent selection were crossed with two parents with high ginning out-turn, and then 14 F_1 populations having five parents were obtained. We aimed (1) to evaluate the cross combinations, (2) to compare the performance of cross combinations over different check varieties via contrast parameters, and (3) to determine the cross combinations to be transferred to the further generations.

MATERIALS and METHODS

The 7 F_3 populations derived from 4 × 3 reciprocal line × tester crosses and recurrent selection (cycle 1) were crossed with Esperia (ES) and advanced line (Genotype-I; G1) having high ginning out-turn in 2020. The details of the F_3 population development were described by Balci et al., 2021a; Balci et al., 2021b) and summarized in Figure 1.

Since the theoretical segregation in the F_3 generation was 75% homozygous and 25% heterozygous, at least 1 cross was made from each plant of all F_3 populations. Fourteen F_1 populations and 9 of their grandparents and parents, 23 genotypes, were planted in Randomized Complete Block Design with three replications in 2021. The weather of the experimental location (Nazilli-Aydin/Turkey; 37°86' N, 28°37' E) was defined as mild, generally warm, and temperate within the class of Csa by Köppen and Geiger. Experimental soil characteristics were slightly alkali, high lime content, adequate potassium, low organic matter, nitrogen, and phosphorus.

The seeds of F_1 and their parents were planted 0.12 m apart with 0.70 m of row spacings. Each plot consisted of one row of 6 m long. Field practices such as fertilization, irrigation, pest, and weed control were managed according to the national recommendation for the cotton growing of the Aegean Region in Türkiye. Ten plants per experimental unit were randomly exampled for data collection, as suggested by Sahito et al. (2016). Seed cotton yield per plant (g), ginning out-turn (%), fiber fineness (mic.), fiber length (mm), and fiber strength (g tex^{-1}) were recorded. The laboratory roller gin was used for ginning out-turn, and the USTER® HVI-1000 instrument was used to determine fiber quality properties.

Data were subjected to analysis of variance using the JMP® 14 statistical program (SAS Institute Inc. 2018), and genotypic differences were tested by using the LSD (0.05) test (Steel & Torrie, 1980). The LSD means contrast function, as implemented in JMP® 14, has been used to test orthogonal contrasts between treatments using F statistics for different means. Orthogonal contrasts for ginning out-turn; C_1; Esperia crosses vs. Genotype-I crosses, C_2; All crosses vs. mean of Esperia and Genotype-I, C_3; All crosses vs. all parents, C_4; Esperia crosses vs. best variety, C_5; Genotype-I crosses vs. best variety and C_6; all crosses vs. best variety. Orthogonal contrasts for other characters; C_7; all crosses vs. check variety (Gloria), and C_8; all crosses vs. best variety.

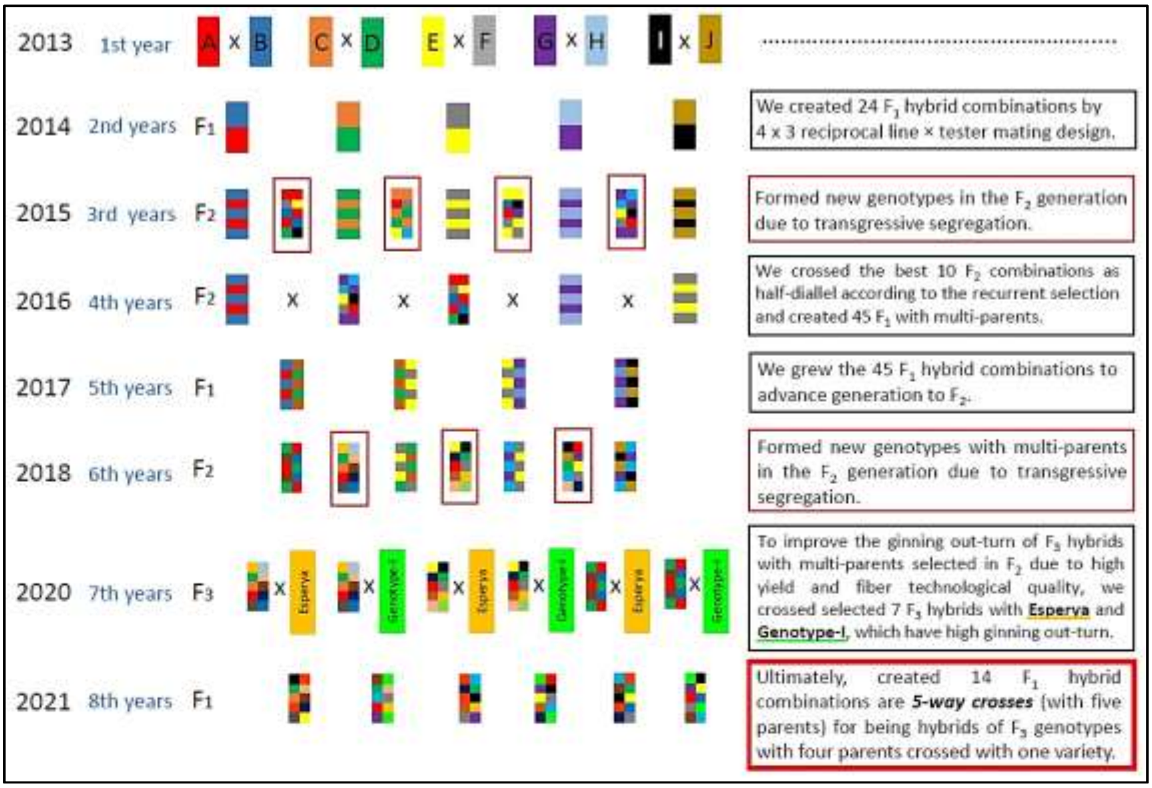

Figure 1. Breeding actions between 2013 and 2021
Şekil 1. 2013 ve 2021 yılları arasında sürdürülen ıslah çalışmaları

The F_1 performance over standard over-check variety was defined as standard heterosis, and the formula;

Standard heterosis (%) = $\frac{F1-check\ variety}{check\ variety} \times 100$ (Fonseca and Patterson, 1968). (1)

The standard error for the significance of standard heterosis was $\sqrt[2]{\frac{2 \times mean\ sum\ of\ square\ due\ to\ error}{number\ of\ replications}}$, according to Cohran & Cox (1957). (2)

RESULTS and DISCUSSION

Genotypic differences were found to be significant for seed cotton yield per plant, ginning out-turn, fiber fineness, and fiber strength (Table 1). The results are in concordance with the findings of Arain (2015), Baloch et al. (2015), Memon et al. (2017), Monicashree et al. (2017) and Premalatha et al. (2020).

Seed cotton yield

[(CA × ST) × (ST × CL)] × G1 (53.66 g), [(ST × CL) × (GL × CR)] × G1 (54.04 g) and [(CR × CA) × (GL × FL)] × ES (54.44 g) were exhibited the lowest seed cotton yield per plant in crosses, whereas the highest seed cotton yield per plant recorded in [(ST × CL) × (GL × CR)] × ES (73.89 g). The comparison of genotypic means indicated that Esperia had the highest seed cotton yield per plant (71.82 g) among parents (Table 2). In addition, mean data showed that seed cotton yield per plant of 6 out of 14 combinations was over the grand mean of crosses (60.57 g). Although orthogonal contrast (C_3) between parents (55.76 g) and crosses means (60.57 g) was favorable significant, crosses vs. check variety (61.30 g) and crosses vs. best variety (71.82 g) were unfavorable significant (C_7 and C_8) (Table 3). In this case, [(ST × CL) × (GL × CR)] × ES was superior for seed cotton yield per plant and was followed by combinations [(GL × FL) × (GL × CR)] × G1, [(CR × CA) × (GL × FL)] × G1 and [(JU × ST) × (CR × CA)] × ES. The positive and significant standard heterosis value of all four combinations corrected the performance of cross combinations. In previous studies, it was revealed that standard heterosis ranged from -12.63% to 30.90%, with 25 of 36 crosses being positive (Bilwal et al., 2018) and from -28.29 to 47.03% with significant and positive in 9 out of 32 crosses (Rathava et al., 2018). We also estimated that standard heterosis was between -12.47% and 20.53%, and 4 out of 14 crosses had significant and positive values (Table 4). In this study, the grandparents and parents in pedigrees of hybrids were the important cultivars grown in recent years. Therefore, the maximum level of standard heterosis in our crosses was lower than that of Bilwal et al. (2018) and Rathawa et al. (2018).

Table 1. Means used for orthogonal contrasts
Çizelge 1. Ortogonal karşılaştırmalar için kullanılan ortalama değerler

Means	SCY	GOT	FL	FF	FS
The grand mean of Crosses	60.57±0.91	45.22±0.24	29.58±0.17	5.34±0.04	31.22±0.19
The grand mean of Parents	55.76±1.44	42.64±0.30	29.66±0.18	4.91±0.05	31.42±0.33
Grand Mean of Genotypes	58.69±0.84	44.21±0.24	29.61±0.13	5.17±0.04	31.30±0.18
Mean of Esperia Crosses		43.99±0.17			
Mean of Genotype-I Crosses		46.45±0.23			
Mean of Esperia and Genotype-I		44.89±0.51			

SCY: Seed cotton yield (g); GOT: Ginning out-turn (%); FL: Fiber length (mm); FF: Fiber fineness (micronaire); FS: Fiber strength (g tex^{-1}).

Ginning Out-Turn

The main purpose of our study is to increase the ginning out-turn in cross combinations. The range of ginning out-turn was 43.32 - 48.00% in cross combinations and 40.73 - 46.11% in parents and grandparents. The ginning out-turn of all cross combinations was higher than all parents except Genotype-I, while four cross combinations, [(JU × ST) × (CR × CA)] × G1, [(GL × FL) × (GL × CR)] × G1, [(CA × ST) × (GL × FL)] × G1 and [(JU × ST) × (GL × CR)] × G1, were higher than Genotype-I (Table 2). In addition, the mean of all crosses and Genotype I crosses were 45.22% and 46.45%, respectively (Table 1). The significant orthogonal contrast values, such as C_2 and C_3, indicated that the performance of all crosses was superior to the mean of Esperia and Genotype-I and all parents (Table 3). Although no significant C_5 confirmed the equality of the mean of the Genotype-I crosses and the best variety (Genotype-I), the mean of all crosses was significantly lower than the best variety Genotype-I (C_6). Moreover, standard heterosis (compared to Gloria) was between 4.71% and 16.03%, with 9 out of 14 crosses being significant. Murthy et al. (2017) found that the mean performance of 4 F_1 populations ranged from 35.74% to 40.98%, and heterosis over two check varieties was completely favorable. Mudhalvan et al. (2021) determined that the ginning out-turn was between 25.47% and 39.10% in 30 F_1 combinations (*Gossypium hirsutum* L), and standard heterosis was mostly negative and significant (Table 4). In another study, the values of the advanced lines selected for ginning out-turn varied between 36.50% and 45.50%, and the average of the control varieties was 40.9% (Çoban and Çiçek, 2017). We recorded higher performance for all cross combinations than the mentioned studies regarding ginning out-turn.

Fiber Length

The most important fiber quality characteristics are fiber length, fineness, and strength in terms of the fiber value for spinning into yarn and marketing. Developing new cultivars with improved fiber properties is the main target of cotton breeders (Constable et al., 2015). The range of fiber length was 28.71 - 30.87 mm for cross combination and 28.63 – 30.87 mm for all parents (Table 2). Although genotypic differences were nonsignificant, the mean of all crosses (29.58) was significantly shorter than that of the best variety, Carmen (30.87 mm). These findings were incompatible with the results obtained by Monicashree et al. (2017) and Premalatha et al. (2020). Despite all this, the maximum fiber length value in our study was higher than that of Arain et al. (2015) and Baloch et al. (2015). [(ST × CL) × (GL × CR)] × G1, [(CA × ST) × (ST × CL)] × G1, [(CA × ST) × (GL × FL)] × G1 and [(CA × ST) × (GL × FL)] × ES were highly performed for fiber length over 30.0 mm, while standard heterosis was favorable in the first three of these hybrids (Table 4). Earlier studies reported that the means of fiber length were 30.0 mm for crosses and 28.1 mm for parents, and standard heterosis was between 2.75% and 14.43% (Ashokkumar et al., 2013). It was seen that genetic variability and standard heterosis were not created for fiber length in the population where nine commercial varieties and advanced lines were crossed.

Fiber Fineness

The stronger and faster yarn process can only be realized thanks to finer mature fibers (Steadman, 1997). The earlier opposite association has been reported among ginning out-turn and fiber length and micronaire, while the direct association between ginning out-turn and strength and micronaire (Percy et al., 2006). Fiber fineness of cross combinations and parents were 5.06 - 5.58 (mic.) and 4.61 - 5.11 (mic.), respectively (Table 2). Although, [(ST × CL) × (GL × CR)] × ES, [(ST × CL) × (GL × CR)] × G1 and [(JU × ST) × (GL × CR)] × ES exhibited the fiber fineness between 5.06 and 5.13 (mic.), other 11 cross combinations had coarse fibers. The fiber fineness of Carisma was considerably finer, and it was seen that three combinations with acceptable fibers have Carmen in their pedigrees. All defined orthogonal contrasts for fiber fineness were significant, and the mean of crosses (5.34 min.) was coarser than the mean of all parents (4.91 min.), standard variety (Gloria; 4.88 mic.), the finest variety (Carisma; 4.61 mic.). These findings indicated that our hybrid population evolved in the direction of coarse fibers. The significant association between ginning out-turn and fiber fineness (Saeed et al., 2014) indicated that coarse fibers could arise from high ginning out-turn in cotton breeding. As Çakmak et al. (2023) emphasized, ginning out-turns should be kept at a certain level to obtain fiber fineness values between certain limits.

Table 2. Mean values of the grandparents, parents, and cross combinations.
Çizelge 2. Ebeveynler ve melez kombinasyonlara ilişkin ortalama değerler

	SCY	GOT	FL	FF	FS
Combinations					
[(CA × ST) × (ST × CL)] × ES	56.60 de	43.78 e-g	28.77	5.48 a-c	31.13 b-g
[(CA × ST) × (ST × CL)] × G1	53.66 fg	45.62 c	30.74	5.32 a-f	29.60 g
[(JU × ST) × (GL × CR)] × ES	60.58 c	43.32 g	29.87	5.13 b-h	31.10 b-g
[(JU × ST) × (GL × CR)] × G1	60.50 c	46.16 bc	29.45	5.38 a-e	30.90 d-g
[(CR × CA) × (GL × FL)] × ES	54.44 e-g	45.63 c	28.76	5.58 a	31.23 b-g
[(CR × CA) × (GL × FL)] × G1	66.90 b	45.01 d	29.22	5.45 a-d	30.17 e-g
[(JU × ST) × (CR × CA)] × ES	65.59 b	43.47 fg	28.71	5.15 b-h	31.37 b-g
[(JU × ST) × (CR × CA)] × G1	57.76 d	48.00 a	29.36	5.41 a-e	31.00 c-g
[(ST × CL) × (GL × CR)] × ES	73.89 a	43.95 of	29.08	5.06 e-h	32.50 a-d
[(ST × CL) × (GL × CR)] × G1	54.04 fg	45.84 c	30.87	5.12 b-h	31.63 b-g
[(GL × FL) × (GL × CR)] × ES	62.78 c	44.10 e	29.50	5.49 ab	32.13 a-e
[(GL × FL) × (GL × CR)] × G1	66.97 b	47.84 a	29.47	5.58 a	30.93 d-g
[(CA × ST) × (GL × FL)] × ES	57.74 d	43.67 e-g	30.06	5.40 a-e	31.63 b-g
[(CA × ST) × (GL × FL)] × G1	56.59 de	46.65 b	30.33	5.22 a-g	31.70 b-f
Grandparents					
ST-468 (ST)	61.53 cd	42.71 hı	28.63	5.10 d-h	30.37 e-g
GLORIA (GL)	61.30 c	41.37 j	30.15	4.88 g-ı	30.70 d-g
FLASH (FL)	53.28 g	40.73 k	29.94	4.89 g-ı	29.83 fg
CARISMA (CR)	53.21 g	42.45 ı	28.88	4.64 ı	30.40 e-g
JULIA (JU)	48.60 h	41.64 j	29.86	5.11 c-h	33.13 ab
CARMEN (CA)	47.11 h	41.83 j	30.87	4.83 h-ı	33.03 a-c
CLAUDİA (CL)	49.32 h	43.31 gh	30.12	4.96 f-ı	33.90 a
Parents					
Genotype-I (G1)	55.70 d-f	46.11 bc	29.64	4.84 h-ı	30.57 d-g
ESPERIA (ES)	71.82 a	43.66 e-g	28.87	4.97 f-ı	30.87 d-g
LSD (0.05)	2.33	0.61	-	0.38	2.05

SCY: Seed cotton yield (g); GOT: Ginning out-turn (%); FL: Fiber length (mm); FF: Fiber fineness (micronaire); FS: Fiber strength (g tex^{-1}).

Table 3. The significance of orthogonal contrasts
Çizelge 3. Ortogonal karşılaştırmaların önemliliği

	Orthogonal contrasts	SCY	GOT	FL	FF	FS
C_1	Esperia crosses vs. Genotype-I crosses		**			
C_2	All crosses vs. mean of Esperia and Genotype-I		**			
C_3	All crosses vs. all parents	**	**	ns	**	ns
C_4	Esperia crosses vs. best variety		**			
C_5	Genotype-I crosses vs. best variety		ns			
C_6	All crosses vs. best variety		**			
C_7	All crosses vs. check variety (Gloria)	**	ns	ns	**	ns
C_8	All crosses vs. best variety	**	ns	*	**	**

*: Significant at $P < 0.05$ and **: Significant at $P < 0.01$. SCY: Seed cotton yield (g); GOT: Ginning out-turn (%); FL: Fiber length (mm); FF: Fiber fineness (micronaire); FS: Fiber strength (g tex^{-1}).

Table 4. Standard heterosis (%)
Çizelge 4. Standart heterosis değerleri (%)

Combinations	SCY	GOT	FL	FF	FS
[(CA × ST) × (ST × CL)] × ES	-7.66**	5.83	-4.59	12.36**	1.41
[(CA × ST) × (ST × CL)] × G1	-12.47**	10.27**	1.97	8.95*	-3.58
[(JU × ST) × (GL × CR)] × ES	-1.17	4.71	-0.94	5.05	1.30
[(JU × ST) × (GL × CR)] × G1	-1.31	11.58**	-2.33	10.25**	0.65
[(CR × CA) × (GL × FL)] × ES	-11.19**	10.30**	-4.62	14.41**	1.74
[(CR × CA) × (GL × FL)] × G1	9.14**	8.80**	-3.10	11.61**	-1.74
[(JU × ST) × (CR × CA)] × ES	7.00**	5.08	-4.79	5.60	2.17
[(JU × ST) × (CR × CA)] × G1	-5.78**	16.03**	-2.62	10.79**	0.98
[(ST × CL) × (GL × CR)] × ES	20.54**	6.24*	-3.56	3.62	5.86
[(ST × CL) × (GL × CR)] × G1	-11.84**	10.80**	2.39	4.85	3.04
[(GL × FL) × (GL × CR)] × ES	2.41	6.60*	-2.14	12.50**	4.67
[(GL × FL) × (GL × CR)] × G1	9.25**	15.64**	-2.27	14.28**	0.76
[(CA × ST) × (GL × FL)] × ES	-5.81**	5.56	-0.30	10.66**	3.04
[(CA × ST) × (GL × FL)] × G1	-7.68**	12.76**	0.61	7.04	3.26

*: Significant at $P < 0.05$ and **: Significant at $P < 0.01$. SCY: Seed cotton yield (g); GOT: Ginning out-turn (%); FL: Fiber length (mm); FF: Fiber fineness (micronaire); FS: Fiber strength (g tex^{-1}).

Fiber Strength

The use of favorable fiber strength improved both ring- and open-end spinning and yarn strength (Simpson & Murray, 1978), and modern textile industries demand stronger, longer, finer, and more uniform cotton fibers (Chapara & Madugula, 2021). In our study, the highest fiber strength recorded in 32.50 g tex^{-1} [(ST × CL) × (GL × CR)] × ES and 32.13 g tex^{-1} [(GL × FL) × (GL × CR)] × ES cross combinations, while Claudia (33.90 g tex^{-1}), Julia (33.13 g tex^{-1}) and Carmen (33.03 g tex^{-1}) were the grandparents with the highest fiber strength (Table 2). When the mean of all crosses (31.22 g tex^{-1}) was compared with the grand mean of parents (31.42 g tex^{-1}) and check variety, Gloria (30.70 g tex^{-1}), the differences were nonsignificant as confirmed by orthogonal comparisons (C_3 and C_7), whereas all cross combinations performed poorly against the best variety, Claudia (C_8) (Table 3). The standard heterosis of all cross combinations except [(CA × ST) × (ST × CL)] × G1 and [(CR × CA) × (GL × FL)] × G1 indicated that a certain genetic improvement over 31.0 g tex^{-1} was achieved in the cross population (Table 4). Sirisha et al. (2019) mostly detected positive standard heterosis between -6.52% and 13.94%. In a study evaluating the mean performances and standard heterosis for fiber strength, Chapara & Madugula (2021) reported performance between 25.20 - 31.15 g tex^{-1} and significant and positive standard heterosis in only 2 of the 20 crosses. When the findings of our study and related literature are evaluated together, standard heterosis varies widely, depending on the performance of the parents used and the standard variety used.

CONCLUSIONS

The F_1 cross combinations of double cross F_3 populations with variety (Esperia) or advanced line (Genotype-I) were successful in terms of seed cotton yield and ginning out-turn, whereas cross combinations have evolved in the direction of coarse fiber, and improvement in fiber length and strength was limited. It was concluded that optimizing yield, ginning out-turn and fiber quality is a challenge for cotton breeding. Based on this information, [(ST-468 × Claudia) × (Gloria × Carisma)] × Esperia with high yielding, medium-high ginning out-turn, fiber fineness of 5.06 mic, fiber length of 29.08 mm and fiber strength of 32.50 g tex^{-1} should be evaluated in advanced generations. Genotype-I could be used as a parent in breeding programs, aiming to increase ginning out-turn. However, [(Gloria × Flash) × (Gloria × Carisma)] × Genotype-I and [(Carisma × Carmen) × (Gloria × Flash)] × Genotype-I hybrids have high ginning out-turn, medium-high seed cotton yield but coarse fibers. It would be beneficial to cross these genotypes with *Gossypium hirsutum* L., *Gossypium barbadense* L., or a hybrid of two species, which can adapt in terms of fine fiber.

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Contribution of the Authors as Summary

The authors declare the contribution of the authors is equal.

Statement of Conflict of Interest

The authors have declared no conflict of interest.

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