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THE GENUS *GOSSYPIMUM* L.: COMPARATIVE ANALYSIS OF ITS PHYSIOLOGICAL TRAITS IN SOME SPECIES AND INTROGRESSIVE LINES

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SUMMARY

The following study sought to determine the chlorophyll and carotenoid content of the cotton species *Gossypium herbaceum* L. and *G. arboreum* L. Results showed the highest levels of chlorophyll a and b, total chlorophyll, and carotenoids emerged in the genotypes of *G. herbaceum* L. subspecies, subsp. *Frutescens*. In the *G. arboreum* L. genotypes, the chlorophyll a and b, total chlorophyll, and carotenoid were prominent in the subsp. *Obtusifolium* var. *Indicum*. By analyzing the introgressive cultivars and lines obtained with the participation of the *G. hirsutum* L., outcomes gave varied values for chlorophyll a and b, total chlorophyll, and carotenoid contents. However, in the first iteration, the optimum levels of chlorophyll a, b, total chlorophyll, and carotenoids appeared in the lines T-5, Sultan, and Genofond-2. In the second iteration, the highest chlorophyll a and b, total chlorophyll, and carotenoid contents resulted in the lines T-5 and Genofond-2. For the third iteration, the topmost values of chlorophyll a, b, total chlorophyll, and carotenoids were evident in the lines T-14 and T-41. The maximum carotenoid content of the *G. herbaceum* subsp. *Frutescens* and *G. arboreum* subsp. *Obtusifolium* var. *Indicum* occurred in Genofond-2, improving the ability of chlorophyll to collect light energy and its efficiency in photosynthesis. Moreover, the ultimate level of carotenoids has a positive effect on photosynthesis, leading to increased yield. Overall, the results confirmed that the differences between these cotton species, introgressive cultivars, and lines reflect the diversity for chlorophyll and carotenoid contents, which serve as an important basis for biological research.

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Keywords: Cotton, *G. herbaceum* L., *G. arboreum* L., *G. hirsutum* L., introgressive lines, photosynthetic pigments, chlorophyll a and b, total chlorophyll, carotenoids

Key findings: In these cotton lines, the enhanced carotenoid content increases the ability of chlorophyll to harvest light energy, improving the efficiency of photosynthesis, which helps cotton to grow more effectively. High photosynthesis rates improve photosynthesis in cotton leaves, resulting in increased seed cotton yield.

INTRODUCTION

The northern limit of the cotton-growing area on Earth is 38°–44° North latitude, and 35° is the South latitude. In these latitudes, cotton growing occurs in more than 90 countries with 32–33 million hectares, producing 19–20 million tons of fiber per year. China, the United States, India, Pakistan, Uzbekistan, Brazil, Turkey, Egypt, and Mexico are the leading cotton-growing countries worldwide, accounting for more than 80% of the total cotton grown in the world (Mauer, 1954; Normurodov and Muminov, 2024).

Uzbekistan also has a prominent position in the development and implementation of advanced innovative technologies in cotton agrotechnology. In this regard, the intensive progress of cotton growing, the radical improvement of land reclamation, the deepening of selection work, the introduction of effective modern agrotechnologies, and the rational use of land, water, and other resources are substantially important (Muminov, 2024a). Uzbekistan is the world leader in cotton pests' biological control. During the years of independence, paying great attention to this sector improved the yield and quality of the cotton, as well as the economic benefits from it (Muminov *et al.*, 2024b). Several high-yielding, early-maturing, disease- and pest-resistant, promising cotton cultivars became included in the state register, with fiber quality centers being established that meet international requirements. In Uzbekistan, each bale of the cotton produced incurred analysis and evaluation based on world market standards (through the HVI system) (Oripov and Ostonov, 2005; Teshayev *et al.*, 2016; Normurodov and Muminov, 2023).

The total leaf area, which determines the total number of leaves on a plant and the order showing leaf distribution, plays a vital role in cotton plant growth and development (Pettigrew *et al.*, 2000). The total leaf area indicates the size of the main assimilation and transpiration apparatus in the cotton plants. The nature of the distribution of the leaves determines the degree to which the total leaf area shades the fruit organs with the leaves, the latter being especially important during the period of bud maturation (Muminov *et al.*, 2023; Muminov *et al.*, 2025). Overall, three types of pigments exist in the plant leaf chloroplasts: chlorophylls, carotenoids, and phycobilins. Chlorophylls' isolation as free pigments from the green leaves dates back to 1817 by the French chemists Pelte and Cavantu (Govindjee *et al.*, 2024). The German scientist Wilstetter studied the chemical composition of chlorophyll a ($C_{55}H_{72}O_5H_4Mg$) and chlorophyll b ($C_{55}H_{70}O_6H_4Mg$) (Robert, 1953).

Chlorophyll a is dark green, and chlorophyll b is yellow-green. The chlorophyll a amount in green leaves is 20%–40% more than the chlorophyll b. Chlorophylls bind to proteins in the cell and form a colloidal solution with an aqueous extract of the leaf. Acetone and alcohol easily separate the chlorophyll from the leaves. The chlorophyll-protein complex is strong and performs its function without breaking down even under various adverse environmental conditions. Chlorophyll a absorbs 660–663 nm of the red spectrum and 428–430 nm of the blue spectrum, while chlorophyll b absorbs 642–644 nm of the red spectrum and 452–455 nm of the blue spectrum. However, neither chlorophyll absorbs green and infrared rays. In a spectroscope, the light absorbed by chlorophyll

appears dark. One of the optical properties of chlorophyll is fluorescence, which can also reflect the absorbed light. In the reflected light, the chlorophyll appears red.

The production of chlorophyll happens in plants grown in light, but the plants grown in the dark do not produce it. Therefore, the plants grown in the dark are mostly yellow or colorless and are the etiolated plants. However, the etiolated plants turn green when exposed to the light. The organic compounds formed during photosynthesis are the main source of the plants' life. During photosynthesis, the oxygen released into the atmosphere is necessary for the respiration of all living organisms (Beknazarov, 2009; Omonov *et al.*, 2023). Photosynthetic pigments are substances with very diverse chemical structures, which are the porphyrin pigments, chlorophylls a and b, and carotenoids (Maisura *et al.*, 2014).

The leaf plate is the main vegetative organ of a plant, where complex physiological and biochemical processes, such as photosynthesis, respiration, and water exchange, occur, and all those activities determine the plant's biological and economic productivity (Muminov, 2021; Muminov *et al.*, 2023). Therefore, the genetic studies of the structural and functional properties of the leaf blade are of significant scientific and practical importance (Omonov *et al.*, 2023). In the genus *Gossypium* L., the leaf blade has a wide range of morphological variations, including its entire, claw-shaped, strongly claw-shaped, and claw-shaped divided forms (Abdullaev, 1974; Abzalov and Fathullaeva, 1979).

MATERIALS AND METHODS

Breeding material

The breeding material of the genus *Gossypium* L. comprised various forms of the cotton species *G. herbaceum* subsp. *Pseudoarborescens*, subsp. *Pseudoarborescens* f. *Harga*, subsp. *Frutescens*, and *G. arboreum* subsp. *Obtusifolium* var. *Indicum*, subsp. *Neglectum*, subsp. *Neglectum* f. *Sanguineum*, subsp.

Perenne, subsp. *Nanking* (white fiber). The study also used introgressive cultivars and lines of the species *G. hirsutum* L.—Genofond-2, Sultan, S-6524, T-5, T-8, T-13, T-14, T-41, T-1001, and T-1005. These genotypes came from the cotton gene pool of the Institute of Genetics and Plants Experimental Biology, Academy of Sciences, Uzbekistan (Mauer, 1954).

The promising research took place at the experimental site of the Faculty of Natural Sciences, Chirchik State Pedagogical University, Tashkent, Uzbekistan. The research used methods of comparative morphology and statistical analysis. Phenological observations, field calculations during the growing season, and agrotechnical measures during the growth and development of the cotton plants proceeded based on generally accepted methods and recommendations. Given the seeds of the species *G. herbaceum* L. were small and had a hard, stone-like shell, the shell on the micropylar part of the seed sustained a slight cutting off before germination in a Petri dish in a thermostat at a temperature of 30 °C–32 °C. The germinated seeds' sowing and growing continued in paper cups prepared with a mixture of manure, soil, and sand in a ratio of 1:1:1. Then, the seedlings succeeded in transferring to other cups at the 2–3 true leaf stage.

Carrying out the study consisted of determining the amount of chlorophyll a and b and carotenoids in the leaves of all the genotypes belonging to different cotton species. In this case, obtained samples came from 3–4 leaves, starting from the plant's growth point under field conditions. The 50 mg of each leaf placed in a test tube (Kodirova and Amanov, 2023) had each leaf sample homogenized in 5 ml of 95% ethyl alcohol solution (Lichtenthaler and Wellburn, 1983). The homogenate received centrifugation at 5000 rpm for 12 min. The chlorophyll a, b, and carotenoid contents' detection in the obtained extract used an Agilent Cary 60 UV-Vis spectrophotometer at 664, 649, and 470 nm, respectively. Based on these physiological traits, the calculation of chlorophyll a, b, total chlorophyll, and carotenoid contents ensued in

the plant leaves using the following equations (Nayek et al., 2014). All obtained data based on various physiological parameters underwent statistical analysis (Dospekhov, 1985).

$$\text{Chlorophyll -a (mg/g)} = 13.36A_{664} - 5.19A_{649}$$

$$\text{Chlorophyll -b (mg/g)} = 27.43A_{649} - 8.12A_{664}$$

$$\text{Carotenoid (mg/g)} = (1000A_{470} - 2.13 \cdot \text{Chl. "a"} - 97.63 \cdot \text{Chl. "b"})/209$$

$$F \text{ (mg/g)} = (V \cdot S)/P.$$

RESULTS AND DISCUSSION

Photosynthetic pigments

According to the results, in the species *G. herbaceum* L. and *G. arboreum* L. genotypes, the average contents of chlorophyll a, b, and the total chlorophyll ranged from 13.8 to 20.0 mg/g, 8.5 to 14.7 mg/g, and 20.1 to 34.8 mg/g, respectively (Table 1). Outcomes also showed the carotenoid content of the

subspecies *G. herbaceum* L. and *G. arboreum* L. averaged at 9.4–16.6 mg/g. The average content of chlorophyll a in genotypes of the species *G. herbaceum* L. ranged from 14.0 to 20.0 mg/g. The highest content of chlorophyll a (20.0 ± 0.01 mg/g) was evident in the subsp. *Frutescens*. The lowest value of chlorophyll a (14.0 ± 0.01 mg/g) appeared in the sample of subsp. *Pseudoarboreum* f. *Harga*.

In the individual genotypes of the *G. arboreum* L., the average content of chlorophyll a varied from 13.8 to 15.5 mg/g. The recorded highest value for chlorophyll a (15.5 ± 0.05 mg/g) emerged in the sample of subsp. *Obtusifolium* var. *Indicum*. The lowest value of chlorophyll a (13.8 ± 0.05 mg/g) resulted in the sample of subsp. *Neglectum* f. *Sanguineum*. Muminov (2021) also reported the same findings while studying the inheritance of various traits in F_1 hybrids of the species *Afro-Asian* cotton.

The average content of chlorophyll b in the cultivars of *G. herbaceum* L. occurred to be 10.9 to 14.7 mg/g. However, the topmost average content of chlorophyll b (14.7 ± 0.02 mg/g) was notable in the subsp. *Frutescens*.

Table 1. Analysis of chlorophyll a, b, and carotenoid contents in the combing phase of *G. herbaceum* L. and *G. arboreum* L.

Chlorophyll content (mg/g)						Carotenoid content (mg/g)	
Chlorophyll a	V%	Chlorophyll b	V%	Total chlorophyll	V%	$\bar{x} \pm S \bar{x}$	V%
$\bar{x} \pm S \bar{x}$		$\bar{x} \pm S \bar{x}$		$\bar{x} \pm S \bar{x}$			
<i>G. herbaceum</i> subsp. <i>Pseudoarboreum</i>							
16.1±0.02	0.27	11.5±0.05	0.76	27.7±0.06	0.36	13.7±0.03	0.43
<i>G. herbaceum</i> subsp. <i>Pseudoarboreum</i> f. <i>Harga</i>							
14.0±0.01	0.12	10.9±0.02	0.35	25.0±0.03	0.21	11.8±0.01	0.19
<i>G. herbaceum</i> subsp. <i>Frutescens</i>							
20.0±0.01	0.09	14.7±0.02	0.20	34.8±0.01	0.05	16.6±0.01	0.15
<i>G. arboreum</i> subsp. <i>Obtusifolium</i> var. <i>Indicum</i>							
15.5±0.05	0.57	13.2±0.11	1.44	28.5±0.16	0.96	13.7±0.07	0.90
<i>G. arboreum</i> subsp. <i>Perenne</i>							
15.4±0.05	0.55	12.9±0.07	0.91	28.3±0.11	0.68	13.4±0.06	0.74
<i>G. arboreum</i> subsp. <i>Neglectum</i>							
14.3±0.03	0.32	12.6±0.04	0.55	26.9±0.06	0.36	12.7±0.03	0.35
<i>G. arboreum</i> subsp. <i>Neglectum</i> f. <i>Sanguineum</i>							
13.8±0.05	0.62	8.5±0.02	0.32	20.1±0.02	0.16	9.4±0.01	0.10
<i>G. arboreum</i> subsp. <i>Nanking</i> (white fiber)							
14.3±0.03	0.34	11.5±0.04	0.58	25.8±0.07	0.44	12.2±0.02	0.27

The lowest indicator of chlorophyll b (10.9 ± 0.02 mg/g) was evident in the subsp. *Pseudoarboreum* f. *Harga* sample. These higher levels of various physiological traits have a positive effect on photosynthesis in cotton leaves, leading to increased seed cotton yield (Normurodov and Muminov, 2023). The average chlorophyll b content in the cultivars of *G. arboreum* L. ranged from 8.5 to 13.2 mg/g. The highest value of the average chlorophyll b content (13.2 ± 0.11 mg/g) resulted in the genotypes of the subsp. *Obtusifolium* var. *Indicum*. The lowest value of chlorophyll b (8.5 ± 0.02 mg/g) appeared in the sample of subsp. *Neglectum* f. *Sanguineum*. These results were greatly analogous to past findings by studying physiological traits in various crop plants (Sikuku *et al.*, 2010; Urokov *et al.*, 2024).

In the cultivars of *G. herbaceum* L., the average total chlorophyll content ranged from 25.0 to 34.8 mg/g. However, the highest value of total chlorophyll content (34.8 ± 0.01 mg/g) was distinct in the subsp. *Frutescens*. The lowest value manifested in the subsp. *Pseudoarboreum* f. *Harga*, with an average total chlorophyll content of 25.0 ± 0.03 mg/g. The results revealed a higher analogy with past findings on spectrophotometric analysis of chlorophylls in various species by using extracting solvents (Biswal *et al.*, 1997; Dai *et al.*, 2009). The total chlorophyll content in *G. arboreum* L. cultivars averaged and ranged between 20.1 and 28.5 mg/g. The utmost value of total chlorophyll was prominent in subsp. *Obtusifolium* var. *Indicum* (28.5 ± 0.16 mg/g). The lowest value of total chlorophyll, with an average of 20.1 ± 0.02 mg/g, was evident in the sample of subsp. *Neglectum* f. *Sanguineum*. Photosynthetic pigments are substances with very diverse chemical structures, and these porphyrin pigments are chlorophylls a and b and carotenoids (Maisura *et al.*, 2014).

The average carotenoid content in the *G. herbaceum* L. cultivars ranged from 11.8 to 16.6 mg/g. The highest value appeared in the subsp. *Frutescens*, with an average carotenoid content of 16.6 ± 0.01 mg/g. The lowest value of the carotenoid content (11.8 ± 0.01 mg/g)

resulted in the subsp. *Pseudoarboreum* f. *Harga*. Therefore, the genetic studies of the structural and functional properties of the leaf blade are scientifically and practically vital (Omonov *et al.*, 2023). The average carotenoid content in the subspecies *G. arboreum* L. had the range of 9.4 to 13.7 mg/g. The maximum value of the carotenoid content (13.7 ± 0.07 mg/g) was remarkable in the form of subsp. *Obtusifolium* var. *Indicum*. The minimum value of the carotenoid content (9.4 ± 0.01 mg/g) was noteworthy to be in the sample of subsp. *Neglectum* f. *Sanguineum*. The presented results were analogous with past findings on the analysis of carotenoids in various plant species (Dawson *et al.*, 2003; Kara and Mujdeci, 2010).

Physiological traits in introgressive cultivars and lines

During this study, the chlorophyll a, b, total chlorophyll, and carotenoid contents of introgressive cultivars and lines obtained involving the species *G. hirsutum* L. underwent analysis in the leaf buds during the budding phase. By analyzing the chlorophyll a in the introgressive cultivars and lines in the first round, it was evident that the chlorophyll a pigment was 10.4–15.1 mg/g. However, the highest value of chlorophyll a pigment emerged in the cultivar Sultan (15.1 mg/g). The lowest value of chlorophyll a pigment occurred in the T-8 line (10.4 mg/g) (Table 2).

The analysis of the chlorophyll b pigment in the introgressive cultivars and lines obtained that include the species *G. hirsutum* L. ranged from 3.40 to 8.66 mg/g. However, the supreme indicator was notable in the cultivar Genofond-2, where the chlorophyll b pigment appeared to be 8.66 mg/g. The lowest value of the chlorophyll b pigment was apparently in the line T-41 (3.40 mg/g). The leaf plate is the main vegetative organ of a plant, wherein complex physiological and biochemical processes, such as photosynthesis, respiration, and water exchange, occur, and all these processes determine the biological and economic productivity of plants (Muminov *et al.*, 2023).

Table 2. Analysis of chlorophyll a, b, and carotenoid contents in the combining phase of introgressive cultivars and lines obtained involving the species *G. hirsutum* L.

No.	Genotypes	Chlorophyll content (mg/g)			Carotenoid content (mg/g)	Chlorophyll content (mg/g)			Carotenoid content (mg/g)	Chlorophyll content (mg/g)			Carotenoid content (mg/g)	
		Chlorophyll a	Chlorophyll b	Total chlorophyll	$\bar{x} \pm S \bar{x}$	Chlorophyll a	Chlorophyll b	Total chlorophyll	$\bar{x} \pm S \bar{x}$	Chlorophyll a	Chlorophyll b	Total chlorophyll	$\bar{x} \pm S \bar{x}$	
$\bar{x} \pm S \bar{x}$	$\bar{x} \pm S \bar{x}$	$\bar{x} \pm S \bar{x}$		$\bar{x} \pm S \bar{x}$	$\bar{x} \pm S \bar{x}$	$\bar{x} \pm S \bar{x}$		$\bar{x} \pm S \bar{x}$	$\bar{x} \pm S \bar{x}$	$\bar{x} \pm S \bar{x}$				
1-repetition					2-repetition					3-repetition				
1.	Genofond-2	10.5±0.14	8.66±0.34	19.2±0.46	10.6±0.29	11.3±0.39	8.46±0.27	19.7±0.49	10.6±0.13	17.3±0.11	7.90±0.42	25.2±0.33	11.1±0.17	
2.	Sulton	15.1±0.20	6.80±0.32	21.9±0.50	10.6±0.57	13.0±0.31	4.20±0.24	17.2±0.32	7.42±0.31	15.4±0.14	5.70±0.20	21.1±0.28	9.15±0.23	
3.	S-6524	13.4±0.24	5.75±0.12	19.2±0.31	9.02±0.21	13.8±0.66	4.90±0.11	18.7±0.61	8.31±0.10	17.2±0.23	7.74±0.19	24.9±0.19	11.6±0.50	
4.	T-5	15.1±0.04	7.70±0.05	22.8±0.07	10.8±0.07	15.7±0.09	7.40±0.38	23.1±0.35	10.8±0.21	13.1±0.05	4.34±0.12	17.4±0.08	7.36±0.07	
5.	T-8	10.4±0.01	4.28±0.03	14.7±0.02	7.09±0.03	10.6±0.09	4.61±0.21	15.2±0.20	7.28±0.38	15.1±0.05	5.46±0.10	20.5±0.05	9.01±0.26	
6.	T-13	15.0±0.31	3.97±0.19	19.0±0.36	7.60±0.43	15.1±0.27	3.88±0.20	18.9±0.47	7.78±0.18	15.4±0.52	7.20±0.35	22.6±0.48	9.65±0.21	
7.	T-14	11.7±0.52	5.70±0.30	17.4±0.22	8.07±0.03	13.2±0.43	5.22±0.28	18.4±0.27	8.22±0.10	20.6±0.84	8.77±0.34	29.4±0.66	12.5±0.26	
8.	T-41	11.2±0.31	3.40±0.08	14.6±0.29	6.26±0.23	15.4±0.38	5.19±0.16	20.6±0.37	8.44±0.10	20.9±0.43	8.61±0.21	29.5±0.61	12.7±0.15	
9.	T-1001	12.1±0.62	5.22±0.28	17.3±0.59	7.66±0.32	13.1±0.31	4.18±0.10	17.3±0.40	7.42±0.19	15.5±0.53	6.65±0.32	22.1±0.59	9.48±0.19	
10.	T-1005	13.3±0.46	5.39±0.15	18.7±0.57	8.57±0.35	14.0±0.55	5.05±0.20	19.1±0.67	7.94±0.38	13.8±0.41	5.73±0.19	19.6±0.54	8.78±0.42	

On the total chlorophyll content evaluation, the study found that the said pigment ranged from 14.6 to 22.8 mg/g in the introgressive cultivars and lines obtained in participation with the species *G. hirsutum* L. The highest value of total chlorophyll content resulted in the line T-5 (22.8 mg/g), while the lowest indicator observed was in line T-8 (14.7 mg/g). Similar results about chlorophyll a and b also had reports from previous studies on the potato crop (Mauromicale *et al.*, 2006; Amanov *et al.*, 2020). In the introgressive cultivars and lines obtained involving the species *G. hirsutum* L., the average carotenoid content ranged from 6.26 to 10.8 mg/g. The maximum value of the carotenoid content (10.8 mg/g) appeared in the line T-5, whereas the lowest value (6.26 mg/g) was pronounced in the line T-41 (Table 2).

In the second iteration, the chlorophyll a pigment's analysis in introgressive cultivars and lines obtained involving the

species *G. hirsutum* L. exhibited the chlorophyll a pigment had a range from 10.6 to 15.7 mg/g. The highest indicator resulted in the T-5 line, with an average chlorophyll a pigment of 15.7 mg/g. The lowest value of an average amount of chlorophyll a pigment appeared in the line T-8 (10.6 mg/g). In introgressive cultivars and lines gathered with the participation of the species *G. hirsutum* L., the chlorophyll b pigment ranged from 3.88 to 8.46 mg/g. The maximum chlorophyll b pigment was notable in the cultivar Genofond-2 (8.46 mg/g). The minimum indicator was evident in the line T-13, where the chlorophyll b pigment emerged to be 3.88 mg/g (Table 2). By analyzing the total chlorophyll content, the study found the coefficient of variation was high, ranging from 15.2 to 23.1 mg/g. Similar findings have also resulted in studying the leaf characteristics from the cotton genotypes (Pettigrew *et al.*, 2000).

The highest value of the total chlorophyll content was available in the line T-5 (23.1 mg/g). The lowest value of the total chlorophyll content (15.2 mg/g) was noticeable in the line T-8. A previous study also provided data on the photosynthetic pigments in cotton genotypes by exposing them to short-term drought stress conditions (Parida *et al.*, 2007; Amanov *et al.*, 2022). Similarly, the average carotenoid content had the range of 7.28 to 10.8 mg/g. The topmost value of the carotenoid content (10.8 mg/g) occurred in the line T-5, while the lowest value appeared in the line T-8 (7.28 mg/g). The organic compounds formed during photosynthesis are the main source of life for all living organisms (Beknazarov, 2009).

In the third iteration, the chlorophyll a pigment's analysis in introgressive cultivars and lines obtained, including the species *G. hirsutum* L., displayed that the chlorophyll a pigment ranged from 13.1 to 20.9 mg/g. The highest value of the chlorophyll a pigment was remarkable in the line T-41 (20.9 mg/g), while the lowest indicator was evident in the line T-5 (13.1 mg/g) (Table 2). By analyzing the chlorophyll b, overall, the said pigment varied from 4.34 to 8.77 mg/g. The premier indicator emerged in the T-14 line, with a chlorophyll b pigment of 8.77 mg/g. The lowest indicator was noticeable in the T-5 line, where the chlorophyll b pigment was 4.34 mg/g. The high and low levels of the chlorophyll pigment depend on the genetic makeup of crop genotypes (Maisura *et al.*, 2014).

The analysis of the total chlorophyll content revealed that the average total chlorophyll content varied from 2.06 to 29.5 mg/g. The maximum value of the total chlorophyll content resulted in the line T-41 (29.5 mg/g), while the minimum value recorded appeared in the line T-8 (2.06 mg/g). Chlorophyll production comes from the plants grown in the light; however, it does not occur in plants grown in the dark (Omonov *et al.*, 2023). The average carotenoid content had a range of 7.36–12.7 mg/g. The highest value of the average carotenoid content was evident in the line T-41 (12.7 mg/g), while the lowest recorded emerged in the line T-5 (7.36 mg/g). Reports on similar physiological parameters

have also existed in past studies on various crop plants (Beknazarov, 2009; Omonov *et al.*, 2023).

CONCLUSIONS

The high levels of chlorophyll a, b, and total chlorophyll resulted in introgressive cultivars and lines of the species *G. herbaceum* L. and *G. arboreum* L., as well as *G. hirsutum* L. (*G. herbaceum* subsp. *Frutescens*, *G. arboreum* subsp. *Obtusifolium* var. *Indicum*, cultivar Genofond-2 (chlorophyll b), and lines T-13 (total chlorophyll) and T-41 (chlorophyll a). The high carotenoid content of the cotton genotypes (*G. herbaceum* subsp. *Frutescens*, *G. arboreum* subsp. *Obtusifolium* var. *Indicum*, and cultivar Genofond-2) increases the ability of chlorophyll to collect light energy and improves the efficiency of photosynthesis. The cotton species, introgressive cultivars, and lines reflect the diversity for chlorophyll and carotenoid contents and serve as the basis for biological research.

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