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UPLAND COTTON RESPONSE TO DROUGHT STRESS CONDITIONS FOR PHYSIOLOGICAL AND YIELD-RELATED TRAITS

H. MATNIYAZOVA[1,2,*], S. NABIEV[1], A. RAXIMOV[2], M. BORATOVA[3] and S. KABILOVA[4]

[1]Institute of Plant Genetics and Experimental Biology, Academy of Sciences, Tashkent, Uzbekistan
[2]Chirchik State Pedagogical University of Tashkent Region, Chirchik City, Uzbekistan
[3]Samarkand State University, Samarkand Region, Samarkand City, Uzbekistan
[4]Termez State Pedagogical Institute, Termez City, Uzbekistan
[*]Corresponding author's email: matniyazova@mail.ru
Email addresses of co-authors: m.saydigani@mail.ru, atanazarkarimov@gmail.com, muxtasam.boratova@mail.ru, sayyoramohizodali@gmail.com

SUMMARY

This study evaluated the physiological and yield-related responses of 18 advanced upland cotton (*Gossypium hirsutum* L.) lines and the cultivar Namangan-77 under different water conditions. Significant differences were evident in total water content, transpiration rate, and yield traits across genotypes under optimal and water deficit environments. Lines L-1, L-29, and L-24 demonstrated lower sensitivity to drought stress for physiological and agronomic traits, suggesting their potential in breeding for drought tolerance. Correlation analysis indicated a weak relationship between leaf water content and transpiration rate under optimal water conditions, whereas under water deficit, a positive association appeared between leaf hydration and cotton weight per boll. Furthermore, under prolonged drought, a strong positive correlation between leaf water content and transpiration rate occurred, highlighting the importance of efficient water use. Lines L-2, L-24, and L-11 produced heavier seeds under optimal water supply, although drought significantly reduced seed weight and fiber yield in most genotypes. These findings contribute valuable insights for future cotton breeding programs targeting improved drought resilience and stable productivity.

Keywords: Upland cotton (*Gossypium hirsutum* L.), water regimes, drought conditions, physiological traits, chlorophyll, carotenoids, morpho-agronomic traits

Key findings: The identification of cotton (*G. hirsutum* L.) lines L-16 and L-23 was successful, exhibiting stability for transpiration rate in plant leaves under water deficit conditions. Consequently, they are beneficial as breeding material in developing drought-tolerant cotton genotypes. Among medium-fiber cotton lines, lines L-1, L-29, and L-24 showed less sensitivity to water deficit as compared with other lines for physiological and economic traits.

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INTRODUCTION

Crop productivity receives great influence from water scarcity, making drought stress a critical challenge for global agriculture. Currently, drought affects approximately 20% of the world's land (Shavkiev *et al*., 2019a and b; Rasheed *et al*., 2023), resulting in an average yield reduction of 11% across all crops (Riyazuddin *et al*., 2023) and up to 67% losses, specifically in cotton production (Zafar *et al*., 2023; Azimov *et al*., 2024). These drought-induced losses surpass those caused by other abiotic stressors. Although drought severely hampers plant growth, development, and physiological functions, plants have evolved complex self-defense mechanisms to cope with such conditions. These adaptive responses involve intricate signaling pathways and biochemical processes that enhance drought tolerance. At the cellular level, plants activate various stress-related responses, including oxidative stress mitigation and the regulation of stress signaling networks (Mahmood *et al*., 2020).

Upland cotton (*Gossypium hirsutum* L.) is the most important fiber crop, providing raw material to the textile industry worldwide. However, its production has been unstable over the years due to climate change-induced biotic stresses, such as insects, diseases, and weeds, as well as abiotic stresses, including drought, salinity, heat, and cold (Ahmed *et al*., 2024). Drought stress is an inevitable factor that disturbs crop production by altering various morphological, physiological, biochemical, and molecular functions. Breeding for drought tolerance earnestly needs complete knowledge of the molecular factors controlling stress-responsive pathways. Generally, crop plants respond to drought stress by adopting four different mechanisms: avoidance, escape, tolerance, and recovery. Traditional plant-breeding tools have been applicable to enhance the cotton plants tolerance; however, the complexity of drought tolerance has limited the use of these conventional breeding methods (Rasheed *et al*., 2023).

Climate change and global warming adversely affect crop production and food security (Jia *et al*., 2022; Farooq *et al*., 2022; Azimov *et al.,* 2024). Abiotic stress factors are considerable hazards to crop production, leading to a 73% reduction in cotton production worldwide (Mahmood *et al.,* 2019). Abiotic stresses, such as cold, drought, salt, waterlogging, heavy metals, and other environmental factors, have also threatened plant growth and development. However, the drought and salt stresses are causing more than 45% yield losses globally. With the continuous increase in global greenhouse gas emissions, the arid and semi-arid areas will spread by more than 50% by the end of this century (Liao and Hou, 2020).

Cotton is a globally cultivated crop of significant economic value, thriving across a wide range of climatic conditions (Noreen *et al*., 2020). Water plays a vital role in plant life, being essential for nutrient transport, biochemical and enzymatic processes, cell elongation, and transpiration (Meshram *et al*., 2022). Previous studies have demonstrated a positive correlation between seed cotton yield and key agronomic traits, such as fiber yield, number of bolls, boll weight, and seed weight (Waleed *et al*., 2022; Matniyazova *et al*., 2022).

Under water deficit conditions, a considerable positive correlation was noticeable between plant productivity and the bolls per plant in cotton (Shavkiev *et al*., 2023). Determining drought tolerance index indicators succeeded based on principal component and cluster analyses for water deficit tolerance. Past studies revealed cotton lines L-1033, L-860, and L-1023 emerged as prone to water deficit conditions. For seed cotton yield, the lines L-1003, L-1050, L-860, L-1033, and C-6524 could serve as suitable donors for selection. The lines L-1002, L-1003, L-1005, L-1050, and Guliston proved to be positive donors in the selection for drought (Makamov *et al*., 2023). Based on this discussion, the presented study aimed to evaluate the 18 advanced cotton lines and cultivar Namangan-77 under water stress conditions to determine their response on physiological and yield-related traits.

MATERIALS AND METHODS

Experimental site and genetic material

The following research commenced during 2023–2024 at the Institute of Genetics and Experimental Biology, Academy of Sciences, Tashkent, Uzbekistan (with an altitude of 398 masl). The climate exhibited sharp fluctuations, with high temperatures in summer (June, July, and August) and a sharp drop in air temperatures in winter (December and January). Sunny days prevailed for 175–185 days and non-cold days for 200–210 days. The rainfall was notable in the fall, winter, and spring, with the air dry in the summer. The experimental field soil was low in humus, typically gray, and moderately sandy, according to the granulometric composition. The terrain is slightly sloping, not saline, and naturally damaged by whitish (verticillus) silt. The measured soil bulk density was 1.32–1.33 g/cm^3, with a limited field moisture capacity (LFMC) of 22%. Groundwaters go deep (8 m and more) (Matniyazova *et al.,* 2022, 2024).

The study comprised the evaluation and response of 18 advanced cotton (*G. hirsutum* L.) lines and cultivar Namangan-77 based on physiological and yield-related traits under non-stress and stressed conditions. In optimum and controlled water regimes, the cotton genotypes received irrigation four times (scheme 1:2:1) during the vegetative and flowering stages, using 4800–5000 m^3 of water per hectare. However, in the stress conditions, which comprised only two irrigations (scheme 1:1:0) received by the genotypes, the total volume of water used for irrigation was 2800-3000 m^3/ha. Under the water-stressed environment, the cotton genotypes received irrigation once each during the seedling and flowering stages to artificially develop the water scarcity (modeled drought).

The comparative study of the upland cotton advanced lines and cultivar Namangan-77 for physiological and yield-related traits transpired under optimum and water stress conditions. The genetic variability in cotton genotypes and inheritance in various traits, depending upon two water regimes, succeeded in their determination. All the parameters' data recording was successful on 30 plants in each cotton genotype before averaging. In cotton genotypes, the identification of essential physiological indicators of water metabolism proceeded with the following methods: For total water content in the leaves, the study used the formula according to Tretyakov *et al*. (1990), with the transpiration rate measured according to Ivanov *et al*. (1950). The yield-related traits, i.e., boll weight, 1000-seed weight, and seed cotton yield per plant, also succeeded in recording per the standard procedure in all the cotton genotypes. The determined levels of cotton lines adaptation to water deficit conditions employed the method according to Eberhart and Russell (1966).

RESULTS AND DISCUSSION

Water content in plant leaves

In cotton genotype plant leaves, the total water content is one of the most important physiological indicators of plant water exchange. According to the results, 18 advanced cotton lines and cultivar Namangan-77 showed considerable differences in the total water content across various water regimes (Table 1). Variant 1 (control group with optimal water supply) showed the total water content in leaves ranged from 75.4% (line L-20) to 79.1% (line L-3). The cotton seeds obtained with optimal water supply conditions and planted in Variant 2 under water deficit conditions displayed the total water content in leaves decreased for all cotton lines. Under water deficit conditions, the water content ranged from 67.8% (L-28) to 71.8% (L-26), and the lines L-20 and L-17 showed considerable genotypic response to water deficit conditions, exhibiting a reduction of 10.9% and 9.2%, respectively. Conversely, the cotton lines L-20, L-2, L-21, L-23, and L-22 showed relatively weak sensitivity to water deficit conditions, and the water reduction ranged from 3.9% to 5.7%.

In Variant 3, where the harvested cotton seeds were under water deficit conditions and subsequently grown under the same stress, the total water content in leaves

Table 1. Total water content and transpiration rate in leaves of advanced cotton lines.

Line number	Total water content in leaves (%)			Transpiration rate (mg H_2O/1 g wet leaf × 1 hour)		
	Variant 1	Variant 2	Variant 3	Variant 1	Variant 2	Variant 3
L-20	75.4	71.5	70.6	248.86	211.2	174.36
L-16	78.7	70.8	71.4	162.55	149.00	154.65
L-1	78.5	70.5	70.3	279.67	173.73	190.33
L-2	76.3	71.7	70.7	220.47	183.28	85.5
L-21	75.9	71.2	69.4	255.25	203.25	120.95
L-15	76.8	68.9	69.1	217.1	177.33	165.92
L-3	79.1	70.8	69.6	241.59	147.19	175.09
L-11	78.6	70.5	69.7	234.24	157.28	139.07
L-22	76.0	70.3	70.7	282.12	239.01	258.39
L-23	76.0	71.2	73.6	341.33	317.59	299.48
L-24	78.5	71.4	75.6	344.89	233.16	301.76
L-29	77.3	71.0	69.4	277.73	273.74	191.91
L-26	78.1	71.8	69.2	300.51	217.33	164.02
L-27	78.6	70.5	68.8	312.93	187.55	125.12
L-30	77.5	68.3	70.5	279.48	227.32	160.45
L-31	75.9	69.8	70.6	284.04	221.04	231.33
L-32	76.2	69.0	68.7	296.45	238.92	136.74
L-28	78.7	67.8	70.7	286.22	276.23	137.17
Namangan-77	79.4	70.9	70.4	297.51	247.10	188.45
LSD_{05}	0.5	0.4	0.4	10.14	8.43	9.27

declined similarly to those observed in Variant 2. However, cotton lines L-24 and L-23 maintained relatively higher leaf water content, measuring 75.6% and 73.6%, respectively. In contrast, lines L-32 and L-27 exhibited the lowest leaf water content at 68.7% and 68.8%, respectively. Lines L-27, L-3, L-11, and L-26 were notably sensitive to water deficit, with reductions in total leaf water content ranging from 8.9% to 9.8%. Conversely, lines L-23, L-24, and L-20 showed lower sensitivity, with leaf water content decreasing only by 2.4% to 4.8%.

Under drought conditions (variants 2 and 3), the observed decline in leaf water content aligns with previous findings in cotton research. Khamdullaev *et al*. (2021) reported water stress significantly reduces leaf turgor pressure and water content, which, in turn, suppresses metabolic activity and impedes plant growth. Consistent with these results, this study identified specific cotton lines (L-20, L-2, and L-23) that exhibited reduced sensitivity to water deficit conditions—mirroring the conclusions of Shavkiev *et al*. (2021), who found genotypes with efficient water-retention mechanisms incurred fewer adverse effects from drought stress. These findings underscore the potential value of these genotypes in breeding programs aimed at enhancing drought tolerance.

Transpiration rate in plant leaves

The transpiration rate is another crucial physiological indicator, which also showed varying measurements under different water supply conditions. Under Variant 1 (with optimal water conditions), the cotton lines L-24, L-23, L-27, and T-26 exhibited the highest transpiration rates, ranging from 344.89 to 300.51 mg. However, the lowest transpiration rate resulted in the line L-16 (162.55 mg). When planting the cotton seeds under water deficit conditions in Variant 2, the highest transpiration rates appeared in cotton lines L-23 (317.59 mg), L-28 (276.23 mg), and L-29 (273.74 mg). Lines T-3 and T-16 displayed the lowest transpiration rates (147.19 and 149.00 mg). Water deficit conditions generally reduced the transpiration rate across all cotton lines, and the genotype L-27 showed the highest sensitivity (-40.1%), while cotton line L-29 enunciated the weakest (-1.4%).

In Variant 3, with seeds obtained under water deficit conditions and planted under the same conditions again, the transpiration rate decreased for all cotton lines compared with Variant 1. The highest transpiration rates were remarkable in cotton lines L-24 (301.76 mg), L-23 (299.48 mg), and L-22 (258.39 mg), while the lowest rates occurred in L-2 (85.50 mg) and L-32 (136.74 mg). In this variant, lines L-2, L-27, L-26, and L-32 exhibited considerable sensitivity to water deficit conditions, with the reduction in transpiration rates ranging from -53.9% to -61.2%. The cotton lines L-16 and L-22 were notably weaker in sensitivity (-4.9% and -8.4%, respectively).

In this study under water deficit conditions, the decrease in transpiration rate was a well-documented physiological response of the cotton plants to drought stress. During limited water supply, plants mostly close their stomata to conserve water, resulting in a reduced transpiration rate. Shavkiev *et al*. (2019a and b) reported that cotton plants under water deficit conditions had lower transpiration rates and a substantial protective mechanism to minimize the water loss. The relevant results further revealed cotton lines L-27 and L-29 emerged as the most sensitive genotypes to water deficit conditions, showing a drastic reduction in transpiration rate. Lambers and Oliveira's (2019) findings revealed some cotton varieties had a higher degree of sensitivity to drought conditions, which negatively affected the plants' physiological processes.

Seed cotton yield

The analysis of seed cotton yield showed water supply during seed formation had a significant effect on the genotypes' seed cotton yield. Under Variant 1, the heaviest seed cotton yield resulted in cotton lines L-2, L-20, L-1, and L-3, ranging from 77.50 to 78.26 g per plant. However, the lightest seed cotton yield per plant was evident in the line L-11 and cultivar Namangan-77 (62.50 and 62.51 g, respectively). In Variant 2, the cotton seeds obtained under optimal water conditions and planted under water deficit conditions revealed the highest seed cotton yield in lines L-1 (64.03 g), L-16 (63.08 g), and L-15 (60.39 g). However, the lowest seed cotton yield was noteworthy in the cultivar Namangan-77 (39.68 g) and lines L-26 (39.73 g), L-30 (41.30 g), and L-32 (42.15 g). Considerable sensitivity to water deficit conditions was apparent in the cotton lines L-32, L-30, L-26, and L-24, where the plant productivity decreased by 36.5% to 38.5%, as compared with Variant 1. However, the weak sensitivity was notable in cotton lines L-16, T-1, T-15, T-29, and T-21, in which the productivity decrease ranged from 14.5% to 21.4%.

In Variant 3, where the obtained cotton seeds were under water stress conditions and planted under the same stress, the maximum seed cotton yield manifested in lines L-1 (56.88 g), L-20 (55.40 g), and L-28 (55.33 g). However, the minimum seed cotton yield emerged in lines T-24 (39.83 g), L-23 (41.55 g), and L-15 (42.94 g). The remarkable decrease in productivity was visible in lines L-15 (-28.9%) and L-21 (-17.7%), as compared with Variant 2. However, some lines, such as L-26, L-27, L-32, and cultivar Namangan-77, showed higher productivity in Variant 3 than in Variant 2. Seed cotton yield based on the yield-related traits is one of the most sensitive traits to water deficit conditions. The cotton lines L-1 and L-2 exhibited the highest seed cotton yield under optimal conditions. The presented results were greatly analogous to the past research highlighting that seed cotton yield sustained significant influence from water availability during seed formation in upland cotton genotypes (Shavkiev *et al*., 2021). The reduction in seed cotton yield under water deficit variants, particularly in cotton lines L-32, L-30, and L-26, supports the conclusions of earlier studies. They indicated that severe drought stress conditions during the seed formation stage lead to a considerable yield loss (Shavkiev *et al*., 2021).

The 1000-seed weight

The 1000-seed weight is a vital trait in cotton breeding, as it directly correlates with seed yield and overall quality. Under optimal water conditions (Variant 1), cotton lines L-2, L-24, and L-11 produced the heaviest seeds, with 1000-seed weights of 12.41, 12.10, and 11.93 g, respectively. However, under water deficit conditions (variants 2 and 3), a significant reduction in 1000-seed weight was evident. Notably, line L-31 exhibited the most substantial decrease, with a reduction of 21.3%. Conversely, some cotton lines, such as L-21 and L-1, received less impact from water deficit, showing minimal decreases of 6.2% and 6.3%, respectively. These findings suggest that certain genotypes possess considerable tolerance to water stress, enabling them to maintain seed quality under adverse conditions. Furthermore, the observed decline in 1000-seed weight under drought stress aligns with previous studies, which stated water deficiency reduces seed size due to inhibited cell division and expansion (Table 2) (Jaleel et al., 2009).

Fiber yield

Fiber yield is a critical economic attribute in cotton cultivation and, as expected, gained marked influences from water deficit conditions. Under optimal irrigation, fiber yield spanned from 37.2% in line T-28 to approximately 41.0% in other lines, with the cultivar Namangan-77 achieving 39.4%, closely matching the top-performing line L-2. In the moderate drought scenario (Variant 2), nine original entries showed an increase in yield, seven experienced declines, and two remained stable—showing the diverse response among genotypes. Under prolonged drought (Variant 3), fiber yield declined in 12 lines relative to Variant 2, indicating cumulative stress effects. However, lines L-24, L-26, and cultivar Namangan-77 maintained comparatively stable yields, signaling notable drought resilience. These findings align with previous research, as they show that although water deficit stress generally reduces cotton yield, specific genotypes, such as Namangan-77, exhibit inherent tolerance and yield stability under stress.

Fiber length

Fiber length is a crucial quality parameter in cotton production. Under optimal conditions (Variant 1), fiber length ranged from 32.7 to 33.3 mm. Under water deficit conditions

Table 2. Effect of stress conditions on plant productivity and 1000-seed weight in advanced cotton lines.

Line number	Plant productivity (g)			1000-seed weight (g)		
	Variant 1	Variant 2	Variant 3	Variant 1	Variant 2	Variant 3
L-20	78.17	55.80	55.40	113.3	93.0	90.5
L-16	73.78	63.08	54.73	98.4	86.5	85.8
L-1	77.86	64.03	56.88	111.9	104.8	99.8
L-2	78.26	50.54	49.80	124.1	103.4	102.3
L-21	74.70	58.72	48.30	104.9	98.4	95.4
L-15	76.41	60.39	42.94	106.6	97.9	101.2
L-3	77.50	59.96	53.70	110.4	89.8	90.7
L-11	62.51	46.14	46.25	119.3	101.6	90.2
L-22	72.09	53.54	49.34	104.2	95.5	92.7
L-23	66.33	45.93	41.55	103.6	95.5	97.9
L-24	68.80	43.70	39.83	121.0	102.0	107.0
L-29	65.97	52.08	50.47	109.3	101.2	98.9
L-26	63.51	39.73	53.86	106.2	95.0	95.9
L-27	65.38	44.00	54.33	110.2	92.4	98.7
L-30	66.28	41.30	49.00	108.9	95.6	97.1
L-31	72.76	48.10	49.47	112.5	88.5	97.4
L-32	68.49	42.15	50.92	109.2	89.5	92.3
L-28	70.42	46.11	55.33	106.0	89.2	98.3
Namangan-77	62.50	39.68	48.08	106.6	92.7	91.5
LSD_{05}	4.61	5.13	4.92	3.1	2.9	2.7

Table 3. Effect of stress conditions on fiber length and fiber output in advanced cotton lines.

Line number	Fiber length (mm)			Fiber output (%)		
	Variant 1	Variant 2	Variant 3	Variant 1	Variant 2	Variant 3
L-20	33.1	30.8	30.8	40.5	40.4	40.1
L-16	33.0	29.3	30.9	37.4	37.7	40.8
L-1	32.9	30.6	29.9	38.0	39.5	38.5
L-2	33.2	29.6	30.2	39.4	37.9	39.5
L-21	32.9	29.2	29.3	38.1	39.8	38.9
L-15	33.1	30.3	29.8	39.2	39.2	35.9
L-3	32.8	29.7	30.3	38.3	43.2	40.2
L-11	33.1	30.2	31.0	38.9	37.0	38.1
L-22	32.9	30.2	30.2	41.0	38.3	37.6
L-23	32.9	30.4	31.1	38.7	37.9	38.3
L-24	33.3	29.9	30.7	37.8	39.1	38.9
L-29	32.5	30.5	31.0	40.4	38.6	37.5
L-26	32.9	30.7	30.7	38.2	40.9	38.3
L-27	32.8	29.6	30.0	40.8	40.2	38.3
L-30	32.7	30.7	30.7	38.5	36.1	36.3
L-31	32.9	30.5	30.1	38.5	40.4	38.8
L-32	33.1	30.1	30.2	38.3	40.3	39.2
L-28	32.8	29.5	30.1	37.2	38.4	37.1
Namangan-77	32.7	29.4	30.3	39.4	41.6	39.6
LSD_{05}	0.5	0.4	0.4	1.1	1.2	1.0

(Variant 2), fiber length decreased by 2.0–3.7 mm, with the greater reduction observed in lines L-16, L-21, and L-2. In Variant 3, the fiber length further decreased in lines L-21 and L-15, and the reduction was 3.6 and 3.3 mm, respectively. Interestingly, the cotton lines L-16 and L-22 showed an increase in fiber length in Variant 3 (Table 3). The results suggested that prior exposure to water stress may trigger adaptive responses improving fiber quality in the subsequent year of study.

The effects of water deficit conditions on fiber yield and fiber length observed in the latest study were consistent with past studies on cotton under drought stress conditions. Shavkiev *et al*.'s (2021) findings revealed water stress generally reduces the fiber yield and fiber quality in upland cotton genotypes. However, in this study, some genotypes, like L-24, L-26, and Namangan-77, exhibited stable fiber yields under drought stress, suggesting these lines have some level of drought resilience, with the same also reported by Khamdullaev *et al*. (2021) in upland cotton. The increase in fiber length of some cotton lines, L-16 and L-22, in Variant 3, despite previous drought exposure, was an interesting finding and has been evident also in previous studies. Azimov *et al*.'s (2024) results suggested prior exposure to water stress conditions could trigger adaptive mechanisms that improve the fiber quality in subsequent growth cycles.

Correlation of physiological and agronomic traits

Correlation analysis revealed interesting insights into the relationship of physiological and productivity traits (Table 4). In the first variant (with optimal water conditions), the total water content in leaves had negative correlations with transpiration rate and plant productivity, indicating that higher leaf water content did not necessarily translate into better productivity and higher transpiration under optimal water conditions. However, in Variant 2 (water deficit conditions), the total water content in plant leaves showed a moderate positive correlation (r = 0.61) with seed cotton weight per boll. It suggests that maintaining leaf water content under stress can contribute to boll development and, eventually, better seed cotton yield. In Variant 3 (with two years

Table 4. Correlation of physiological and economic traits in advanced cotton lines.

Traits	Variant 1	Variant 2	Variant 3
Total water content in leaves:			
Transpiration rate	-0.11	-0.18	0.72
Plant productivity	-0.25	0.18	-0.51
Seed cotton weight per boll	0.10	0.61	0.07
Transpiration rate:			
Plant productivity	-0.46	-0.52	-0.51
See cotton weight per boll	0.26	-0.18	0.02
Plant productivity:			
Seed cotton weight per boll	-0.30	0.54	-0.007

of water deficit conditions), the total water content in cotton plant leaves gave a significantly positive correlation (r = 0.72) with transpiration rate, highlighting the important role of efficient water use under prolonged water deficit conditions.

In this promising study, the correlation between physiological and yield-related traits provides deeper insights into the relationship of water retention, transpiration, and seed cotton yield. In Variant 1 (with optimal water conditions), a weak correlation between leaf water content and transpiration rate suggested that higher leaf water content did not necessarily translate into better transpiration and higher seed cotton yield. These findings corroborated the conclusions made by Nabiev *et al.* (2020). Contrastingly, under water deficit conditions (Variant 2), the positive correlation between leaf water content and cotton weight per boll highlights the importance of maintaining leaf hydration to support boll development, with the same also reported by Shavkiev *et al*. (2023). Additionally, the remarkable positive correlation between leaf water content and transpiration rate under prolonged drought conditions (Variant 3) was in agreement with the findings of Chorshanbiev *et al*. (2023). They also proposed efficient water use during drought stress conditions is crucial for plant survival and productivity.

CONCLUSIONS

The presented study identified the specific cotton genotypes for improving seed cotton yield under drought stress conditions. The cotton lines L-2, L-24, and L-11 produced the heaviest seeds under optimal water conditions; however, the seed weight decreased across all cotton lines under drought stress conditions. Fiber yield responses to water deficit conditions varied, with some cotton lines showing increased seed cotton yield under stress conditions. The findings suggest that cotton lines L-1, L-16, and L-24 were effective candidates for selection in breeding drought-tolerant cotton varieties. Overall, this research provides valuable insights for future selection and breeding programs aimed at enhancing cotton productivity with better fiber quality under water stress conditions.

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