PRODUCTIVITY TRAITS IN F1 HYBRIDS DERIVED FROM COTTON CULTIVARS, A WILD SPECIES, AND INTROGRESSIVE FORMS

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Abstract. *This study investigated the formation and inheritance of productivity traits in F_1 hybrids obtained from cotton cultivars, wild species, and introgressive forms. The total number of bolls per plant, the number of opened bolls, the number of seeds per boll, and the percentage of fully developed seeds were evaluated. Reciprocal and stepwise hybridization methods were applied in the study. The results demonstrated that hybrids involving the cultivars Golib, Andijon-35, Namangan-77, and Qizil Baraka exhibited high productivity indicators. In contrast, some hybrids involving* G. mustelinum *and T-85 showed relatively lower productivity performance. Positive and negative overdominance, dominance, and intermediate inheritance patterns were identified in the inheritance of the studied traits, and promising initial breeding materials were recommended for selection programs.*

Keywords: *cotton, F_1 hybrids, productivity, reciprocal crossing, stepwise hybridization, inheritance, breeding, Gossypium.*

Introduction

Cotton is one of the most important industrial crops in agriculture, and increasing its yield remains one of the primary objectives of modern breeding programs. Productivity is a complex quantitative trait that is determined by numerous genetic and environmental factors. The number of bolls per plant, the number of opened bolls, the proportion of fully developed seeds, and other biological characteristics are considered major components of yield performance. Wild cotton species and introgressive forms represent valuable sources of genetic diversity, and their hybridization with cultivated varieties provides opportunities for obtaining promising breeding materials. Therefore, the investigation of productivity traits in F_1 hybrids derived from cotton cultivars, wild species, and introgressive forms, as well as the determination of their inheritance patterns and the identification of promising hybrid combinations, is of considerable scientific and practical importance.

Literature Review

According to Sirojidinov and co-authors, productivity in cotton is determined by the plant's genetic potential and is formed through the interaction of several traits and characteristics [1].

Seyitmusayev and Tishin [2], as well as Ernazarova [3], reported that productivity is largely determined by the number of opened bolls, the number of fully developed seeds in each boll, and fiber content.

Azimov [4], while studying wilt resistance and boll number in interspecific cotton hybrids, demonstrated that the development and inheritance of this trait depend on the parental genotypes selected for crossing. He further noted that greater differences between parental forms in boll number increase the probability of obtaining highly heterozygous hybrid populations in

subsequent generations. The author emphasized the importance of conducting genetic and breeding studies using such heterogeneous populations.

Umbetayev, Eleshev, and Atakulov [5] investigated the productivity of cultivars belonging to *Gossypium hirsutum* L. under different mineral nutrition conditions and found that the number of bolls per plant increased proportionally under both minimum and maximum fertilizer regimes.

Karimova [6] studied the development of cotton cultivars and lines under drought-prone soil conditions and observed a substantial reduction in both the number of bolls per plant and the proportion of fully developed seeds under water-deficit conditions.

Saidov [7], while investigating the genetic and physiological potential of cotton cultivars and hybrids under various ecological conditions, reported that boll number and boll size are primarily determined by the genotype and tend to be expressed according to their inherent genetic potential regardless of environmental influences.

Rao and Gopinath [8] confirmed the relationship between cotton yield and fiber quality and demonstrated that the number of bolls per plant plays a more important role in yield improvement than the weight of cotton per boll.

Avtonomov and Kimsanbayev [9] emphasized that the number of bolls per plant should be considered one of the principal components determining cotton productivity and, therefore, warrants detailed investigation.

Chorshanbiyev [10] studied this trait in F_1 and F_2 hybrids of *Gossypium barbadense* L. cultivars and found that the number of bolls per plant was inherited with positive overdominance in the F_1 generation. Furthermore, he demonstrated that cytoplasmic genes also participate in the genetic regulation of this trait in reciprocal hybrid combinations.

Murtaza [11] investigated the genetic effects controlling boll number and boll weight through diallel crosses involving eight different genotypes of *Gossypium hirsutum* L. He concluded that the inheritance of these traits in diallel hybrid populations is a complex process and emphasized that the achievement of high productivity depends on proper parental selection and the use of mature, well-developed seeds.

Materials and Methods

The formation and inheritance of productivity-related traits, including the total number of bolls per plant, the number of opened bolls per plant, the total number of seeds per boll, and the numbers of fully developed and undeveloped seeds, were investigated in cultivars, lines, and F_1 hybrid plants obtained through reciprocal and stepwise hybridization methods.

Phenological observations were conducted to determine the total number of bolls and the number of opened bolls per plant. The data collected during these observations, together with the results obtained from seed analyses of individual bolls, were subjected to statistical evaluation.

Results and Discussion

Among the tetraploid cultivars belonging to *Gossypium hirsutum* L., the total number of bolls per plant ranged from 13.5 to 23.7, whereas the number of opened bolls varied between 9.1 and 12.5. Namangan-77 exhibited the highest value for total boll number (23.7 bolls per plant), while Golib and Andijan-35 showed intermediate values of 15.2 and 18.4 bolls per plant, respectively. Qizil Baraka displayed the lowest value, with 13.8 bolls per plant.

Although the wild species *Gossypium mustelinum* Miers ex Watt produced a relatively high total number of bolls (17.1 per plant), it exhibited a comparatively low number of opened bolls (7.8 per plant). The T-85 line showed the poorest performance among the experimental materials, with only 11.1 total bolls and 5.2 opened bolls per plant (Table 1).

Table 1. Productivity traits in F_1 cotton hybrids

No.	Genotypes and Hybrid Combinations	Plants (n)	Total Bolls per Plant	Opened Bolls per Plant	Analyzed Bolls (n)	Total Seeds per Boll	Fully Developed Seeds per Boll	Unfilled Seeds pe	Percentage of Fully Developed Seeds per Boll (%)				
									X±m%	min±max	S	V%	*hp*
Parental Forms													
1	Golib	10	15,2	9,7	10	33,2	32	1,2	96,5±0,7	91,7-100,0	2,3	2,4	
2	Andijon-35	10	18,4	10,2	10	34,3	32,5	1,8	94,8±1,5	80,6-100,0	4,8	5,1	
3	Namangan-77	10	23,7	12,5	10	32,3	29,5	2,8	91,5±1,2	83,8-96,7	3,9	4,2	
4	Qizil baraka	10	13,8	9,1	10	30,1	27,9	2,2	93,02±2,6	66,7-100,0	8,1	8,7	
5	*G.mustelinum* Miers ex Watt	10	17,1	7,8	10	29,4	22,7	6,7	77,1±2,7	62,5-94,4	8,5	11,0	
6	T-85	10	11,1	5,2	10	20,5	17,3	3,2	84,4±2,1	77,3-94,4	6,7	7,9	
Reciprocal hybridization combinations of F_1 plants													
1	Golib x Andijon-35	30	16,3	9,1	30	35,4	33,6	1,8	94,8±1,5	88,2-100	4,6	4,9	-0,6
2	Andijon-35 x Golib	30	18,5	10,3	30	31,8	31,1	0,7	97,8±0,67	93,5-100	2,10	2,15	2,5
3	Golib x Namangan-77	30	17,3	11,2	30	36	34,6	1,4	96,1±0,56	92,1-97,6	1,8	1,9	0,6
4	Namangan77 x Golib	30	19,1	12,1	30	37,5	35,5	2	94,6±1,3	85-97,6	4,1	4,2	0,1
5	Golib x Qizil baraka	30	16,4	10,2	30	34,3	32,6	1,7	96,9±2,78	79,4-100	4,78	5,1	1,2
6	Qizil baraka x Golib	30	15,1	9,5	30	32,4	31,1	1,3	96,1±1,60	78,6-100	5,05	5,25	0,8
7	Golib x *G.mustllinum* Miers. ex Watt.	30	14,1	7,8	30	34,5	28,1	6,4	81,4±1,69	72,2-100	5,33	6,54	-0,6
8	*G.mustllinum* Miers. ex Watt. x Golib	30	14,4	8,1	30	31,8	26,2	5,6	82,3±3,34	63,6-96,9	10,55	12,82	-0,5
9	T-85 x Golib	30	7,8	3,4	30	28,5	23,3	5,2	81,5±3,5	60-100	11,14	13,66	-1,6
10	Andijon-35 x Namangan-77	30	21,3	12,7	30	30,1	28,9	1,2	96,4±2,50	92-100	2,41	2,50	1,9
11	Namangan-77 x Andijon-35	30	19,8	13,4	30	31,4	30,2	1,2	96,1±1,24	81,5-100	3,91	4,06	1,8
12	Andijon-35 x *G.mustllinum* Miers. ex Watt.	30	18,7	8,9	30	29,7	23,9	5,8	80,6±2,37	64,5-96,4	7,48	9,28	-0,6
13	*G.mustllinum* Miers. ex Watt. x Andijon-35	30	16,6	7,1	30	31,6	24,4	7,2	76,9±1,9	66,7-86,5	6	7,81	-1,1
14	Namangan-77 x Qizil baraka	30	22,3	11,8	30	35,9	34,2	1,7	95,6±1,19	85,7-100	3,77	3,94	4,4
15	Qizil baraka x Namangan-77	10	16,3	9,8	10	32,4	31,5	0,9	97,2±0,8	90,3-100,0	2,7	2,8	6,5
16	Namangan-77 x *G.mustelinum* Miers ex Watt	10	15,1	9,5	10	32,7	25,5	6,2	77,9±1,9	66,7-94,4	6,0	7,4	-0,4
17	*G.mustelinum* Miers ex Watt x Namangan-77	10	19,1	11,2	10	29,2	24,2	5,0	82,7±5,7	48,3-96,7	17,9	21,7	-0,2
18	Namangan-77 x T-85	10	15,8	4,3	10	30,9	27,8	3,1	89,9±2,8	73,1-100,0	8,9	9,9	0,5
19	T-85 x Namangan-77	10	16,3	5,4	10	28,2	24,1	4,1	85,2±4,3	62,9-96,5	13,7	16,1	-0,9
20	Qizil baraka x *G.mustelinum* Miers ex Watt	10	14,9	9,5	10	30,9	26,9	4,0	87,4±2,0	69,7-100,0	6,5	7,4	-0,4
21	*G.mustelinum* Miers ex Watt x Qizil baraka	10	13,7	8,8	10	29,3	24,1	5,2	82,3±1,8	71,4-96,4	5,8	7,0	-0,3
22	Qizil baraka x T-85	10	11,3	5,2	10	25,1	23	2,1	91,7±1,1	85,2-100,0	3,5	3,8	0,7
23	T-85 x Qizil baraka	10	10,3	4,1	10	29,7	22,1	7,6	73,2±4,7	46,2-94,4	14,8	20,2	-3,9
24	*G.mustelinum* Miers ex Watt x T-85	10	13,1	3,1	10	28,6	25,8	2,8	90,5±3,2	58,6-100,0	10,9	11,1	2,4
25	T-85 x *G.mustelinum* Miers ex Watt	10	12,6	4,2	10	29,1	20	9,1	68,8±3,3	53,3-82,8	10,5	15,3	-3,1
19	T-85 x Namangan-77	10	16,3	5,4	10	28,2	24,1	4,1	85,2±4,3	62,9-96,5	13,7	16,1	-0,9
20	Qizil baraka x *G.mustelinum* Miers ex Watt	10	14,9	9,5	10	30,9	26,9	4,0	87,4±2,0	69,7-100,0	6,5	7,4	-0,4
21	*G.mustelinum* Miers ex Watt x Qizil baraka	10	13,7	8,8	10	29,3	24,1	5,2	82,3±1,8	71,4-96,4	5,8	7,0	-0,3
22	Qizil baraka x T-85	10	11,3	5,2	10	25,1	23	2,1	91,7±1,1	85,2-100,0	3,5	3,8	0,7
23	T-85 x Qizil baraka	10	10,3	4,1	10	29,7	22,1	7,6	73,2±4,7	46,2-94,4	14,8	20,2	-3,9
24	*G.mustelinum* Miers ex Watt x T-85	10	13,1	3,1	10	28,6	25,8	2,8	90,5±3,2	58,6-100,0	10,9	11,1	2,4
25	T-85 x *G.mustelinum* Miers ex Watt	10	12,6	4,2	10	29,1	20	9,1	68,8±3,3	53,3-82,8	10,5	15,3	-3,1
Stepwise hybridization combinations of F_1 plants													
1	(Golib x Andijon-35) x Qizil baraka	10	12,3	8,2	10	30,2	29	1,2	95,9±1,2	86,2-100,0	3,8	4,0	1,1
2	(Golib x Andijon-35) x *G.mustelinum* Miers ex Watt	10	16,3	6,3	10	31,4	25,5	5,9	81,1±1,9	70,3-92,6	5,9	7,36	-0,5
3	(Golib x Andijon-35) x T-85	10	12,3	4,4	10	29,8	24,9	4,9	83,3±3,2	62,1-100,0	10,1	12,2	-1,3

4	(Andijon-35 x Golib) x Qizil baraka	10	15,1	9,2	10	31,9	30,6	1,3	95,8±1,3	76,0-100,0	4,2	4,4	0,2
5	(Andijon-35 x Golib) x *G.mustelinum* Miers ex Watt	10	17,5	8,2	10	30,9	25,2	5,7	82,1±2,8	64,5-100,0	8,9	10,9	-0,5
6	(Golib x Namangan-77) x Qizil baraka	10	18,2	10,2	10	32,2	30,1	1,1	93,5±1,8	73,1-100,0	5,7	5,9	1,0
7	(Golib x Namangan-77) x *G.mustelinum* Miers ex Watt	10	17,1	7,5	10	33,1	26,2	6,9	79,4±2,5	64,3-92,1	8,0	10,1	-0,7
8	(Golib x Namangan-77) x T-85	10	12,1	4,8	10	25,4	22,1	3,3	86,7±2,7	61,5-97,8	8,6	9,9	-0,7
9	(Andijon-35 x Namangan-77) x Qizil baraka	10	15,1	9,6	10	30,9	29,8	1,1	96,7±0,9	90,2-100,0	2,8	2,9	1,2
10	(Andijon-35 x Namangan-77) x *G.mustelinum* Miers ex Watt	10	17,8	9,1	10	28,7	23,5	5,2	81,9±1,8	68,9-93,3	5,5	6,8	-0,5
11	(Andijon-35 x Namangan-77) x T-85	10	10,1	3,7	10	24,1	21,2	2,9	88,3±2,7	70,4-100,0	8,7	9,8	-0,4
12	(Namangan-77 x Andijon-35) x Qizil baraka	10	14,4	8,8	10	32,1	30,4	1,7	94,7±1,4	83,3-100,0	4,3	4,5	0,1
13	(Namangan-77 x Andijon-35) x *G.mustelinum* Miers ex Watt	10	16,9	9,5	10	31,7	25,1	6,6	79,1±2,5	63,3-100,0	7,8	9,8	-0,8
14	(Namangan-77 x Andijon-35) x T-85	10	11,5	4,8	10	29,1	23,4	5,7	80,8±3,3	66,7-95,4	10,4	12,9	-1,7

Note: CV - coefficient of variation; hp - degree of dominance; values are presented as mean ± standard error.

Regarding the percentage of fully developed seeds per boll, the cultivar Golib exhibited the highest value (96.5%), whereas the wild species *G. mustelinum* Miers ex Watt demonstrated the lowest value (77.1%). In terms of variation amplitude, Golib, Andijan-35, and Namangan-77 displayed relatively narrow and similar ranges (80.6-100.0%), indicating greater genetic uniformity. In contrast, Qizil Baraka, *G. mustelinum*, and T-85 exhibited wider ranges of variation (62.5-100.0%), suggesting greater genetic divergence among these genotypes.

The coefficient of variation (V%) was lowest in Golib (2.4%) and highest in *G. mustelinum* Miers ex Watt (11.0%). These findings indicate that Golib possesses a more stable genetic system controlling seed development, whereas the wild species displays greater phenotypic variability. Such differences may substantially influence the expression and inheritance of productivity traits in hybrid populations.

The stability of a gene or gene complex responsible for the phenotypic expression of any quantitative trait can be assessed through the coefficient of variation of that trait. Low values of variation for quantitative characteristics generally indicate that the genes controlling their phenotypic expression are predominantly in a homozygous state and that the genotype has reached a high degree of varietal stabilization.

Based on the above-mentioned data and the results presented in Table 3.2, the cultivars Golib, Andijan-35, and Namangan-77 exhibited stable varietal characteristics for the traits under investigation. In contrast, the cultivar Qizil Baraka, the wild species *Gossypium mustelinum* Miers ex Watt, and the T-85 line appeared to possess less stable genetic systems controlling seed development within the boll. Such genetic differences among the experimental materials significantly influenced the expression of productivity traits in the resulting hybrid populations.

In reciprocal hybrids involving the cultivar Golib and various cultivars and lines, the total number of bolls per plant ranged from 7.8 to 19.1, while the number of opened bolls varied from 3.4 to 12.1. The highest performance was observed in reciprocal hybrids involving Namangan-77, whereas the lowest values were recorded in combinations with the T-85 line, where the total number of bolls and opened bolls amounted to only 7.8 and 3.4 per plant, respectively.

The percentage of fully developed seeds per boll in hybrids derived from Golib ranged from 81.4% to 97.8%. Higher values for this trait were observed in F_1 hybrids involving Andijan-

35, Namangan-77, and Qizil Baraka. In contrast, the hybrids Golib × *G. mustelinum* Miers ex Watt and Golib × T-85 exhibited comparatively lower percentages of fully developed seeds [12].

The broad variation amplitude (60-100%) and relatively high coefficients of variation (12.8% and 13.7%) observed in hybrids involving *G. mustelinum* Miers ex Watt and the T-85 line suggest considerable genetic divergence between these forms and the cultivar Golib with respect to the genes controlling seed development.

Analysis of inheritance patterns for the percentage of fully developed seeds per boll in F_1 populations derived from Golib and other parental forms revealed positive and negative overdominance, weak, moderate, and strong positive dominance, as well as moderate negative dominance.

The productivity traits observed in F_1 hybrids between Andijan-35 and Namangan-77, as well as those involving *G. mustelinum* Miers ex Watt, were generally comparable to the results obtained from Golib-derived hybrids. In reciprocal combinations of Andijan-35 × Namangan-77, the percentage of fully developed seeds per boll exhibited positive overdominance in both crossing directions (hp = 1.9 and 1.8). Even stronger overdominance effects were observed in F1 hybrids between Namangan-77 and Qizil Baraka, where hp values reached 4.4 and 6.5.

Similar trends were observed in reciprocal hybrids involving Namangan-77 and Qizil Baraka crossed with *G. mustelinum* Miers ex Watt and the T-85 line. The total number of bolls per plant ranged from 10.3 to 22.3. Among these combinations, Namangan-77 × Qizil Baraka, *G. mustelinum* Miers ex Watt × Namangan-77, and Qizil Baraka × *G. mustelinum* Miers ex Watt exhibited satisfactory numbers of opened bolls, averaging 11.8, 11.2, and 9.5 bolls per plant, respectively.

The highest coefficients of variation were recorded in F1 hybrids involving Namangan-77 and Qizil Baraka crossed with *G. mustelinum* Miers ex Watt and T-85, reaching 16.1%, 21.7%, and 20.2%, respectively (Table 1). These elevated values indicate substantial genetic variability within the hybrid populations and suggest considerable opportunities for obtaining recombinant genotypes valuable for future breeding programs.

Reciprocal F_1 hybrids obtained between the geographically distant and genomically divergent forms, namely the wild species *Gossypium mustelinum* Miers ex Watt and the T-85 line, produced 12.6-13.1 bolls per plant, whereas the number of opened bolls ranged from 3.1 to 4.2 per plant. In hybrids where *G. mustelinum* Miers ex Watt served as the maternal parent, the percentage of fully developed seeds per boll reached 90.5%, representing a relatively high value. However, due to the very low average number of opened bolls, this result cannot be considered favorable from a breeding perspective. Overall, all productivity-related traits evaluated in these reciprocal hybrids exhibited undesirable performance (Table 1).

To further investigate productivity traits in F1 hybrids, stepwise hybridization was carried out using F_1 progenies derived from reciprocal crosses among the cultivars Golib, Andijan-35, and Namangan-77, followed by crossing with the cultivar Qizil Baraka, the wild species *G. mustelinum* Miers ex Watt, and the T-85 line. The resulting F0 hybrid seeds were planted, F1 plants were obtained, and their productivity characteristics were subsequently evaluated (Table 1).

As a result of stepwise hybridization involving F_1 Golib × Andijan-35 plants crossed with Qizil Baraka, *G. mustelinum* Miers ex Watt, and T-85, the total number of bolls per plant ranged from 12.3 to 16.3, while the number of opened bolls varied from 4.4 to 8.2. The percentage of fully developed seeds per boll ranged from 81.1% to 95.9%.

The variation amplitude for this trait ranged from 62.1% to 100.0%, whereas the coefficient of variation varied between 4.0% and 12.2%. Analysis of inheritance patterns for the percentage of fully developed seeds per boll in the F_1 populations revealed positive and negative overdominance as well as moderate negative dominance.

The productivity traits observed in the stepwise hybrid combination F_1 (Golib × Andijan-35) × Qizil Baraka demonstrated the highest values among the studied populations. Intermediate performance was recorded in F_1 (Golib × Andijan-35) × *Gossypium mustelinum* Miers ex Watt, whereas the lowest productivity was observed in F_1 (Golib × Andijan-35) × T-85 hybrids. Based on these findings, it can be inferred that the genomic constitution of the F_1 Golib × Andijan-35 hybrid is genetically closer to the cultivar Qizil Baraka, moderately divergent from the wild species *G. mustelinum* Miers ex Watt, and substantially different from the T-85 line.

Similar patterns were observed in the remaining stepwise hybrid combinations. In general, F_1 progenies derived from reciprocal crosses among Golib, Andijan-35, and Namangan-77 exhibited superior productivity when crossed with Qizil Baraka, intermediate performance when crossed with *G. mustelinum* Miers ex Watt, and lower productivity when crossed with the T-85 line.

Conclusion.

Among the reciprocal F_1 hybrids, the highest productivity, as determined by total boll number per plant, number of opened bolls, and percentage of fully developed seeds per boll, was observed in hybrid combinations involving the cultivars Golib, Andijan-35, Namangan-77, and Qizil Baraka. Similarly, superior productivity performance was recorded in the stepwise hybrid combinations F_1 (Andijan-35 × Golib) × Qizil Baraka, F_1 (Golib × Namangan-77) × Qizil Baraka, F_1 (Andijan-35 × Namangan-77) × Qizil Baraka, F_1 (Andijan-35 × Namangan-77) × *G. mustelinum* Miers ex Watt, and F_1 (Namangan-77 × Andijan-35) × *G. mustelinum* Miers ex Watt.

These hybrid combinations were characterized by narrow ranges of variation for the percentage of fully developed seeds per boll, low coefficients of variation, and positive overdominance effects. Therefore, they can be recommended as promising initial breeding materials for cotton improvement programs aimed at increasing yield potential.

Analysis of reciprocal and stepwise F_1 hybrid populations revealed diverse inheritance patterns for the percentage of fully developed seeds per boll, including positive and negative overdominance as well as weak, moderate, and strong positive and negative dominance effects. In most cases, this trait tended to shift toward the parental genotype exhibiting lower expression values.

The results further demonstrated that hybridization between geographically distant forms creates opportunities for obtaining recombinant populations with broad genetic variability and enhanced breeding potential for productivity traits.

Moreover, the substantial genomic divergence among the parental forms used in the present study provides valuable novel genetic resources for future cotton breeding programs.

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