RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
57 (4) 1575-1583, 2025
http://doi.org/10.54910/sabrao2025.57.4.23
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

DOMINANCE AND HETEROTIC EFFECTS FOR BOLL NUMBER AND BOLL WEIGHT IN UPLAND COTTON HYBRIDS

A. AZIMOV[1], A. KHATAMOV[1], S. NABIEV[1], J. SHAVKIEV[1*], S. KHAMDULLAEV[1], SH. KUZIEV[2], D. SULTONOVA[3], and T. MAIMAITI[4]

[1]Institute of Genetics and Plant Experimental Biology, Academy of Sciences, Tashkent, Uzbekistan
[2]National University of Uzbekistan named after M. Ulugbek
[3]Chirchik State Pedagogical Institute, Tashkent Region, Chirchik City, Amir Temur, Uzbekistan
[4]China National Cotton Research and Development Center, Institute of Cash Crops, Xinjiang Academy of Agricultural Sciences, Urumqi, Xinjiang, China
*Corresponding author's email: jaloliddinshavkiev1992@gmail.com
Email addresses of co-authors: azimov.abdulahat@bk.ru, axrorxujax@gmail.com, m.saydigani@mail.ru, xamdullayevshuxrat@gmail.com, kuziev.sherali@gmail.com, liliya77027@gmail.com, 412401608@qq.com

SUMMARY

The succeeding study sought to determine the mean performance of parental cultivars and heterotic effects in F_1 hybrids of upland cotton (*Gossypium hirsutum* L.). Six parental genotypes (Guliston, AN-Boyovut-2, Buxoro-102, Yuksalish, Shodlik-11, and Kelajak) underwent crossing to develop 30 complete diallel F_1 hybrids and evaluation in comparison with the standard cultivar (Guliston). The experiment layout in a randomized complete block design (RCBD) had three replications. Analysis of variance revealed significant differences among the parental genotypes and F_1 hybrids for most traits, except the staple length. The F_1 hybrids Guliston × AN-Boyovut-2 and AN-Boyovut-2 × Buxoro-102 produced the most bolls per plant, while the F_1 hybrids Guliston × Yuksalish, Guliston × AN-Boyovut-2, and Shodlik-11 × AN-Boyovut-2 showed the maximum boll weight. Parental genotype performance individually did not reliably predict the hybrid performance, indicating the complex genetic interactions in F_1 hybrids. The heterosis analysis showed the hybrids Guliston × AN-Boyovut-2 and AN-Boyovut-2 × Buxoro-102 exhibited relative heterosis exceeding 15%–20% and heterobeltiosis above 10%–15% for bolls per plant and boll weight, respectively. The considerable heterotic effects in the F_1 hybrids for bolls per plant and boll weight suggest that utilizing heterosis breeding could be effective.

Keywords: Upland cotton (*G. hirsutum* L.), hybrids, heterosis, heterobeltiosis, dominance, bolls per plant, boll weight, yield-related traits

Communicating Editor: Prof. Naqib Ullah Khan

Manuscript received: November 29, 2024; Accepted: March 04, 2025.

Citation: Azimov A, Khatamov A, Nabiev S, Shavkiev J, Khamdullaev S, Kuziev SH, Sultonova D, Maimaiti T (2025). Dominance and heterotic effects for boll number and boll weight in upland cotton hybrids. *SABRAO J. Breed. Genet.* 57(4): 1575-1583. http://doi.org/10.54910/sabrao2025.57.4.23.

Key findings: The upland cotton (*G. hirsutum* L.) hybrid Gulistan × AN-Boyovut-2 showed the best performance for boll weight and bolls per plant in the F_1 generation and proved to be the promising genotype for further improvement through breeding programs.

INTRODUCTION

Cotton (*Gossypium* L.) is the most significant textile crop globally, renowned for its high-quality natural fiber production. During 2017–2018, global cotton production and utilization estimates were at 25.1 million tons, with forecasts predicting an increase to 26.1 million tons by 2026. Cotton supports the textile industry but also plays a vital role in the edible oil industry by providing high-quality cottonseed oil. Globally, approximately 350 million people participate in cotton-related activities, including production, ginning, transportation, storage, and textile manufacturing that utilizes cotton fibers. The global cotton market, valued at USD 20 billion annually, thrives due to the unique contribution of the *Gossypium* genus, which produces single-celled, seed-borne, and long-lint fibers (Shavkiev *et al*., 2023; Khamdullaev *et al*., 2025).

The leading cotton-producing countries are China, India, and the United States, followed by Pakistan, Brazil, Australia, Uzbekistan, Turkey, Turkmenistan, Burkina Faso, Mali, Greece, and Myanmar. The upland cotton (*G. hirsutum* L.) is a vital cash crop in tropical and subtropical regions. It is crucial in the global textile industry, contributing to an economic impact of USD 600 billion annually (Aslam *et al.,* 2020; Amanov *et al.,* 2020; Samanov *et al.,* 2024; Shavkiev *et al*., 2025).

In Uzbekistan, cotton is a key cash and industrial crop, being a primary source of fiber, food, and feed. Cotton fibers significantly boost the country's economy. Uzbekistan ranks fourth worldwide for cotton cultivation area and production. However, in Uzbekistan, the yield per unit area remains relatively low compared with other cotton-growing nations (Sanaev *et al.,* 2021; Khamdullaev *et al.,* 2021; Shavkiev *et al*., 2023). Efforts to develop high-yielding cotton cultivars with improved fiber quality are ongoing to address these constraints and enhance the seed cotton yield (Nabiyev *et al.,* 2020; Shavkiev *et al.,* 2020, 2022; Chorshanbiev *et al.,* 2023; 2025).

Plant breeding plays a pivotal role in enhancing genetic variation, improving the potential of genotypes, and developing stress resistance to increase crop productivity. Conventional breeding involves hybridization, such as the crossing of different genotypes to develop new high-yielding cultivars with desirable traits for passing on to future generations (Shavkiev *et al.,* 2019a, 2019b; Rajabov *et al.,* 2024).

Breeding research explores all possibilities to boost the yield, including the utilization of heterosis (Khan *et al.,* 2017; Narimonov *et al.,* 2023). Heterosis has long been a primary objective in cotton breeding programs. Numerous studies have documented the yield advantages of hybrids over mid-parent, better-parent, and commercial cultivars. However, the major constraints in utilizing heterosis in cotton include the unavailable efficient crossing system, and therefore, producing F_1 hybrid seeds through hand emasculation and pollination is labor-intensive (Azimov *et al.,* 2024a).

In cotton, heterosis can enhance seed cotton yield by 10%–20% while also improving fiber quality. A recent review reported that F_1 hybrids exhibited an average useful heterosis of 21.4%, whereas F_2 hybrids averaged 10.7% (Meredith, 1998). Both F_1 and F_2 hybrids demonstrated significantly higher yields than high-yielding parental genotypes and commercial cultivars (Wu *et al*., 2004).

Heterosis refers to the superior performance of F_1 hybrids relative to their parental cultivars. Though positive heterosis is typically desirable, negative heterosis can be advantageous for specific traits, such as plant height, days to first flowering, micronaire, and gossypol content. For effective hybrid development, a heterosis level of 50% over the promising cultivar and 20% over the best hybrid is considered optimal (Batool and Khan, 2012).

Heterosis is a complex multigenic trait, resulting from extensive gene interaction and physiological processes. F_1 hybrids exhibit heterozygosity, which counteracts inbreeding depression. Past studies have shown the causes of heterosis include the cumulative effects of multiple physiological and phenotypic traits (Azimov *et al.,* 2024b). Additionally, Rosas *et al.* (2010) emphasized the role of gene expression among the parental genotypes and its impact on the phenotype, and the F_1 hybrids mostly exhibit enhanced growth and performance. The presented study aimed to evaluate the performance of F_1 hybrids in comparison with their parental genotypes and the heterosis in F_1 hybrids for bolls per plant and boll weight in upland cotton.

MATERIALS AND METHODS

Genetic material

The breeding material consisted of six parental genotypes of upland cotton (*Gossypium hirsutum* L.) and their 30 F_1 hybrids, developed using a 6 × 6 complete diallel-crossing system, along with a standard cultivar (Guliston) used as the control. The parental cultivars (Guliston, AN-Boyovut-2, Bukhara-102, Yuksalish, Shodlik-11, and Kelajak) representing a diverse genetic base sustained evaluation for key traits, including the number of bolls per plant and boll weight.

Experimental design and field procedure

The field experiments conducted began during the crop seasons of 2022–2023 and 2023–2024 in Sirdaryo, Uzbekistan (40°25′N, 68°40′E). The study comprises two phases: a crossing block and an evaluation of the F_1 populations of upland cotton. In April 2022, six upland cotton genotypes reached planting in a non-replicated crossing block. Each plot consisted of five rows measuring 25 m long, with plant and row spacings of 60 cm and 90 cm, respectively. Performing hand emasculation and crossing continued in a complete diallel fashion. The resulting 30 F_1 populations proceeded to plant in comparison with parental genotypes and the check cultivar (Guliston) in April 2023 in a randomized complete block design (RCBD) with three replications.

In F_1 hybrids, the experimental plots consisted of a single row, 5.3 m in length, containing 25 plants per replication. Plant and row spacings remained at 20 cm and 90 cm, respectively. Recommended agronomic practices, including fertilization, hoeing, irrigation, and pest control, were uniform in application to all entries to minimize field variations. Harvesting ensued in October-November, with ginning performed using the eight-saw gin to obtain lint for further analysis.

Traits' measurement and statistical analysis

The data recorded comprised the randomly selected plants in each experimental unit for the number of bolls per plant and boll weight (g). The mean data incurred analysis of variance (ANOVA) following Steel *et al*. (1997) to test the null hypothesis of no differences among the F_1 hybrids and parental cultivars in comparison with the standard cultivar. Statistical parameters, including the Fisher criterion (F), standard deviations (S.D.), standard error (S.E.), and significance levels ($P \leq 0.05^*$, $P \leq 0.01^{**}$, and $P \leq 0.001^{***}$), underwent evaluation of the reliability of the cotton genotype differences for each trait.

In F_1 hybrids, the dominance coefficient determination was according to Griffing (1950):

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

Where hp = dominance coefficient; F_1 = the evaluated arithmetic mean of the hybrid; MR = the evaluated arithmetic mean of both parents; and R = the evaluated arithmetic mean of the best parents.

In F_1 hybrids, detecting the heterotic effects over mid- and better-parents followed the method of Mather and Jinks (1982):

Heterosis (H%) = ([F_1 – MP] / MP) × 100

Heterobeltiosis (Hb%) = ([F_1 – BP] / BP) × 100

Where F_1 is the mean value of the F_1 hybrid and MP is the mean value of two parental genotypes involved in the cross, while BP is the mean value (over replications) of the better parents of the particular cross.

The correlation coefficient (r), as determined among the various variables, used the approach described by Snedecor and Cochran (1981). In this analysis, the correlation value less than 0.3 indicates a weak relationship between traits, the correlation value between 0.3 and 0.7 indicates a moderate correlation, while the correlation value greater than 0.7 was considerably a strong association.

RESULTS

Bolls per plant

The evaluation of six cotton parental cultivars and their F_1 hybrids succeeded for the total number of bolls per plant, as generated through diallel crossing (Table 1). Compared with the control cultivar (Guliston), the cultivars Yuksalish and Shodlik-11 exhibited higher boll numbers (28.8 ± 2.4 and 30.0 ± 3.9 bolls per plant, respectively). In contrast, the cultivar AN-Boyovut-2 had the lowest boll number (18.6 ± 1.1).

Among the F_1 hybrid combinations, the most bolls per plant resulted in hybrids Guliston × Yuksalish, Yuksalish × Guliston, Yuksalish × Bukhara-102, and AN-Boyovut-2 × Shodlik-11, ranging between 26 and 28 bolls per plant (Table 1). Conversely, the F_1 hybrids, such as Bukhara-102 × AN-Boyovut-2, Bukhara-102 × Kelajak, Shodlik-11 × Guliston, Kelajak × AN-Boyovut-2, Bukhara-102 × Yuksalish, and AN-Boyovut-2 × Guliston, demonstrated the fewest bolls per plant (<20).

Overdominance in bolls per plant

Overdominance in bolls per plant is a genetic phenomenon that can be beneficial in improving seed cotton yield. Overdominance is a model suggesting that the interaction of alleles at a single heterozygous locus can result in a synergistic effect surpassing both homozygous parental genotypes. For bolls per plant, overdominance was evident in the F_1 hybrids, such as Guliston × Bukhara-102, Guliston × AN-Boyovut-2, AN-Boyovut-2 × Bukhara-102, AN-Boyovut-2 × Kelajak, and Kelajak × Guliston (Table 1). Conversely, the hybrids, including Guliston × Shodlik-11, Yuksalish × Shodlik-11, Bukhara-102 × Kelajak, AN-Boyovut-2 × Guliston, AN-Boyovut-2 × Yuksalish, Shodlik-11 × Guliston, Shodlik-11 × Yuksalish, Shodlik-11 × Kelajak, and Kelajak × Shodlik-11, exhibited negative overdominance.

Heterotic effects for bolls per plant

By assessing the heterotic effects of F_1 hybrids relative to their parental lines for the bolls per plant, significant and moderate heterotic effects appeared (Table 1). Hybrids, such as Guliston × AN-Boyovut-2 and AN-Boyovut-2 × Bukhara-102, displayed notable heterosis for the number of bolls per plant. Based on the analysis, the F_1 hybrids Guliston × Bukhara-102, Guliston × AN-Boyovut-2, AN-Boyovut-2 × Bukhara-102, AN-Boyovut-2 × Kelajak, and Kelajak × Guliston occurred with superior genetic and breeding values. These hybrids exhibited the higher boll number, dominance, and remarkable heterotic effects, arising as promising cross combinations for further breeding programs.

Boll weight

Among the parental cotton cultivars, the heaviest boll weight recording was in cultivar Bukhara-102, where the boll weight per boll exceeded 8.0 g (Table 2). Conversely, the lightest boll weight manifested in cultivar Yuksalish, with an average of 6.2 ± 0.1 g boll weight. In F_1 hybrids Guliston × Shodlik-11, Guliston × Kelajak, Yuksalish × AN-Boyovut-2, Yuksalish × Shodlik-11, Yuksalish × Kelajak, Shodlik-11 × Guliston, and Shodlik-11 × Yuksalish, the boll weight ranged from 6.0 to 7.0 g. In the remaining F_1 hybrids, boll weight exceeded 7.0 g, indicating a higher performance in these cross combinations.

Table 1. Degree of dominance and heterotic effects for bolls per plant in parental genotypes and F_1 hybrids of upland cotton.

Parental genotypes and F_1 hybrids	M±SE	S.D.	Dominance Coefficient	Heterosis	Heterobeltiosis
Guliston (control cultivar)	20.3±1.4	5.8	-	-	-
AN-Boyovut-2	18.6±1.1	4.1	-	-	-
Buxoro-102	20.7±2.0	6.8	-	-	-
Yuksalish	28.8±2.4	14.6	-	-	-
Shodlik-11	30.0±3.9	12.9	-	-	-
Kelajak	23.2±1.4	4.8	-	-	-
Guliston x Yuksalish	26.6±2.5	10.5	0.5	8.4	-7.6
Guliston x Buxoro-102	21.3±1.3	6.9	4.0	3.9	2.9
Guliston x AN-Boyovut-2	22.6±1.4	6.6	3.7	16.2	11.3
Guliston x Shodlik-11	22.1±1.4	8.0	-1.4	-12.1	-26.3
Guliston x Kelajak	23.0±1.3	7.3	0.9	5.7	-0.9
Yuksalish x Guliston	26.8±1.8	6.9	0.5	9.2	-6.9
Yuksalish x Buxoro-102	26.4±1.4	5.8	0.4	6.7	-8.3
Yuksalish x AN-Boyovut-2	21.7±2.0	10.4	-0.4	-8.4	-24.7
Yuksalish x Shodlik-11	21.5±1.0	5.3	-13.2	-26.9	-28.3
Yuksalish x Kelajak	25.4±1.2	6.3	-0.2	-2.3	-11.8
Buxoro-102 x Guliston	20.5±1.0	5.8	0.0	0.0	-1.0
Buxoro-102 x Yuksalish	19.8±0.9	5.5	-1.2	-20.0	-31.3
Buxoro-102 x AN-Boyovut-2	18.3±0.8	4.9	-0.1	-6.9	-11.6
Buxoro-102 x Shodlik-11	21.2±1.3	7.4	-0.1	-16.4	-29.3
Buxoro-102 x Kelajak	18.5±0.9	5.2	-2.8	-15.7	-20.3
AN-Boyovut-2 x Guliston	18.5±0.8	4.4	-1.1	-4.9	-8.9
AN-Boyovut-2 x Yuksalish	21.3±1.0	5.3	-5.8	-10.1	-26.0
AN-Boyovut-2 x Buxoro-102	23.6±1.3	7.0	2.9	20.1	14.0
AN-Boyovut-2 x Shodlik-11	28.1±1.7	6.8	0.7	15.6	-6.3
AN-Boyovut-2 x Kelajak	23.6±2.1	9.1	1.2	12.9	1.7
Shodlik-11 x Guliston	19.9±0.7	3.8	-1.0	-20.9	-33.7
Shodlik-11 x Yuksalish	20.5±1.2	7.2	-14.8	-30.3	-31.7
Shodlik-11 x Buxoro-102	22.6±1.4	6.5	-0.6	-10.8	-24.7
Shodlik-11 x AN-Boyovut-2	21.4±1.1	6.3	-0.5	-11.9	-28.7
Shodlik-11 x Kelajak	20.5±1.2	6.7	-1.8	-22.9	-31.7
Kelajak x Guliston	24.2±1.2	4.6	1.7	11.3	4.3
Kelajak x Yuksalish	24.8±1.4	6.7	-0.4	-4.6	-13.9
Kelajak x Buxoro-102	21.6±1.2	5.6	-0.3	-1.6	-6.9
Kelajak x AN-Boyovut-2	19.7±1.0	5.8	-0.5	-5.7	-15.1
Kelajak x Shodlik-11	23.1±1.2	6.3	-1.0	-13.2	-23.0

Table 2. Degree of dominance and heterotic effects for boll weight in parental genotypes and their F_1 hybrids in upland cotton.

Parental genotypes and F_1 hybrids	M±SE	S.D.	Dominance Coefficient	Heterosis	Heterobeltiosis
Guliston (control cultivar)	7.1±0.26	0.46	-	-	-
AN-Boyovut-2	7.1±0.15	0.26	-	-	-
Buxoro-102	8.1±0.12	0.21	-	-	-
Yuksalish	6.2±0.1	0.17	-	-	-
Shodlik-11	7.2±0.09	0.15	-	-	-
Kelajak	7.5±0.23	0.40	-	-	-
Guliston x Yuksalish	7.5±0.28	0.49	2.0	12.8	5.6
Guliston x Buxoro-102	7.7±0.1	0.17	0.1	1.3	-4.9
Guliston x AN-Boyovut-2	7.6±0.18	0.31	54.0	7.0	7.0
Guliston x Shodlik-11	6.4±0.38	0.66	-18.2	-10.4	-11.1
Guliston x Kelajak	6.9±0.35	0.60	-1.7	-5.5	-8.0
Yuksalish x Guliston	7.2±0.27	0.47	1.2	8.3	1.4
Yuksalish x Buxoro-102	7.1±0.07	0.12	0.0	-0.7	-12.3
Yuksalish x AN-Boyovut-2	6.8±0.45	0.78	0.4	2.3	-4.2
Yuksalish x Shodlik-11	6.9±0.29	0.50	0.4	3.0	-4.2
Yuksalish x Kelajak	6.8±0.3	0.51	-0.1	-0.7	-9.3
Buxoro-102 x Guliston	7.7±0.38	0.66	0.2	1.3	-4.9
Buxoro-102 x Yuksalish	7.2±0.18	0.31	0.1	0.7	-11.1
Buxoro-102 x AN-Boyovut-2	7.7±0.29	0.50	0.4	1.3	-4.9
Buxoro-102 x Shodlik-11	7.9±0.5	0.87	0.6	3.3	-2.5
Buxoro-102 x Kelajak	8.3±0.1	0.17	1.8	6.4	0.0
AN-Boyovut-2 x Guliston	7.3±0.27	0.47	19.0	2.8	1.4
AN-Boyovut-2 x Yuksalish	7.1±0.52	0.90	1.0	6.8	0.0
AN-Boyovut-2 x Buxoro-102	7.1±0.32	0.55	-0.8	-6.6	-12.3
AN-Boyovut-2 x Shodlik-11	7.1±0.1	0.17	-0.4	-0.7	-1.4
AN-Boyovut-2 x Kelajak	7.2±0.17	0.29	-0.2	-1.4	-4.0
Shodlik-11 x Guliston	6.5±0.13	0.23	-14.5	-9.1	-13.3
Shodlik-11 x Yuksalish	6.4±0.34	0.59	-0.5	-4.5	-11.1
Shodlik-11 x Buxoro-102	7±0.12	0.20	-1.4	-8.5	-13.6
Shodlik-11 x AN-Boyovut-2	7.5±0.03	0.06	7.0	4.9	4.2
Shodlik-11 x Kelajak	7.6±0.09	0.15	1.6	3.4	1.3
Kelajak x Guliston	7.7±0.59	1.03	2.1	5.5	2.7
Kelajak x Yuksalish	7.4±0.09	0.15	1.9	8.0	-1.3
Kelajak x Buxoro-102	8.2±0.35	0.61	1.0	5.1	1.2
Kelajak x AN-Boyovut-2	7.5±0.4	0.70	-0.1	2.7	0.0
Kelajak x Shodlik-11	7.5±0.85	1.47	1.1	2.0	0.0

Overdominance in boll weight

For boll weight, positive overdominance resulted in the F_1 hybrids Guliston × Yuksalish, Guliston × AN-Boyovut-2, Yuksalish × Guliston, Bukhara-102 × Kelajak, AN-Boyovut-2 × Guliston, AN-Boyovut-2 × Yuksalish, Shodlik-11 × AN-Boyovut-2, Shodlik-11 × Kelajak, Kelajak × Guliston, Kelajak × Yuksalish, Kelajak × Bukhara-102, and Kelajak × Shodlik-11 (Table 2). However, the negative overdominance was notable in the F_1 hybrids, such as Guliston × Shodlik-11, Guliston × Kelajak, Shodlik-11 × Guliston, and Shodlik-11 × Bukhara-102.

Heterotic effects for boll weight

In F_1 hybrids, the heterotic effect for boll weight, compared with their parental lines, revealed significant and moderate heterosis (up to 10%) (Table 2). The promising F_1 hybrids exhibited heterotic effects, including Guliston × Yuksalish, Guliston × AN-Boyovut-2, Yuksalish × Guliston, AN-Boyovut-2 × Guliston, Shodlik-11 × AN-Boyovut-2, Shodlik-

11 × Kelajak, Kelajak × Guliston, and Kelajak × Bukhara-102. Based on the analysis, the F_1 hybrids Guliston × Yuksalish, Shodlik-11 × AN-Boyovut-2, Shodlik-11 × Kelajak, Kelajak × Guliston, and Kelajak × Bukhara-102 came out with better genetic potential.

DISCUSSION

The F_1 hybrids, obtained through the crosses Guliston × Yuksalish*,* Shodlik-11 × AN-Boyovut-2*,* Shodlik-11 × Kelajak*,* Kelajak × Guliston*,* and Kelajak × Bukhara-102, demonstrated the maximum boll weight, averaging 7.0 g. Boll weight is a crucial yield component, and many assume it positively influences the seed cotton yield if the number of bolls per plant remains constant. These findings align with previous research, which suggested that significant heterotic effects for boll weight may be due to both the additive and non-additive gene effects in upland cotton (Khan and Qasim, 2012).

The results also indicate the parental cultivars Kelajak and Shodlik-11, along with the testers Guliston and AN-Boyovut-2, were the best general combiners, making them highly suitable for hybridization and breeding programs. An increase in the number of bolls per plant in cotton significantly enhances the overall seed cotton yield, demonstrating a strong positive correlation between the number of bolls per plant and seed cotton yield. In terms of heterotic effects, the F_1 hybrids Guliston × Yuksalish, Shodlik-11 × AN-Boyovut-2, Shodlik-11 × Kelajak, Kelajak × Guliston, and Kelajak × Bukhara-102 exhibited higher relative heterosis and heterobeltiosis than the other hybrids.

These hybrids expressed superior hybrid vigor for the number of bolls per plant, making them promising candidates for hybrid crop development. Past studies also reported the highest heterosis over the better parent and check cultivars for boll formation, with the said trait found remarkably associated with seed cotton yield in upland cotton (Azimov *et al.,* 2024c). In F_1 hybrids, the heterotic effects for bolls per plant ranged from moderate to high. Dong *et al*. (2007) mentioned the significant heterosis for boll size and boll number compared with the standard cultivar, while Basal and Turgut (2003) reported considerable heterosis for boll weight in upland cotton.

Since boll weight is a major yield-contributing factor and has a positive association with seed cotton yield, boll numbers remain constant. Similarly, Yuan *et al*. (2002) observed average heterosis (13.3%) for boll weight over the mid-parent. However, boll weight differences appeared minimal by comparing with the better parent. Khan *et al*. (2007, 2009) stated the topmost heterosis over better parents for boll weight, which could mean an improved seed cotton yield. The study results were also consistent with past findings of Kumar *et al*. (2014), who also noted significant heterotic effects in F_1 and F_2 populations for bolls per plant.

For bolls per plant, the F_1 hybrids Guliston × AN-Boyovut-2 and AN-Boyovut-2 × Bukhara-102 delivered the maximum relative heterosis and heterobeltiosis. Moreover, the F_1 hybrids Guliston × Yuksalish*,* Guliston × AN-Boyovut-2*,* and Shodlik-11 × AN-Boyovut-2 showed moderate heterosis over mid and better parents for boll weight. Previous studies have consistently reported the significant heterosis over the mid and better parents for yield-contributing traits, which further supported this study's present results (Komal *et al.,* 2014; Baloch *et al.,* 2015).

CONCLUSIONS

The significance of heterotic effects was a revelation of the substantial mean square differences among the parental genotypes and their F_1 hybrids. The F_1 hybrids outperformed their parental lines for key yield traits due to the expression of heterotic effects. Guliston × AN-Boyovut-2 and AN-Boyovut-2 × Bukhara-102 produced the higher number of bolls per plant among the F_1 hybrids. For boll weight, the best-performing F_1 hybrids were Guliston × Yuksalish, Guliston × AN-Boyovut-2, and Shodlik-11 × AN-Boyovut-2. Overall, the cross combination Guliston × AN-Boyovut-2 exhibited an excellent performance in the F_1

generation, receiving authentication as a promising candidate genotype for further breeding programs.

ACKNOWLEDGMENTS

The authors thank the Institute of Genetics and Plants Experimental Biology, Academy of Sciences of Uzbekistan, for their scientific research support.

REFERENCES

Amanov B, Abdiev F, Shavkiev J, Mamedova F, Muminov K (2020). Valuable economic indicators among hybrids of Peruvian cotton genotypes. *Plant Cell Biotechnol. Mol. Biol.* 21(67-68): 35–46.

Aslam S, Khan S, Ahmed A, Dandekar A (2020). The tale of cotton plant: From wild type to domestication, leading to its improvement by genetic transformation. *Am. J. Mol. Biol*. 10: 91–127.

Azimov A, Aliqulov E, Ergashev O, Shavkiev J (2024a). Estimation of dominance and heterosis of morpho-economic traits in intraspecific F1 hybrids of upland cotton. *J. Wildlife Biodivers*. 8(3): 162–174. https://doi.org/10.5281/zenodo.11409018.

Azimov A, Shavkiev J, Ahmedjanov A, Temirova Y, Koraev A, Nurmetov Kh, Rasulova O (2024b). Genetic analysis and inbreeding depression for yield-related parameters in upland cotton. *SABRAO J. Breed. Genet.* 56(4):1345–1356. http://doi.org/10.54910/sabrao2024.56.4.2.

Azimov A, Shavkiev J, Saidjanov S, Ziyaev Z, Valiyev L (2024c). Mung bean (*Vigna radiata* L.) genotypes assessment for drought tolerance in Uzbekistan. *J. Wildlife Biodivers*. 8(1): 65–75.

Azimov A, Shavkiev J, Nabiev S, Khamdullaev S, Pulatov S, Rajabov Z (2024). Cobalt-60-γ-radiation effect on morpho-yield and earliness traits in colored cotton (Gossypium hirsutum L.). *SABRAO J. Breed. Genet.* 56(6): 2248-2259.

Baloch MJ, Sial P, Arain BT, Arain MA (2015). Assessment of heterotic effects in F1 hybrids of cotton (*G. hirsutum* L.). *Pak. J. Agric. Agric. Engg. Vet. Sci.* 31(2): 193–202.

Basal H, Turgut I (2003). Heterosis and combining ability for yield components and fiber quality parameters in a half-diallel cotton (*G. hirsutum* L.) population. *Turk. J. Agric. For.* 27: 207–212.

Batool A, Khan A (2012). Effective levels of heterosis for hybrid development. *J. Crop Improv.* 25(3): 102–110.

Chorshanbiev NE, Nabiev SM, Azimov AA, Shavkiev JSH, Pardaev EA, Quziboev AO (2023). Inheritance of morpho-economic traits and combining ability analysis in intraspecific hybrids of *Gossypium barbadense* L. *SABRAO J. Breed. Genet*. 55(3): 640-652. http://doi.org/10.54910/sabrao2023.55.3.4.

Chorshanbiev NE, Pardaev EA, Nabiev SM, Azimov AA, Shavkiev JSH, Quziboev AO, Egamberdiev RR, Diyorov GK, Ergashev OR, Makhmudov TKH (2025). Combining ability and inheritance studies in diallel crosses of the Pima cotton (Gossypium barbadense L.). *SABRAO J. Breed. Genet*. 57(3): 900-910.

Dong HZ, Li WJ, Tang W, Li ZH, Zhang DM (2007). Heterosis in yield, endotoxin expression and some physiological parameters in *Bt* transgenic cotton. *Plant Breed.* 126: 169–175.

Griffing J (1950). Analysis of quantitative gene action by constant parent regression and related techniques. *Genetics* 35: 303–321.

Khamdullaev S, Nabiev S, Azimov A, Shavkiev J, Yuldashov U (2021). Combining ability of yield and yield components in upland cotton (*G. hirsutum* L.) genotypes under normal and water-deficit conditions. *Plant Cell Biotechnol. Mol. Biol.* 22(35&36): 176–186.

Khamdullaev SA, Nabiev SM, Azimov AA, & Shavkiev, JS (2025). Evaluation of drought tolerance in naturally colored cotton (Gossypium hirsutum) under water deficit conditions. *Regul.Mech.Biosyst*. *16*(1): e25035. https://doi.org/10.15421/0225035

Khan AB, Khan UN, Ahmed M, Iqbal M, Ullah I, Saleem M, Khurshid I, Kanwal A (2017). Heterosis and inbreeding depression in F2 populations of upland cotton (*Gossypium hirsutum* L.). *Agric. Sci*. 8: 1283–1295. https://doi: 10.4236/as.2017.811093.

Khan NU, Hassan G, Kumbhar MB, Kang S, Khan I, Parveen A, Aiman U, Saeed M (2007). Heterosis and inbreeding depression and mean performance in segregating generations in upland cotton. *Eur. J. Sci. Res.* 17: 531–546.

Khan NU, Hassan G, Kumbhar MB, Marwat KB, Khan MA, Parveen A, Aiman U, Saeed M (2009). Combining ability analysis to identify suitable parents for heterosis in seed cotton yield, its components, and lint % in upland cotton. *Ind. Crops Prod.* 29: 108–115.

Khan TM, Qasim MU (2012). Genetic studies of yield traits in cotton (*G. hirsutum* L.). *J. Agric. Res.* 50(1): 21–28.

Komal P, Madariya RB, Raval L (2014). Assessment of heterosis and inbreeding depression in cotton (*G. hirsutum* L.). *The Bio-Scan.* 9(4): 1853–1856.

Kumar KS, Kumar K, Ravikesavan R (2014). Genetic effects of combining ability studies for yield and fiber quality traits in diallel crosses of upland cotton (*G. hirsutum* L.). *Afr. J. Biol.* 13(1): 119–126.

Mather K, Jinks JL (1982). Biometrical Genetics. 3rd Ed. Chapman and Hall Ltd, London.

Meredith WRJ (1998). Continued progress in breeding for yield in the USA? Proceedings of the World Cotton Research Conference - 2. Athens, Greece, September 6–12, 1998. pp. 97–101.

Nabiyev SM, Usmanov RM, Xamdullayev SA, Chorshanbiyev NE, Shavkiev JSH (2020) The study of physiological indicators of water exchange of plants and morphological characteristics of the leaf of fine-staple cotton under different conditions of water availability. *Uzbek Biol. J.* 1: 51–65.

Narimonov A, Azimov A, Yakubjanova N, Shavkiev J (2023). Scientific basis of cotton seed germination inthe Central Region of Uzbekistan. SABRAO J. Breed. Genet. 55(5): 1561-1572.

Rajabov Z, Azimov A, Shavkiev J, Narimanov A, Xotamov A (2024). Yield and yield component traits of the new Niyat variety of cotton under field conditions in the Khorezm region of Uzbekistan. *J. Wildlife Biodivers*. 8(3): 213–222. https://doi.org/10.5281/ zenodo.11530879.

Rosas U, Barton NH, Copsey L, Coen E (2010). Gene expression dynamics and its role in hybrid phenotype enhancement. *Plant Genet. and Develop*. 18(4): 345–360.

Samanov S, Arslanov D, Ernazarova Z, Iskandarov A, Muhammad X, Bunyod G, Gulomov G, Sirojjodinov B, Dusmatova G, Shavkiev J (2024). The diversity and breeding potential of *G. hirsutum* L. genotypes based on the Uzbekistan cotton gene bank collection. *J. Wildlife Biodivers*. 8(4): 119–128. https://doi.org/10.5281/ zenodo.13823671.

Sanaev NN, Gurbanova NG, Azimov AA, Norberdiev TN, Shavkiev JS (2021). Inheritance of the plant shape trait of the varieties and introgressive lines of *G. hirsutum* L. in drought conditions. *Plant Cell Biotechnol. Mol. Biol.* 22(25-26): 122–129.

Shavkiev J, Azimov A, Khamdullaev S, Karimov H, Abdurasulov F, Nurmetov K (2023). Morpho-physiological and yield contributing traits of otton varieties with different tolerance to water deficit. *J. Wildlife Biodivers*. 7(4): 214–228.https://doi.org/10.5281/zenodo. 8304871.

Shavkiev J, Hamdullaev SH, Nabiev S, Usmanov R, Bozorov T, Erjigitov D (2019a). Water sensitivity and tolerance indices upon productivity in upland cotton and other economic valuable traits. *Bull. Gulistan State Uni*. 2: 64–68.

Shavkiev J, Nabiev S, Azimov A, Chorshanbiev N, Nurmetov KH (2022). Pima cotton (*Gossypium barbadense* L.) lines assessment for drought tolerance in Uzbekistan. *SABRAO J. Breed. Genet.* 54(3): 524–536.http://doi.org/10.54910/ sabrao2022.54.3.6.

Shavkiev J, Nabiev S, Azimov A, Khamdullaev S, Amanov B, Matniyazova H, Nurmetov K (2020). Correlation coefficients between physiology, biochemistry, common economic traits and yield of cotton cultivars under full and deficit irrigated conditions. *J. Crit. Rev.* 7(4):131–136.

Shavkiev J, Nabiev S, Khamdullaev Sh, Usmanov R, Chorshanbiev N (2019b). Physiologic-biochemical and yield traits parameters of cotton varieties under different water irrigated regimes. *Bull. Agrarian Sci. Uzbekistan* 78(4(2): 157–162.

Shavkiev J, Azimov A, Khamdullayev Sh, Ahmedjanov A, Karimov E, Mamarasulov U, Nurmetov X (2025). Multifactorial ANOVA analysis of genotype and environment effects on morphological and agronomic traits in G. barbadense L. cotton. *J. Wildlife and Biodivers.* 9(2): 388–408.

Snedecor GW, Cochran WG (1981). Statistical Methods. 6th Ed. Iowa State Univ. Press. Ames. Iowa, USA, pp. 175–191.

Steel RG, Torrie JH, Dicky DA (1997). Principles and Procedures of Statistics, A Biometrical Approach, 3rd Ed. McGraw Hill, Inc. Book Co., New York, pp. 352–358.

Wu YT, Yin JM, Guo WZ, Zhu XF, Zhang TZ (2004). Heterosis performance of yield and fibre quality in F1 and F2 hybrids in upland cotton. *Plant Breeding.* 123: 285–289.

Yuan YL, Zhang TZ, Guo WZ, Pan JJ, Kohel RJ (2002). Heterosis and gene action of boll weight and lint percentage in high-quality fiber property varieties in upland cotton. *Acta Agron. Sin*. 28: 196–202.