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INHERITANCE OF AGRONOMICALLY VALUABLE TRAITS IN NATURALLY COLORED COTTON (*Gossypium hirsutum L.*): ANALYSIS OF DOMINANCE DEGREE AND HETEROSIS

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ABSTRACT

Naturally colored cotton fiber is an environmentally friendly and economically beneficial raw material, as its cultivation reduces the need for chemical dyes and enables the production of health-safe textile products. However, the industrial application of such fibers is limited, primarily due to their shorter length and lower strength. In this study, naturally brown and green fibered cotton samples belonging to the species Gossypium hirsutum L. were crossed with white fibered varieties in a full diallel scheme. The resulting F1 hybrids were evaluated for the inheritance patterns of key agronomic traits, including vegetation period, plant productivity, boll weight, lint yield, lint index, and 1000-seed weight. Analysis based on dominance coefficient (hp) and heterosis effect (Ht) revealed that plant productivity exhibited positive overdominance in 90% of combinations. At the same time, lint yield and vegetation period were mostly inherited under incomplete dominance. These findings provide a significant genetic basis for improving selection programs aimed at developing high-quality, naturally colored cotton varieties with desirable agronomic traits.

Keywords: Naturally Colored Cotton, Gossypium Hirsutum L., Selection, Agronomic Traits, Degree of Dominance, F1 Hybrid, Fiber Quality, Heterosis

1. INTRODUCTION

In recent years, the growing demand for eco-friendly and health-safe products has accelerated the development of organic textile production. In this context, naturally colored cotton fiber has gained significant importance due to its cost-effectiveness, non-toxic nature, and the elimination of the need for chemical dyeing processes. According to international data, more than 146,000 tons of naturally colored cotton raw material are currently being produced in countries such as China, the USA, India, Australia, and others (ICAC, 2022).

Compared to white cotton, naturally colored cotton fibers are less commonly used in the textile industry. This is primarily due to their lower fiber length, strength, and overall quality characteristics. To overcome these limitations, complex genetic and selection studies are required in naturally colored cotton. In particular, studying the inheritance of economically valuable traits such as vegetation period, yield, boll weight, lint index, and seed weight in F_1 hybrids can significantly enhance the effectiveness of breeding programs.

Scientific studies in this field have shown that the duration of the vegetation period is a key morpho-biological trait that determines the ripening time of the plant. During all stages of cotton

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ontogenesis (germination, true leaf formation, budding, flowering, and maturation), important physiological and biochemical processes occur that are crucial for selection. The duration of these stages is closely linked to plant productivity and fiber quality, and is influenced not only by genotype-specific characteristics but also by agro-technical factors and environmental conditions (Bekmuxamedov et al., 2014; Narkizilova et al., 2022).

Traditional breeding approaches have made it possible to improve key traits such as yield, fiber quality, and fiber color. In particular, studies by S. Fox (1988), N.A. Saakova (2000), Taofik and Stoilova (2000), Zhang et al. (2019), and others have demonstrated the strong heterosis effect in F_1 hybrids, with positive impacts on boll weight, fiber quality, and productivity. Moreover, the weight of a single boll has been identified as a significant factor directly influencing lint yield (Karademir et al., 2009; Batool et al., 2010; Li et al., 2009).

Another important breeding trait is the 1000-seed weight, which affects seed germination, early plant development, and future yield potential (Barotova et al., 2023). Unfortunately, most existing research has focused on white-fibered cotton, while the inheritance of economically important traits in naturally colored cotton varieties remains insufficiently studied.

Therefore, in this study, naturally brown and green fibered *Gossypium hirsutum L.* samples were hybridized with white-fibered varieties in reciprocal crosses. The resulting F_1 hybrids were analyzed for inheritance patterns and dominance degrees of key traits, including vegetation period, plant productivity, boll weight, lint yield and index, and 1000-seed weight. This research aims to provide a genetic foundation for scientifically grounded selection and the development of improved naturally colored cotton cultivars.

2. MATERIALS AND METHODS

The field experiments for this study were conducted at the regional experimental base of the Institute of Genetics and Experimental Plant Biology, Academy of Sciences of the Republic of Uzbekistan, located in the Zangiota district, Tashkent region.

This experimental site is situated 0.5 km northeast of Tashkent city, at 41°20′ N latitude and 69°18′ E longitude, on the upper terrace of the Chirchiq River, at an altitude of 398 meters above sea level. The soil of the trial field is typical sierozem with low humus content and a moderately sandy texture. The terrain is slightly sloping, non-saline, and weakly affected by Verticillium wilt. Groundwater is located at a depth of 7–8 meters. The climate is sharply continental, characterized by hot summers (June–August) and sharply cold winters (especially in December and January). The region receives precipitation in autumn, winter, and spring, while summers are dry, requiring artificial irrigation for cotton cultivation.

Agrotechnical practices were carried out under the standard protocols of the Institute's experimental farm. Sowing was conducted in a marked field using a 90×20×1 cm scheme. Seeds were planted at a depth of 4–5 cm. Experimental plots were arranged in a randomized design with three replications, each consisting of a single row with 12 hills per row.

The study involved brown fibered accessions (catalog numbers: 010765, 010108), green fibered accessions (011460, A-800), and white fibered cultivars "Gulshan" and "Sadaf." F_1 hybrids were obtained through full diallel crossing of these lines and cultivars.

Research methods: Field and laboratory experiments were conducted following the methods described by Dospekhov (2011). Genetic and breeding methods such as hybridization, single

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plant selection, phenological observations, statistical data processing, and scientific analysis were employed.

The dominance coefficient (hp) in the F_1 hybrids was calculated using the formula described by G.M. Beil and R.E. Atkins (1965) (Beil & Atkins, 1965).

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

In this case:

- hp – dominance coefficient;
- F_1 – arithmetic mean of the trait in the F_1 hybrid;
- MP – mid-parent value, i.e., the arithmetic mean of the trait in both parental forms;
- P – arithmetic mean of the best performing parent (either male or female);

The dominance coefficient (hp) is interpreted as follows:

- hp = ±0.00–0.09 – no dominance (intermediate inheritance);
- ±0.1 < hp < ±0.9 – incomplete dominance;
- hp = ±1.0 – complete dominance;
- hp > ±1.0 – overdominance.

The dominance coefficient (hp) can be either positive (+) or negative (−). A positive hp indicates dominance of the higher performing parent, while a negative hp indicates dominance of the lower performing parent.

The heterosis effect (Ht) in F_1 hybrids was calculated using the formula proposed by Fonseca and Patterson (1968) (Fonseca & Patterson, 1968).

$$Ht\ (\%) = \frac{F_1 - MP}{MP} \times 100$$

In this formula:

- Ht – heterosis effect;
- F_1 – arithmetic mean of the trait in the F_1 hybrid;
- MP – mid-parent value, i.e., the arithmetic mean of the trait in both parental forms.

3. RESULTS

In this study, thirty F_1 hybrids were developed through full diallel crosses between naturally colored cotton genotypes (two brown and two green fibered accessions) and two white fibered cultivars of *Gossypium hirsutum* L. These hybrids were evaluated for key agronomic traits including vegetation period, plant productivity, boll weight, lint yield, lint index, and 1000-seed weight. Inheritance patterns were analyzed based on dominance coefficient (hp) and heterosis effect (Ht), providing insight into the genetic behavior of these traits.

Vegetation Period

Vegetation period varied among the hybrids and was generally longer in naturally colored genotypes compared to white fibered parents, indicating medium to late maturity. The shortest period was observed in the white cultivar ‘Sadaf’ (120.1 ± 0.7 days), and the longest in the green fibered accession 011460 (134.1 ± 0.9 days).

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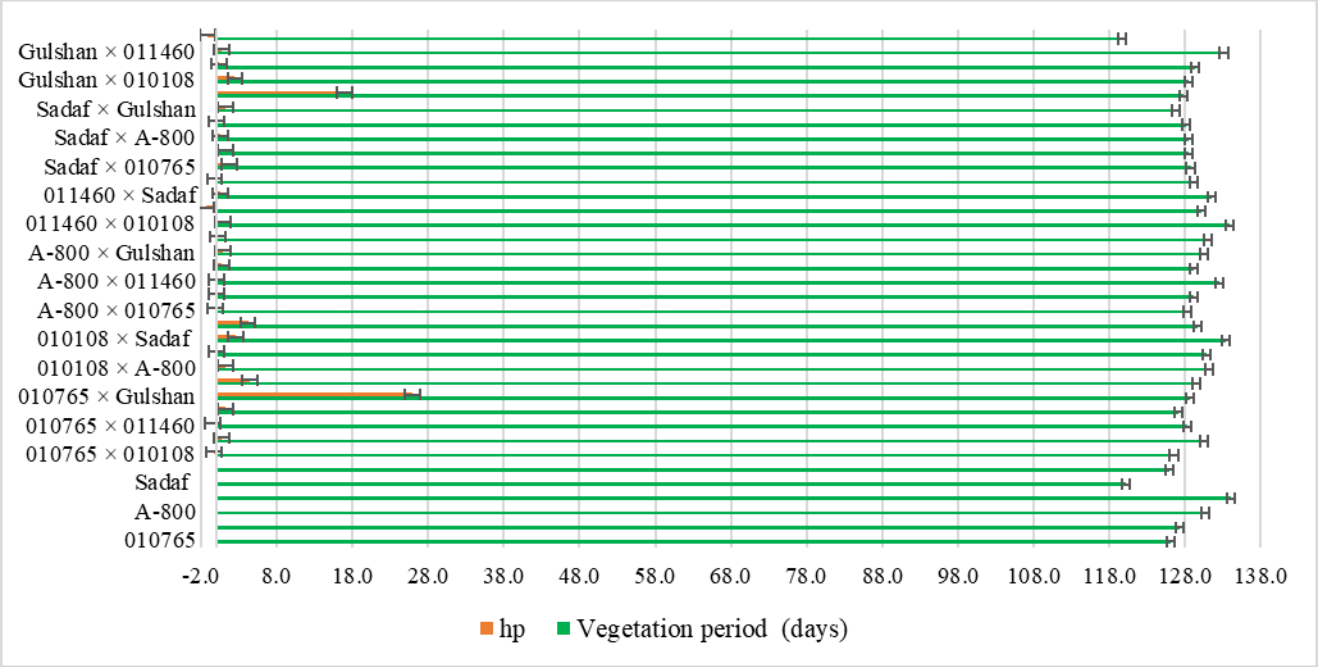

Figure 1. Inheritance of the vegetation period trait (hp – dominance coefficient) in F_1 hybrids obtained from crosses between naturally colored *G. hirsutum L.* accessions and white fibered cultivars.

Among the 30 F_1 hybrids, 11 combinations exhibited incomplete dominance of the longer-period parent, 11 showed overdominance, while others showed either lower-parent dominance or intermediate inheritance. These results confirm the complex genetic control of maturity traits in naturally colored cotton.

Plant Productivity

Plant productivity, defined as the total yield per plant, demonstrated overdominance in 27 of the 30 F_1 hybrids, indicating strong heterotic effects. For example, the combinations 011460×010108 and A-800×010108 recorded high hp values (hp = 43.4 and 16.0, respectively). Positive heterosis was observed in all hybrids, with the highest values in 010108×Sadaf (Ht = 24.6%), A-800×Gulshan (Ht = 19.5%), and Gulshan×A-800 (Ht = 18.9%). These results highlight the potential of hybrid vigor in improving yield traits.

Boll Weight

The inheritance of boll weight showed variation: 14 hybrids demonstrated overdominance, 8 incomplete dominance, 4 complete dominance, and 4 others showed lower-parent dominance or intermediate inheritance. The highest dominance values were observed in hybrids like 011460×010108 (hp = 13.0) and Gulshan×Sadaf (hp = 11.0). White fibered cultivars ‘Sadaf’ and ‘Gulshan’ had the highest boll weights (6.1 ± 0.3 g and 6.0 ± 0.1 g), whereas the green fibered line A-800 showed the lowest (4.2 ± 0.7 g).

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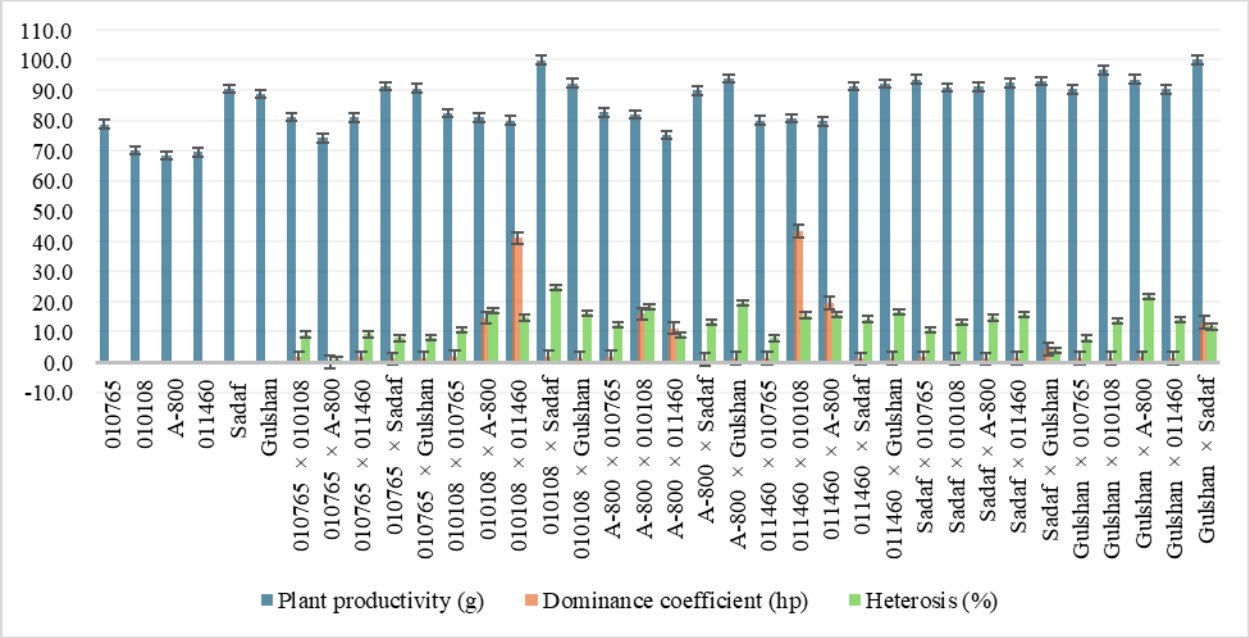

Figure 2. Inheritance of the plant productivity trait (hp – dominance coefficient) and heterosis effect (Ht%) in F_1 hybrids obtained from crosses between naturally colored *G. hirsutum L.* accessions and white fibered cultivars.

Lint percent (%)

The white cultivar 'Sadaf' had the highest lint yield (40.3 ± 0.6%), while the green fibered line 011460 had the lowest (22.3 ± 0.7%). Among the hybrids, 16 combinations showed incomplete dominance, 6 overdominance, and others exhibited variable inheritance patterns. Notably, hybrids such as 010765×Sadaf and 010108×Gulshan exhibited strong positive dominance effects. These results demonstrate significant genotypic influence on lint yield.

Lint Index

The lint index, which reflects fiber mass per 100 seeds, showed incomplete dominance in 14 hybrids, overdominance in 5, and various forms of lower-parent dominance in others. High values were recorded in Sadaf×Gulshan (7.2 ± 0.4 g; hp = 0.8) and Sadaf×010765 (7.8 ± 0.4 g; hp = 1.5). These findings support the role of both parental types in improving this complex trait.

1000-Seed Weight

Among parental lines, the highest 1000-seed weights were observed in green fibered accessions 011460 (125.2 ± 0.9 g) and A-800 (120.0 ± 1.5 g), while the lowest was in the brown accession 010108 (94.7 ± 2.4 g). In hybrids, overdominance of the higher-performing parent was found in 10 combinations, with extreme dominance coefficients in A-800×Gulshan (hp = 203.0) and Gulshan×A-800 (hp = 43.0) hybrids. These results underscore the polygenic nature of seed weight and its potential for improvement through hybridization.

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Table 1. Inheritance of key agronomically valuable traits (hp – dominance coefficient) in F_1 hybrids obtained from crosses between naturally colored accessions and white fibered cultivars of *G. hirsutum* L.

Genotypes	Cotton weight per boll (g)	hp	Lint (%)	hp	Lint Index (g)	hp	1000 seed weight (g)	hp
010765	5,0±0,1	-	31,7±0,5	-	5,3±0,2	-	109,1±1,4	-
010108	4,6±0,1	-	29,2±1,0	-	4,5±0,2	-	104,8±1,8	-
A-800	4,2±0,2	-	27,0±0,5	-	4,2±0,2	-	120,0±2,0	-
011460	4,5±0,1	-	22,3±0,7	-	4,6±0,1	-	125,2±1,8	-
Sadaf	6,1±0,1	-	40,3±0,6	-	7,3±0,2	-	110,3±1,9	-
Gulshan	6,0±0,2	-	35,2±0,6	-	6,0±0,2	-	119,9±1,4	-
010765 × 010108	4,7±0,1	-0,5	32,2±0,5	1,4	5,4±0,4	1,2	105,8±1,9	-0,5
010765 × A-800	5,4±0,1	2,0	32,8±0,3	1,5	5,3±0,3	1,0	112,4±1,5	-0,4
010765 × 011460	5,9±0,1	5,5	29,3±0,4	0,5	4,7±0,2	-0,7	114,7±1,5	-0,3
010765 × Sadaf	6,1±0,1	1,0	40,0±0,5	0,9	7,0±0,1	0,7	106,0±1,3	-6,1
010765 × Gulshan	6,1±0,1	1,2	38,8±0,4	3,1	7,0±0,1	3,8	111,6±1,3	-0,5
010108 × 010765	5,2±0,1	2,0	31,6±0,9	0,9	5,0±0,2	0,2	115,5±1,9	4,0
010108 × A-800	4,1±0,2	-1,5	24,3±0,5	-3,4	4,1±0,2	-1,7	105,6±1,3	-0,8
010108 × 011460	5,0±0,1	9,0	20,3±0,3	-1,6	3,5±0,1	-21,0	121,2±1,6	0,6
010108 × Sadaf	5,8±0,1	0,6	34,5±0,4	-0,05	6,1±0,3	0,1	111,4±1,6	1,4
010108 × Gulshan	6,1±0,1	1,1	34,9±0,5	0,9	6,2±0,2	1,3	116,2±1,0	0,5
A-800 × 010765	4,8±0,2	0,5	32,8±0,3	1,5	5,1±0,2	0,6	121,4±1,8	1,3
A-800 × 010108	4,6±0,1	1,0	27,0±0,4	-1,0	4,6±0,2	1,7	122,7±1,2	1,4
A-800 × 011460	4,6±0,2	1,7	25,6±0,5	0,4	4,0±0,4	-2,0	126,4±1,6	1,4
A-800 × Sadaf	5,1±0,1	-0,05	35,1±0,5	0,2	5,8±0,3	0,03	107,8±1,2	-1,5
A-800 × Gulshan	5,6±0,1	0,6	31,5±0,4	0,1	5,6±0,1	0,6	130,1±1,2	203,0
011460 × 010765	5,1±0,2	1,4	28,7±0,5	0,4	4,9±0,1	-0,1	126,3±1,7	1,1
011460 × 010108	5,2±0,1	13,0	22,9±0,6	-0,8	3,8±0,2	-15,0	124,8±1,8	1,0
011460 × A-800	5,0±0,1	4,3	24,9±0,7	0,1	4,3±0,2	-0,5	127,7±1,9	2,0
011460 × Sadaf	5,5±0,2	0,2	31,8±0,4	0,1	5,5±0,2	-0,3	118,0±1,9	0,03
011460 × Gulshan	6,3±0,1	1,4	29,0±0,3	0,04	5,5±0,3	0,3	127,2±1,3	1,7
Sadaf × 010765	6,5±0,1	1,7	42,0±0,5	1,4	7,8±0,4	1,5	106,5±1,3	-5,3
Sadaf × 010108	6,1±0,1	1,0	36,3±0,4	0,3	6,2±0,4	0,2	108,4±1,5	0,3
Sadaf × A-800	5,5±0,1	0,4	37,0±0,7	0,5	6,4±0,7	0,4	106,2±0,5	-1,8
Sadaf × 011460	5,8±0,1	0,6	33,2±0,4	0,2	5,8±0,2	-0,1	117,5±1,6	-0,03
Sadaf × Gulshan	6,1±0,1	1,0	38,1±0,6	0,1	7,2±0,4	0,8	119,3±0,9	0,9
Gulshan × 010765	5,7±0,1	0,4	36,7±0,4	1,9	5,8±0,2	0,4	111,2±1,9	-0,6
Gulshan × 010108	6,4±0,1	1,6	33,7±0,4	0,5	5,7±0,2	0,6	115,4±1,1	0,4
Gulshan × A-800	5,8±0,2	0,8	31,1±0,5	0,01	5,5±0,2	0,4	122,2±1,9	45,0
Gulshan × 011460	6,0±0,1	1,0	28,3±0,3	-0,1	5,6±0,2	0,4	132,8±1,1	3,9

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Gulshan × Sadaf	6,6±0,1	11,0	39,5±0,4	0,7	7,0±0,4	0,5	112,5±1,8	-0,5

4. DISCUSSION

The results of this study demonstrate that naturally colored cotton genotypes (*Gossypium hirsutum* L.) possess substantial genetic variability for agronomically important traits. The dominance and heterosis analyses revealed different inheritance patterns across the evaluated characteristics, indicating the complex genetic architecture controlling these traits. The longer vegetation periods observed in colored fibered lines, especially green types, are consistent with previous findings suggesting delayed maturity in such genotypes (Fursov, 1995). This may be due to the pleiotropic effects of pigment-related genes or linkage with maturity genes. The presence of overdominance and incomplete dominance for vegetation duration suggests that careful parent selection can lead to improved maturity synchronization in hybrid breeding.

Plant productivity exhibited strong overdominance in 90% of the hybrids, along with positive mid-parent heterosis, indicating a high degree of non-additive gene action. These findings are in line with reports by Ali & Khan (2007) and Hussain et al. (2009), who emphasized the importance of dominance and epistasis in yield traits. The consistent heterosis across most hybrids confirms the potential of exploiting hybrid vigor to improve cotton yield, particularly in colored fiber accessions.

Boll weight and lint yield also displayed favorable inheritance patterns with high values of hp in several combinations. The boll weight trait, which encompasses both seed and fiber components, is influenced by polygenic inheritance, as supported by the results and earlier studies (Razzokovna, 2022). The observed dominance effects in lint yield are in agreement with reports that highlight its quantitative nature and environmental sensitivity (Abzalov, 2010).

Interestingly, the lint index and 1000-seed weight traits showed both positive and negative dominance effects, reflecting their complex genetic control. The occurrence of lower-parent dominance in some crosses may be attributed to cytoplasmic or maternal effects, gene interactions, or epigenetic factors. The high 1000-seed weights in green fibered lines may serve as an important selection trait for breeding programs focused on seed vigor and early seedling establishment.

Overall, the results suggest that valuable traits such as fiber yield, boll size, and seed weight can be improved in naturally colored cotton through hybridization. The identification of specific cross combinations showing high dominance or heterosis effects provides a solid basis for selecting promising F_2 populations and advancing them in selection programs. This study contributes to the understanding of trait inheritance in colored cotton and supports its potential for sustainable and eco-friendly fiber production.

5. CONCLUSION

This study investigated the inheritance of key agronomic traits in 30 F_1 hybrids derived from full diallel crosses between naturally brown and green fibered *Gossypium hirsutum* L. accessions and white fibered varieties. The results revealed substantial genetic variability and non-additive gene action across multiple traits.

Vegetation period and lint yield were primarily inherited under positive incomplete dominance and overdominance, indicating potential for selecting hybrids with favorable maturity and fiber output. Single boll weight exhibited positive overdominance and incomplete

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dominance, while lint index and 1000-seed weight showed both positive and negative incomplete dominance patterns. Plant productivity, one of the most economically important traits, was predominantly inherited under positive overdominance. Several F_1 hybrids demonstrated significant positive heterosis effects.

Overall, the findings underscore the importance of hybridization in enhancing valuable traits in naturally colored cotton. These results provide a strong genetic foundation for breeding programs aiming to develop high-performing, eco-friendly cotton cultivars with improved yield and fiber characteristics.

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