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INHERITANCE OF MORPHO-ECONOMIC TRAITS AND COMBINING ABILITY ANALYSIS IN INTRASPECIFIC HYBRIDS OF *GOSSYPIUM BARBADENSE* L.

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SUMMARY

In intraspecific F_1 diallel hybrids of *Gossypium barbadense* L., the inheritance study of traits plant height, boll weight, plant productivity, and 1000-seed weight, with combining ability analysis took place in 2020–2022 at the Institute of Genetics and Plant Experimental Biology, Academy of Sciences, Uzbekistan**.** These polygenic traits' inheritance showed different ways in the fine-fiber cotton F_1 hybrids. The plant height trait's inheritance with overdominance and intermediate level of the high/low-performance cultivars. The boll weight trait was mainly in negative overdominance with incomplete dominance of the low-performance cultivar. The inheritance of seed cotton yield had the positive overdominance main control, while the 1000-seed weight had negative and positive overdominance. According to combining ability analysis, the highest positive general combining ability effects resulted in fine-fiber cotton cultivars Surkhan-14 ($\hat{g}i$ = 8.71) and Bo'ston ($\hat{g}i$ =1.86) for plant height, Guzor ($\hat{g}i$ = 0.12) for boll weight, in genotypes Marvarid ($\hat{g}i$ = 2.44) and Surkhan-14 ($\hat{g}i$ = 2.95) for plant productivity, and in cultivars Marvarid ($\hat{g}i$ = 2.3) and Guzor ($\hat{g}i$ = 2.8) for 1000-seed weight. The F_1 hybrids Guzor × Surkhan-14, Marvarid × Bo'ston, and Bo'ston × Surkhan-14 showed the highest positive and desirable specific combining ability effects for 1000-seed weight and seed cotton yield. Results concluded that fine-fiber cotton cultivars Marvarid, Surkhan-14, and Guzor can benefit as initial breeding material in selecting high-yielding cotton cultivars.

Keywords: *G. barbadense* L., cotton cultivars, F_1 diallel hybrids, inheritance, heterosis, combining ability, yield traits, cotton productivity

Key findings: Results authenticated that it is feasible to use fine-fiber cotton cultivars Marvarid, Surkhan-14, and Guzor as initial genetic material in selecting high-yielding cotton cultivars.

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INTRODUCTION

Cotton is the foremost cash and industrial crop grown in many countries. The growing population has greater demand for cotton fiber and its byproducts, equally with food sources. Cotton was before and still is the most valuable and popular crop providing natural fiber for the textile industry (Akter *et al*., 2019; Shavkiev *et al*., 2021; Matniyazova *et al*., 2022). The most crucial tetraploid species of cotton are *G. hirsutum* L. and *G. barbadense* L. (Rehman *et al*., 2020). Cultivars of these two species' cultivation covers 80% of cotton fields in the world (Imran *et al*., 2012). About 90% of the world's cotton crop comes from *G. hirsutum* L. cultivars, with only 3% of the fiber produced by cultivars of *G. barbadense* L. (Fang *et al*., 2017). In the international cotton market, the fiber of cotton cultivars belonging to *G. barbadense* L. is valued more expensive than the medium fiber cultivars of *G. hirsutum* L.

Recently various types of scientific and practical research on *G. barbadense* L. has taken place in Uzbekistan (Khudarganov and Usmanov, 2015; Avtonomov *et al*., 2017; Nabiyev *et al*., 2020; Amanov and Abdiev, 2021). At present, the Government of Uzbekistan delivered the task of developing new fine-fiber cotton cultivars as defined in the following decisions. Decree of the President of the Republic of Uzbekistan No. PQ-170 dated 18 March 2022, "On measures to improve the system of implementation of fine-fiber cotton cultivars in Surkhandarya region on a scientific basis" and No. PQ-206 dated 28 January 2022, "Addition on the further development of seed production of crops."

Cotton cultivars belonging to the fine-fiber species *G. barbadense* L. are very demanding based on their biological characteristics and heat tolerance, grown in small areas in the Southern regions of Uzbekistan. Establishing the cultivation of fine fiber cotton will highly benefit and boost the country's national economy. Therefore, the development of early-maturing and high-yielding cultivars with good fiber quality of *G. barbadense* L. crucially needs action along with the expansion of cultivated areas that play an essential role in the national economy (Abdullaev *et al*., 2013; Zhang *et al*., 2017).

Several studies are progressive to assess the unused genetic variability of cotton genotypes and to develop new cotton cultivars worldwide (Yehia and El-Hashash, 2019). In the selection process, attaining increased productivity through collecting genes leads to high productivity and eliminating the genes with negative consequences in Egyptian cotton (Abdel-Monaem *et al*., 2020). A result of the scientific research conducted by Shavkiev (2022) developed the fine cotton cultivar 'Boston' from the line T-663 based on cross combination through hybridization of Bukhara-7 × Surkhan-9 and the cotton cultivar 'Durdona-2' from the line T-77 obtained based on the hybrid combination (8763-I × Karshi-8), then, put into cultivation.

Boyxona *et al*. (2021) finding revealed that the cotton F_1 hybrid combinations 6465-V × L-130 and 9280-I × L-130 exhibited significant heterosis for the fiber length, and their indicators were 2.6 and 1.6, respectively. The F_2 populations 6465-V × L-130, 6465-V × L-160, 9280-I × L-130, and 9280-I × L-160 provided the highest heritability coefficient of 0.82, 0.81, 0.88, and 0.80, respectively, and they recommended that breeders should select individual plants with high fiber length in the F_2 segregating populations. Past studies enunciated that it is possible to obtain valuable resources with helpful traits based on intraspecies, interspecies, and cultivars hybridization in cotton (Jawahar and Patil, 2017).

Comparing genetic variability, combining ability, and heterotic values in F_1 and F_2 populations, and greater use of F_2 hybrids proved effective in increasing the seed cotton yield in upland cotton (Chen *et al*., 2022). Hybrids showed higher heterosis values for vegetative, generative, and stress tolerance traits than parental cultivars (Shahzad *et al*., 2019). The use of hybrids in crops, including rice (Li *et al*., 2016), maize and tomato (Yu *et al*., 2020, 2021), and turnip (Singh *et al*., 2019) enhanced productivity. With heterosis, the yield increased by 10%–20% compared with common cultivars of rice (Luo *et al*., 2013). In addition, the hybrid climate is highly adaptable and stable to changing nature and climatic conditions in upland cotton (Shahzad *et al*., 2019).

Many breeders aim to use F_2 populations because these segregating hybrids are relatively cheap and can grow in several environmental conditions. According to past findings, F_2 populations showed more competition than the parental cultivars in cotton (Meng *et al*., 2019; Chen *et al*., 2021). Notably, the analysis used to evaluate the combining ability of cultivars helped to discuss the interaction of genes and their importance in the inheritance of quantitative traits. Cultivating fine-fiber cotton cultivars, processing their high-quality fiber, and cloth and textile products will surely benefit the state economy. In achieving these goals, it is vital to develop early-maturing and high-yielding cotton cultivars with desirable fiber-quality traits and expand their cultivated areas (Avtonomov *et al*., 2017; Zhang *et al*., 2017; Amanov *et al*., 2020; Nabiyev *et al.*, 2020; Amanov *et al*., 2022; Shavkiev *et al*., 2022; Makamov *et al*., 2023).

A review of the literature on cotton economic traits shows conflicting conclusions; hence, these issues require further study in various genotypes of *G. barbadense* L. Based on earlier discourse, it is earnestly needed to introduce new cotton varieties into hybridization, genetic analysis of inheritance, and variability of morpho-economic traits in hybrids to create new fine-fiber, early-ripening, and high-yielding cultivars. Therefore, the presented study aimed to determine the inheritance of yield-related traits and carry out the combining ability analysis in intraspecific F_1 diallel hybrids of *G. barbadense* L. to develop some new promising variants.

MATERIAL AND METHODS

Plant material and growing conditions

The presented research happening in 2020–2022 ran at the experimental field Zangiota, Institute of Genetics and Plant Experimental Biology, Academy of Sciences, Uzbekistan. The soil was a typical gray loam, non-saline, with a deep groundwater table (more than 8.0 m). Agrotechnical activities ensured good growth and development of plants. Generally, the temperature increases in April during the cotton sowing season and decreases in late September before the harvest period. Five local cultivars of *G. barbadense* L., i.e., Marvarid, Guzor, Bo'ston, Surkhan-14, and L-167, and their F_1 diallel hybrids, served as breeding materials. The study team grew each parental cultivar and F_1 hybrid in a randomized complete block design with three replications and recommended cotton production technology.

Statistical analysis

The dominance coefficient in F_1 hybrids determination was according to Beil and Atkins (1965):

$$hp = \frac{F_1 - MP}{P - MP}$$

Where:
hp – dominance coefficient;
F_1 – mean of the hybrid;
MP – mean of both parents;
P – mean of the best parents.

The recorded data gained further analysis by dispersion, the reliability of differences between cultivars and hybrids using Fisher's criterion (F), total mistake of the experiment ($S\bar{x}$), error of the mean (S_d), and the minimum difference ($LSD_{0.05}$) determined by the level of reliability for 95%. Moreover, the data obtained for each trait underwent statistical analysis using the modern analysis of variance with the ANOVA program (Dospexov, 1985). Litun and Proskurin (1992) reported that Griffing combining ability is widely used in practical selection to determine combining ability (Griffing, 1956).

Estimates of variation on all the diallel types due to the F_1 hybrids received further partitioning into sources from GCA and SCA. Therefore, the differences among the diallel were according to whether parents or reciprocal effects gained inclusion in the model.

The reciprocal crosses estimate the variation according to material effects coming for some traits. A relatively higher GCA/SCA variance ratio demonstrates the importance of additive genetic effects, and a lower ratio indicates the predominance of dominance and epistatic gene effects. Calculating GCA and SCA effects for the individual parental line followed after confirming the significant mean squares due to GCA and SCA.

RESULTS AND DISCUSSION

Inheritance of cultivars and hybrids

Assessment of paternal dominance and heritability in the inheritance of F_1 hybrid traits provides relevant information. It is necessary to comprehensively study the laws of inheritance of morphological features in F_1 hybrids for the successful conduct of cotton genetics and selection. Therefore, the presented research determined the genetic-selection indicators for the studied characters in F_1 hybrids of fine-fiber local cotton (*G. barbadense* L.) cultivars. Khudarganov and Usmanov's (2015) studies revealed that the trait weight boll, inherited with an intermediate value of heredity in the F_1 generations. Amanturdiev (2021) observed that agronomic traits in F_1 hybrids' inheritance were partial, dominance, and overdominance of gene action.

Among all studied parental cultivars, the cultivar Marvarid had the highest plant height (100.0 cm), with relatively shorter plants observed in cultivar L-167 (88.0 cm) (Table 1). Among the F_1 hybrids, the maximum plant height observed was in the four cross combinations Surkhan-14 × Marvarid (121.7 cm), Surkhan-14 × Bo'ston (110.0 cm), Surkhan-14 × Guzor (103.8 cm), and Guzor × Surkhan-14 (102.9 cm). However, plants with the minimum plant height were usually in the hybrid combinations obtained with the participation of the parental cultivar L-167.

Inheritance of the plant height trait with negative overdominance occurred in 11 out of 20 F_1 hybrids, six with positive overdominance, and two were incomplete dominance of the taller cotton cultivar (Table 1). Dominance did not show in F_1 hybrid Guzor × Marvarid combination. When crossing the tallest cultivar Marvarid with the medium-high cultivar Guzor, an extreme dominance of the cultivar Guzor was distinct in the correct hybrid combination, but the dominance state did not exhibit in the reverse crossing.

Crossing cultivar Bo'ston and Surkhan-14, which do not differ significantly from each other for this trait, the cultivar Bo'ston was extremely dominant (hp = 5.3) for inheritance in the cross combination Bo'ston × Surkhan-14 and its reciprocal Surkhan-14 × Bo'ston, noting the superiority of the cultivar Bo'ston (hp = 26.5). The cultivar Guzor crossed with the cultivar Bo'ston differed sharply in plant height. In the F_1 hybrid Guzor × Bo'ston, the cultivar Guzor inherited with extreme dominance (hp = -6.0), while in the reciprocal cross, the cultivar Bo'ston inherited with dominance (hp = 1.5).

Thus, in F_1 hybrids of fine-fiber cotton cultivars, inheritance in the plant height trait was with overdominance and the intermediate position of the high/low performance depending on the parental cultivars. The cultivar Surkhan-14 crossing with cultivars Bo'ston and Guzor and the cultivar Bo'ston with Marvarid showed reciprocal differences in the direct and reverse combinations, indicating the said trait has nuclear and cytoplasmic genes controlling it.

Among the cultivars, the highest boll weight recorded was in cultivars Bo'ston, Surkhan-14, and Guzor (3.71 g, 3.63 g, and 3.62 g, respectively) (Table 1). In the F_1 hybrids, the highest boll weight resulted in the reciprocal cross combination obtained by crossing the cultivar Marvarid with Guzor (3.82 g and 3.80 g, respectively). In addition, ranking the hybrids with the highest boll weight were as follows: Guzor × Surkhan-14, Bo'ston × Marvarid, Marvarid × Bo'ston, Bo'ston × Guzor, and Bo'ston × Surkhan-14 (3.73 g, 3.63 g, 3.59 g, 3.56 g, and 3.55 g, respectively). Relatively low values for boll weight showed in cultivars L-167 and Marvarid (3.54 g and 3.51 g, respectively), and F_1 hybrids L-167 × Marvarid (3.07 g), L-167 × Surkhan-14 (3.02 g), and L-167 × Marvarid (3.07 g).

Table 1. Inheritance of plant height and boll weight and heterotic effects in fine-fiber cotton F_1 hybrids.

No.	Parental cultivars and F_1 hybrids	Plant height (cm)			Boll weight (g)		
		$\bar{x}$	Hp	Heterosis (%)	$\bar{x}$	Hp	Heterosis (%)
1	Marvarid	100.0			3.51		
2	Guzor	92.0			3.62		
3	Bo’ston	99.8			3.71		
4	Surxon-14	99.0			3.63		
5	L-167	88.0			3.54		
6	Marvarid × Guzor	87.4	-2.15	95.0	3.80	4.6	105.0
7	Marvarid × Bo’ston	92.8	-71.0	93.0	3.59	-0.2	-
8	Marvarid × Surxon-14	94.8	-9.4	-	3.34	-3.8	-
9	Marvarid × L-167	76.5	-2.9	86.9	3.20	-33.0	91.1
10	Surxon-14 × Marvarid	121.7	44.4	122.9	3.32	-4.2	-
11	Surxon-14 × Bo’ston	110.0	26.5	110.2	3.34	-8.3	92.0
12	Surxon-14 × Guzor	103.8	2.4	-	3.31	-0.3	-
13	Surxon-14 × L-167	94.6	0.2	-	3.46	-3.3	-
14	L-167 × Guzor	80.0	-5.0	90.9	3.34	-2.4	94.4
15	L-167 × Bo’ston	80.4	-2.3	91.4	3.02	-7.6	85.3
16	L-167 × Marvarid	70.5	-3.9	80.1	3.07	-46.0	86.7
17	L-167 × Surxon-14	84.1	-1.7	-	2.87	-18.0	81.1
18	Guzor × Surxon-14	102.9	2.1	-	3.73	0.1	-
19	Guzor × L-167	76.3	-6.7	86.7	3.24	-8.5	91.5
20	Guzor × Bo’ston	72.5	-6.0	78.8	3.54	-3.3	-
21	Guzor × Marvarid д	96.0	0.0	-	3.82	5.0	105.0
22	Bo’ston × Surxon-14	101.5	5.3	-	3.55	-3.0	-
23	Bo’ston × Guzor	101.7	1.5	-	3.56	-2.75	-
24	Bo’ston × L-167	96.3	0.4	-	3.25	-4.75	91.8
25	Bo’ston × Marvarid	88.1	-118.0	88.3	3.63	0.2	-
$LSD_{0.05}$		6.2			0.2		

Boll weight inherited with negative super dominance was in 14 out of 20 F_1 hybrids, in two with incomplete dominance of low-performance cultivar, in two with incomplete dominance of high-performance cultivar, and in two hybrids with positive super dominance (Table 1). Crossing cultivars Guzor and Surkhan-14 (having the same boll weight) resulted in the inheritance of said trait with incomplete dominance of the low- and high-value cultivars in reciprocal crosses (hp = -0.3, hp = 0.13). Combining cultivars Marvarid and Guzor differed for boll weight came up with the extreme dominance (hp = 4.6) of the cultivar Guzor with relatively large pockets in the F_1 hybrid Marvarid × Guzor, while extreme positive dominance (hp = 5.0) in F_1 reciprocal hybrid Guzor × Marvarid. Thus, inheriting the boll weight trait in the F_1 hybrids was with negative super dominance and incomplete dominance of the low-value cultivar.

According to plant productivity data, the cultivar Bo'ston had the highest seed cotton yield (56.6 g plant) of the studied fine-fiber cotton cultivars (Table 2). The said promising cultivar had cultivars Guzor, Marvarid, Surkhan-14, and L-167, following closely with values of 55.0, 52.4, 51.3, and 54.2 g, respectively. The plant productivity trait’s inheritance with positive super dominance resulted in 14 out of 20 F_1 hybrids, with negative super dominance in five, and incomplete dominance of the high-performing L-167 line in F_1 hybrid L-167 × Surkhan-14. In the reciprocal cross combinations of cultivars Surkhan-14, Marvarid, and Guzor, the plant productivity trait displayed a positive super dominance of inheritance. Negative super dominance occurred in the reciprocal cross of cultivars Guzor and Bo'ston (both at par for the said traits). Thus, the inheritance of the plant productivity was mainly in the positive super

Table 2. Inheritance of plant productivity and 1000-seed weight and heterotic effects in fine-fiber cotton F_1 hybrids.

No.	Parental cultivars and F_1 hybrids	Plant productivity (g plant^{-1})			1000-seed weight (g)		
		$\bar{x}$	Hp	het, %	$\bar{x}$	Hp	het, %
1	Marvarid	52.4			120.0		
2	Guzor	55.0			121.0		
3	Bo’ston	56.6			123.0		
4	Surxon-14	51.3			117.0		
5	L-167	54.2			118.0		
6	Marvarid × Guzor	76.4	15.3	138.9	119.0	-3.0	-
7	Marvarid × Bo’ston	76.1	10.3	134.5	123.0	1.0	-
8	Marvarid × Surxon-14	62.6	21.4	119.5	119.0	0.33	-
9	Marvarid × L-167	59.9	7.3	110.5	117.0	-1.0	-
10	Surxon-14 × Marvarid	61.8	19.8	117.9	116.0	-1.67	-
11	Surxon-14 × Bo’ston	50.1	-1.5	-	99.0	-7.0	84.6
12	Surxon-14 × Guzor	73.5	11.3	133.6	116.0	-1.5	-
13	Surxon-14 × L-167	54.7	1.4	-	121.0	7.0	102.5
14	L-167 × Guzor	59.6	12.5	108.4	117.0	-1.7	-
15	L-167 × Bo’ston	43.5	-9.9	80.2	108.0	-5.0	91.5
16	L-167 × Marvarid	44.9	-9.3	85.7	121.0	2.0	-
17	L-167 × Surxon-14	53.4	0.4	-	110.0	-15.0	94.0
18	Guzor × Surxon-14	70.3	9.5	127.8	123.0	2.0	-
19	Guzor × L-167	55.4	2.0	-	110.0	-6.3	93.2
20	Guzor × Bo’ston	40.9	-18.6	74.4	124.0	2.0	-
21	Guzor × Marvarid д	62.2	6.5	113.1	128.0	15.0	105.8
22	Bo’ston × Surxon-14	89.7	13.7	158.5	117.0	-1.0	-
23	Bo’ston × Guzor	40.1	-19.6	72.9	129.0	7.0	104.9
24	Bo’ston × L-167	63.2	6.5	111.7	114.0	-2.6	96.6
25	Bo’ston × Marvarid	64.9	5.0	114.7	120.0	-1.0	-
$LSD_{0.05}$		3.5			3.0		

dominance state in the F_1 cross combinations of the studied fine-fiber cotton cultivars.

In F_1 hybrid Bo'ston × Surkhan-14, the heterosis was 158.5% for plant productivity, making this a promising cross combination for use in heterotic selection for improving fine fiber productivity (Table 2). Crossing cultivar Marvarid with cultivars Guzor, Bo'ston, and L-167 and the resulting reciprocal differences in the mean values for plant productivity, in cultivars Surkhan-14 and Boston and line L-167, the cytoplasmic genes in addition to nuclear genes determined inheritance of the seed cotton yield.

This study further determined the 1000-seed weight in the parental cultivars and F_1 hybrids (Table 2). The heaviest seeds recorded resulted in the cultivar Bo'ston (123.0 g), whereas the smallest were in Surkhan-14 (117.0 g). However, no reliable difference appeared between the cultivars Guzor and Marvarid based on the average seed index. In reciprocal combinations of cultivars Bo'ston and Guzor, as well as in F_1 hybrids Guzor × Marvarid and Marvarid × Bo'ston combinations, the seeds were heavy, and the 1000-seed weight amounted to 123.0–129.0 g.

In the direct hybrid combination of the cultivar Surkhan-14 with Marvarid, the 1000-seed weight ranged from 99.0 to 116.0 g. For direct hybrid combinations Surkhan-14 x Marvarid and Bo'ston × Surkhan-14, the 1000-seed weight was 116 and 117 g, respectively. In the reciprocal cross combinations Marvarid × Surkhan-14, Guzor × Surkhan-14, and Guzor × Bo'ston, the 1000-seed weight values were 119, 123, and 124 g, respectively (Table 2). The inheritance of 1000-seed weight trait by 20 F_1 hybrids displayed in nine with negative super dominance, six with positive super dominance, three with complete dominance of the low-performing cultivar, one with the high-performing cultivar, and one with incomplete dominance of the high-performing cultivar. Thus, in the intervarietal F_1 hybrids of *G. barbadense* L., inheriting the trait of 1000-seed weight exhibited different levels of negative and positive super dominance.

Statistically, the F_1 hybrids of cultivars Marvarid and Guzor were not significantly different from each other, and the 1000-seed weight was 119.0 g inherited with the dominance coefficient (hp = -3.0), with the character's inheritance in the state of extreme negative dominance (Table 2). The effect of weak heterosis for 1000-seed weight was evident only in three cross combinations, i.e., Surkhan-14 × L-167 (102.5%), Bo'ston × Guzor (104.9%), and Guzor × Marvarid (105.8%). It shows that the effect of heterosis according to the 1000-seed weight was not very distinctive for intraspecific F_1 hybrids of *G. barbadense* L.

Results of crossing cultivar Marvarid with Guzor and L-167 line; cultivar Surkhan-14 with Bo'ston, Guzor, and L-167, and line L-167 with Surkhan-14, Guzor, and Bo'ston revealed there were reciprocal differences in the average 1000-seed weight. This situation indicates the involvement of both cytoplasmic and nuclear genes in the genetic control of the 1000-seed weight in these cotton F_1 hybrids.

Combining ability analysis

Combining ability is one of the influential biometrical analyses, which evaluates the ability to transmit the necessary characters and whether the hybrid combinations are beneficial. It helps to select the required parental genotypes and their new recombinations to increase the efficiency of breeding programs (Liu *et al*., 2019; Shi *et al*., 2021). Several studies have evaluated parental cultivars and their hybrid populations' general and specific combining abilities and identified the best donors for genetic improvement in cotton (Abro *et al*., 2009; Karademir *et al*., 2009; Singh *et al*., 2010).

General combining ability effects

The analysis of variance validated significant differences among the cultivars in terms of general combining ability (GCA). Determining the GCA effects among the cultivars for various traits followed. In the study, the cotton cultivars showed significantly different GCA effects on plant productivity (Table 3). A high positive GCA effect resulted in cultivars Surkhan-14 (ĝi = 8.71) and Bo'ston (ĝi = 1.86). Notably, having a positive index of GCA means that the additive gene effects mainly controlled said trait.

However, the recorded lowest and highest negative GCA effects occurred in line L-167 (ĝi = -8.96) and cultivar Guzor (ĝi = -1.97) (Table 3). In these genotypes, the average plant height values were 88.0 cm and 92.0 cm, respectively, which reveals that the recessive genes mainly controlled the productivity in these cultivars. A high positive GCA effect obtained for boll weight was in cultivar Guzor (ĝi = 0.12), with a boll weight of 3.62 g (Table 3). The other cotton cultivars, Bo'ston and Marvarid, have the GCA efficiency values of ĝi = 0.05 and ĝi = 0.06, respectively. Possibly, the highest negative GCA effect emerged in line L-167 (ĝi = -0.18) and cultivar Surkhan-14 (ĝi = -0.02). Cultivars Guzor, Bo'ston, and Marvarid, which have a high efficiency of GCA for boll weight, can serve as valuable donors in selecting cotton genotypes with sizable bolls.

The fiber cotton cultivars revealed significantly different GCA effects for plant productivity (Table 3). Cultivars Surkhan-14 (ĝi = 2.95) and Marvarid (ĝi = 2.44) recorded high positive GCA effects for seed cotton yield per plant. Notably, on average, the GCA effects were higher in these cultivars than in the other three. The lowest and highest negative GCA efficiency recording was in L-167 (ĝi = -4.6), followed by cultivars Bo'ston and Guzor with GCA effects, i.e., ĝi = -0.73 and ĝi = -0.06, respectively. Bear in mind that having a positive index of GCA means that the additive genes mainly controlled the trait.

Table 3. General and specific combining ability effects of fine fiber cotton parental cultivars and their F_1 hybrids, respectively, for plant height, boll weight, plant productivity, and 1000-seed weight.

♂ ♀	Marvarid	Guzor	Bo'ston	Surxon-14	L-167	ĝi
Plant height						
Marvarid	-	-0.9	-4.19	-10.32	-3.35	0.35
Guzor	-	-	6.76	-5.22	2.75	-1.97
Bo'ston	-	-	-	4.18	3.02	1.86
Surxon-14	-	-	-	-	-2.83	8.71
L-167	-	-	-	-	-	-8.96
Boll weight						
Marvarid	-	0.21	0.08	-0.13	-0.18	0.06
Guzor	-	-	-0.06	-0.02	-0.09	0.12
Bo'ston	-	-	-	-0.02	-0.17	0.05
Surxon-14	-	-	-	-	-0.07	-0.02
L-167	-	-	-	-	-	-0.18
Plant productivity						
Marvarid	-	8.02	9.89	-2.19	-4.34	2.44
Guzor	-	-	-17.61	10.11	3.26	-0.06
Bo'ston	-	-	-	8.78	-0.17	-0.73
Surxon-14	-	-	-	-	-3.15	2.95
L-167	-	-	-	-	-	-4.6
1000-Seed weight						
Marvarid	-	0.4	1.2	1.3	-4.7	2.3
Guzor	-	-	-0.3	5.7	-7.5	2.8
Bo'ston	-	-	-	1.2	-4.4	0.0
Surxon-14	-	-	-	-	2.6	-2.5
L-167	-	-	-	-	-	-2.6

Results discovered that fine-fiber cotton cultivars Marvarid and Surkhan-14 suit as initial materials in selecting high-yielding cotton cultivars (Table 3). The at par and average plant productivity values of three cotton cultivars, Guzor, Bo'ston, and line L-167, were 55.0, 56.6, and 54.2 g, with negative GCA effects -0.06, -0.73, and -4.6, respectively. Despite the mean values, the cultivars Guzor, Bo'ston, and line L-167 showed low and negative values of GCA efficiency. It means that recessive genes highly controlled productivity in these cultivars.

In the fine-fiber cotton cultivars for 1000-seed weight, the highest positive GCA effects emerged in cultivars Marvarid (ĝi = 2.3) and Guzor (ĝi = 2.8) (Table 3). On average, the GCA values in these promising cultivars were also higher than other cultivars for 1000-seed weight. The cultivar Surkhan-14 (ĝi = -2.5) and line L-167 (ĝi = -2.6) gave the lowest and highest negative GCA effects. General combining ability (GCA) shows the average values of the parental genotypes in the hybrids and mainly predicts the role of additive genes in managing the inheritance and variation of the traits (Liu *et al*., 2019; Khamdullaev *et al*., 2021). High levels of GCA and heritability enhance the probability of selecting a hybrid with high trait values in the initial generations (Jia *et al*., 2017).

Specific combining ability effects

In the F_1 generation of the studied cultivars, for plant height, the highest values of the specific combined ability (SCA) effects resulted in F_1 hybrids, i.e., Guzor × Bo'ston ($\hat{s}_{ij}$ = 6.76), Bo'ston × Surkhan-14 ($\hat{s}_{ij}$ = 4.18), Bo'ston × L-167 ($\hat{s}_{ij}$ = 3.02), and Guzor × L-167 ($\hat{s}_{ij}$ = 2.75) (Table 3). The above-mentioned hybrid combinations had the SCA indicated positive, whereas all other cross-combinations revealed negative SCA effects. The lowest and highest negative SCA value occurred in the F_1 hybrid Marvarid × Surkhan-14 ($\hat{s}_{ij}$ = -10.32). For boll weight, positive SCA values observed were in two F_1 hybrids, viz., Marvarid × Guzor ($\hat{s}_{ij}$ = 0.21) and Marvarid × Bo'ston ($\hat{s}_{ij}$ = 0.08), and all other cross combinations revealed negative SCA effects.

In the F_1 hybrids for plant productivity, the highest SCA values appeared in F_1 hybrids, i.e., Guzor × Surxon-14 ($\hat{s}_{ij}$ = 10.11), Marvarid × Bo'ston ($\hat{s}_{ij}$ = 9.89), Bo'ston × Surkhan-14 ($\hat{s}_{ij}$ = 8.78), Marvarid × Guzor ($\hat{s}_{ij}$ = 8.02), and Guzor × L-167 ($\hat{s}_{ij}$ = 3.26) (Table 3). The above-mentioned hybrid combinations have positive and desirable SCA effects, but all other cross combinations were negative in SCA effects. The lowest and highest negative SCA value resulted in the F_1 hybrid Guzor × Bo'ston ($\hat{s}_{ij}$ = -17.61).

In F_1 hybrids of fine-fiber cotton cultivars, for 1000-seed weight the highest and positive SCA effects came from hybrids, i.e., Guzor × Surkhan-14 ($\hat{s}_{ij}$ = 5.7), Surkhan-14 × L-167 ($\hat{s}_{ij}$ = 2.6), Marvarid × Surkhan-14 ($\hat{s}_{ij}$ = 1.3), Marvarid × Bo'ston ($\hat{s}_{ij}$ = 1.2), and Bo'ston × Surkhan-14 ($\hat{s}_{ij}$ = 1.2) (Table 3). In these promising cross combinations, the SCA effects were positive, with the rest having negative SCA effects. The minimum and highest negative SCA values were from the cross combination Guzor × L-167 ($\hat{s}_{ij}$ = -7.5).

In the total variance, the additive part comprised the general combining ability, whereas the non-additive fraction consisted of the variance for specific combining ability caused by dominance and epistatic deviations (Acquaah, 2012; Sincik *et al*., 2011). Specific combining ability is a vital measure of an inbred line's ability to produce superior hybrid combinations (Zhang *et al*., 2015). The assessment of specific combining ability reflects that the average effects of hybrid combinations are mainly due to the influence of dominant and epistatic genes. Thus, evaluating SCA provides a prediction of whether the potential of hybrid combinations is in a particular generation or by environmental influence (Khan *et al*., 2015).

Assessment of genetic material with intraspecific hybridization

The research further studied the lines obtained from intraspecific hybridization for morpho-economic traits. As a continuation, the progressive research work was an offshoot from cross-breeding and selection of hybrid generations of local cultivars of fine-fiber cotton with a different genetic basis, i.e., Surkhan-9, Surkhan-10, Termiz-32, Bukhara-7, and Duru-gavhar, which have different genealogical origins. Planting lines L-449, L-450, L-451, L-452, L-453, L-479, L-480, L-481, L-536, L-537, L-563, L-564, L-596, L-631, L-632, L-634, L-663, L-669, L-735, and L-736 in the experimental field used the randomization method with three replications (Table 4).

During the study, the necessary agrotechnical measures proceeded on time. Appropriate phenological observations and calculations continued during the vegetation period. The economic traits determined in these newly developed lines were bolls per plant, boll weight, fiber yield, and 1000-seed weight. Results of these lines based on intraspecific hybrids for various traits, i.e., boll weight, fiber yield, and 1000-seed weight, are in Table 5.

Results revealed that fiber yield was low in most cotton cultivars with fine fibers (up to 33%). In the presented study, the lines T-449, T-450, T-481, T-663, T-735, T-669, T-632, T-452, and T-479 fiber yield was higher than 34%, which indicates that these lines have the potential for developing new fine-fiber cotton cultivars with higher fiber yield. One of the valuable economic characteristics, i.e., the highest 1000-seed weight, resulted in lines T-596, T-564, and T-631, with values of 145.45, 140.89, and 140.68 g, respectively. The cotton line T-481 showed the lowest value for the 1000-seed weight (110.98 g). However, the remaining lines were in the range of 116.37–136.28 g for said trait.

Table 4. Genealogy of lines obtained from intraspecific cross combinations of local fine-fiber cotton cultivars.

No.	Lines	Genesis
1	L -449	Surxon -9 × Termiz-32
2	L -450	Surxon -9 × Duru-gavxar
3	L -451	Surxon -9 × Buxoro -7
4	L -452	Surxon -9 × Buxoro -7
5	L -453	Surxon -9 × Surxon -10
6	L -479	Termiz -32 × Surxon -9
7	L -480	Termiz -32 × Surxon -9
8	L -481	Termiz -32 × Duru-gavxar
9	L -536	Termiz -32 × Surxon -10
10	L -537	Termiz -32 × Buxoro -7
11	L -563	Duru-gavxar × Termiz -32
12	L -564	Duru-gavxar × Surxon -9
13	L -596	Duru-gavxar × Buxoro -7
14	L -631	Buxoro -7 × Surxon -9
15	L -632	Buxoro -7 × Surxon -9
16	L -634	Buxoro - 7 × Termiz -32
17	L -663	Buxoro -7 × Surxon -9
18	L -669	Surxon -10 × Duru-gavxar
19	L -735	Buxoro -7 × Duru-gavxar
20	L -736	Buxoro-7 × Surxon -10

Table 5. Economic traits of fine-fiber cotton lines obtained based on intraspecific hybrids.

No.	Lines	Boll weight (g)			GOT (%)			1000-seed weight (g)		
		X	Σ	V (%)	X	σ	V (%)	X	σ	V (%)
1	L -449	3.18	0.16	4.99	35.56	1.81	4.81	126.53	5.19	4.10
2	L -450	3.70	0.26	7.04	34.19	0.68	1.94	128.97	11.64	9.02
3	L -451	3.43	0.39	11.48	28.88	9.42	32.61	131.54	3.19	2.42
4	L -453	2.79	0.36	12.92	33.99	1.96	5.17	121.63	3.65	3.00
5	L -480	3.20	0.16	5.12	33.10	1.87	5.32	121.70	11.23	9.23
6	L -481	3.56	0.17	4.82	35.77	6.82	17.15	110.98	5.82	5.24
7	L -536	3.76	0.34	9.06	33.52	3.94	10.67	117.97	7.18	6.08
8	L -537	2.91	0.10	3.57	28.47	9.77	34.33	121.95	4.97	4.07
9	L -564	3.67	0.50	13.70	33.67	5.61	14.89	140.89	3.90	2.77
10	L -563	3.22	0.20	6.35	33.76	1.89	5.27	123.83	7.69	6.21
11	L -596	3.15	0.03	0.95	30.42	4.30	14.15	145.45	4.53	3.12
12	L -663	3.35	0.26	7.87	34.14	0.69	2.03	136.28	3.79	2.78
13	L -634	3.10	0.19	5.98	33.33	1.30	3.90	119.82	4.34	3.62
14	L -735	3.02	0.45	14.85	34.98	1.12	3.11	129.49	10.02	7.74
15	L -736	3.27	0.33	10.24	33.38	1.40	4.07	128.61	8.20	6.38
16	L -669	3.10	0.47	15.27	35.14	5.40	13.44	124.20	5.29	4.26
17	L -632	3.54	0.56	15.77	34.42	3.04	8.58	132.38	10.38	7.84
18	L -452	3.22	0.26	8.21	35.29	5.14	13.43	133.44	4.68	3.50
19	L -479	3.20	0.43	13.50	34.24	1.41	3.89	116.37	6.36	5.47
20	L -631	3.19	0.21	6.54	32.64	2.27	6.75	140.68	1.90	1.35
$LSD_{0.05}$		0.26			1.39			4.68		

CONCLUSIONS

Results authenticated that it is possible to use the fine-fiber cotton cultivars, viz., Marvarid, Surkhan-14, and Guzor, as initial breeding materials in selecting productive cotton cultivars.

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