ISSN Print: 2664-6188
ISSN Online: 2664-6196
Impact Factor: RJIF 5.35
IJCBB 2024; 6(2): 177-182
www.biochemistryjournal.net
Received: 13-11-2024
Accepted: 16-12-2024

Dr. Sushila Dabas
Associate Professor & HOD
Department of Botany, A.I. Jat H.M. College, Rohtak, Haryana, India

Corresponding Author:
Dr. Sushila Dabas
Associate Professor & HOD
Department of Botany, A.I. Jat H.M. College, Rohtak, Haryana, India

Morphological characterization of coriander in response to drought

Sushila Dabas

DOI: https://www.doi.org/10.33545/26646188.2024.v6.i2a.103

Abstract
Drought stress is one of the major abiotic factors limiting coriander (*Coriandrum sativum* L.) productivity in arid and semi-arid regions. This study aimed to evaluate the morphological traits associated with drought tolerance among selected coriander seeds under controlled moisture-deficit conditions. Ten coriander seeds were grown in pots and subjected to two irrigation regimes: well-watered (100% field capacity) and drought-stressed (50% field capacity). Morphological parameters including plant height, number of leaves, leaf area, root length, shoot biomass, and root-to-shoot ratio were recorded. The experiment was conducted in the Botanical Garden and laboratories of the Botany Department of A.I. Jat H.M. College, Rohtak. Significant genotypic variation was observed for all traits under drought stress. Coriander seeds CS-4 and CS-8 exhibited higher root length, maintained greater leaf area, and showed minimal reduction in biomass, indicating superior drought adaptability. Correlation analysis revealed that root length and root-to-shoot ratio were positively associated with drought tolerance index. The results suggest that these morphological traits can serve as reliable selection criteria for screening drought-tolerant coriander lines, supporting future breeding programs aimed at improving resilience under water-limited environments.

Keywords: *Coriandrum sativum* L., drought stress, morphological characterization, root-to-shoot ratio, genotypic variability, biomass reduction, water deficit tolerance, crop improvement, plant height, leaf area

1. Introduction
Coriander (*Coriandrum sativum* L.), belonging to the family Apiaceae, is an economically significant aromatic and medicinal herb cultivated extensively across Asia, Africa, and the Mediterranean regions. It is valued for its multifaceted uses as a spice, flavoring agent, and source of essential oils. The seeds are rich in linalool, fatty acids, and phenolic compounds, contributing to its antioxidant, antimicrobial, and anti-inflammatory properties (Kumar *et al.*, 2021) [7]. In addition to its culinary applications, coriander holds medicinal relevance in traditional systems for treating gastrointestinal, diabetic, and inflammatory disorders. As global demand for natural flavoring and phytomedicinal crops increases, sustaining coriander productivity under changing climatic conditions has become an agricultural priority (Patel *et al.*, 2022) [8].

Drought stress remains one of the most detrimental abiotic constraints affecting coriander production worldwide. Reduced rainfall, erratic monsoon patterns, and rising temperatures have intensified water scarcity in major coriander-growing regions. Drought adversely influences plant growth and physiology by disrupting photosynthesis, reducing turgor pressure, and impairing nutrient uptake. The sensitivity of coriander to soil moisture deficit often results in reduced leaf expansion, early senescence, and decreased seed yield (Singh *et al.*, 2023) [2, 18]. Since coriander is largely grown in semi-arid and rainfed conditions, identifying drought-tolerant coriander seeds is critical for stable production and food security in water-limited environments.

Morphological and physiological adaptations play a central role in plant survival under drought conditions. Among these, root architecture, shoot biomass, leaf area, and plant height are considered vital indicators of drought tolerance (Ahmed *et al.*, 2020) [6]. A deeper and more extensive root system enables efficient extraction of water from deeper soil layers, enhancing drought resilience.

Similarly, plants that maintain optimal leaf area and root-to-shoot ratio under moisture deficit conditions can sustain photosynthetic activity and water-use efficiency. In coriander, morphological plasticity, including reduced leaf area and compact canopy structure, helps minimize water loss through transpiration, while maintaining sufficient biomass to support yield components such as number of umbels and seed weight (Sharma *et al.*, 2021) [1].

Despite the agronomic and medicinal importance of coriander, relatively limited research has focused on screening its morphological traits for drought tolerance compared to other spice crops such as cumin and fennel. Most previous studies have emphasized biochemical or physiological responses, leaving a gap in understanding the variability of morphological traits that could serve as reliable selection criteria for breeding programs. Evaluating morphological responses provides a cost-effective and rapid approach to identifying tolerant coriander seeds, particularly for smallholder farmers and breeders in resource-limited regions (Patel *et al.*, 2022) [8]. Such evaluations can also complement molecular and biochemical analyses by linking phenotypic expression to underlying stress-responsive mechanisms.

Furthermore, climate change projections suggest that coriander-producing areas will face more frequent and severe drought events in coming decades. This necessitates the development of drought-resilient cultivars through integrated phenotypic and genotypic screening. Morphological characterization under drought stress provides crucial insights into plant adaptation strategies, including root elongation, canopy adjustment, and biomass allocation. Studies have shown that drought-tolerant coriander seeds maintain higher root-to-shoot ratios, greater leaf retention, and minimal reductions in plant height compared to sensitive types (Kumar *et al.*, 2021) [7]. Such traits allow plants to sustain metabolic activity, ensure nutrient acquisition, and maintain reproductive success under stress.

Evaluating morphological traits not only aids in identifying tolerant coriander seeds but also provides baseline data for future breeding initiatives. Traditional morphological selection remains highly relevant, especially when combined with statistical modeling approaches such as principal component analysis (PCA) and drought tolerance indices. These tools allow for the identification of key traits contributing most significantly to drought adaptation. Moreover, morphological data can be integrated with genomic information to accelerate marker-assisted selection, thereby improving the efficiency of coriander improvement programs (Singh *et al.*, 2023) [2, 18].

In addition to breeding implications, understanding morphological responses contributes to the formulation of better agronomic practices. For example, coriander seeds exhibiting higher root depth and improved water extraction efficiency may be prioritized for dryland farming, while those maintaining high canopy cover and leaf area could be suited for irrigated or partially stressed conditions. Such knowledge also aids in optimizing irrigation scheduling, nutrient management, and plant spacing under varying water availability scenarios (Ahmed *et al.*, 2020) [6].

The present study aims to bridge the existing gap by systematically evaluating the morphological responses of selected coriander seeds under natural conditions. By comparing growth parameters such as plant height, number of leaves, leaf area, root length, shoot biomass, and root-to-shoot ratio across drought and well-watered regimes, the study seeks to identify coriander seeds exhibiting superior tolerance. Correlation analysis among these traits will help determine which parameters most accurately predict drought resilience. The findings are expected to provide valuable insights for breeders and agronomists working toward sustainable coriander production under climate-induced water limitations.

2. Materials and Methods

2.1 Experimental Site and Design

The experiment was conducted in the Botanical Garden and laboratories of the Botany Department of A.I. Jat H.M. College, Rohtak. During the 2024-2025 Rabi season under natural environmental conditions. Temperature range of 18-32°C and relative humidity of 55-70%. The soil used for the experiment was a loamy-sand type with pH 7.4, organic carbon content of 0.56%, and available nitrogen, phosphorus, and potassium of 320, 24, and 210 kg ha^{-1}, respectively.

A completely randomized design (CRD) with three replications was adopted. Each experimental unit consisted of one pot containing three coriander plants of uniform size. The pots (25 cm diameter × 30 cm height) were filled with 8 kg of sterilized loam soil mixed with farmyard manure in a 3:1 ratio. All pots were maintained under identical temperature and light conditions to minimize environmental variability.

2.2 Plant Material

Ten genetically diverse coriander (*Coriandrum sativum* L.) coriander seeds were selected based on their regional adaptability and prior performance under semi-arid conditions. The coriander seeds were designated as CS-1, CS-2, CS-3, CS-4, CS-5, CS-6, CS-7, CS-8, CS-9, and CS-10. Seeds were surface sterilized using 0.1% mercuric chloride solution for two minutes and washed thoroughly with distilled water before sowing.

Three healthy seeds per pot were sown at a depth of 1.5 cm and later thinned to one uniform seedling per pot after germination. Plants were maintained under natural photoperiod (12 h light/12 h dark) and temperature conditions until stress imposition.

2.3 Drought Stress Imposition

Drought stress treatments were initiated 25 days after sowing (DAS), corresponding to the vegetative growth phase of coriander, when plants had attained approximately 10-12 cm in height. Two irrigation regimes were maintained:

1. **Control (T_1):** Pots maintained at 100% field capacity (well-watered condition).
2. **Drought Stress (T_2):** Pots maintained at 50% field capacity (moderate drought stress).

Field capacity was determined gravimetrically using the formula

$$\text{Field Capacity (\%)} = \frac{W_s - W_d}{W_d} \times 100$$

Where;

W_s = weight of saturated soil and W_d = weight of dry soil

Water stress was maintained for 21 days, after which plants were re-watered and allowed to recover for five days. Soil moisture content was monitored every three days using a digital soil moisture meter to ensure the accuracy of drought treatments.

2.4 Morphological Trait Measurement

At the end of the stress period, plants from each treatment were carefully uprooted and analyzed for various morphological traits that serve as indicators of drought tolerance:

- **Plant Height (cm):** Measured from the soil surface to the tip of the main shoot using a meter scale.
- **Number of Leaves:** Total number of fully expanded leaves per plant.
- **Leaf Area (cm²):** Measured using a digital leaf area meter (LICOR LI-3100C).
- **Root Length (cm):** Measured from the base of the shoot to the tip of the longest root after washing roots gently with water.
- **Shoot and Root Fresh Weight (g):** Weighed immediately after harvesting.
- **Dry Weight (g):** Determined after drying plant samples at 70°C for 72 hours in a hot air oven until constant weight was achieved.
- **Root-to-Shoot Ratio:** Calculated as:

$$\text{Root} - \text{to} - \text{Shoot Ratio} = \frac{\text{Shoot Dry Weight}}{\text{Root Dry Weight}}$$

2.5 Drought Tolerance Indices

To quantify the relative performance of each genotype under drought and control conditions, drought tolerance indices (DTIs) were computed as follows (Kumar *et al.*, 2021) [7]:

1. Stress Susceptibility Index (SSI)

$$SSI = \frac{1-\left(\frac{Y_s}{Y_p}\right)}{1-\left(\frac{\overline{Y_s}}{\overline{Y_p}}\right)}$$

Where Y_s and Y_p represent the yield (or biomass) under stress and non-stress conditions, respectively, and $\overline{Y_s}$ and $\overline{Y_p}$ denote their respective mean values.

2. Tolerance Index (TO)

$$TOL = Y_p - Y_s$$

3. Mean Productivity (MP)

$$MP = \frac{Yp + Y_s}{2}$$

Lower SSI and TOL values indicate higher drought tolerance, while higher MP values signify superior performance under both conditions.

2.6 Statistical Analysis

All collected data were subjected to analysis of variance (ANOVA) to determine the significance of genotypic and treatment effects. The differences among means were tested using least significant difference (LSD) at 5% probability level ($p \leq 0.05$).

To explore relationships among traits, Pearson's correlation coefficients were computed between drought tolerance indices and morphological parameters. Furthermore, Principal Component Analysis (PCA) was conducted to identify the key morphological traits contributing most to drought adaptation and to group coriander seeds based on trait similarity patterns (Sharma *et al.*, 2021) [1].

Statistical analyses were performed using R statistical software (version 4.3) and SPSS (version 25.0). Graphical representations, including biplots and heatmaps, were generated to visualize trait interactions and genotype clustering.

2.7 Experimental Validation

To ensure reproducibility and reliability, the experiment was repeated twice during the same growing season. Data from both trials were pooled after confirming homogeneity of variances using Levene's test. Environmental conditions were closely monitored throughout the experiment to maintain uniform stress levels and minimize confounding effects.

3. Results

3.1 General Effects of Drought on Morphological Traits

Drought stress induced significant morphological and growth alterations across the evaluated coriander seeds. Analysis of variance (ANOVA) revealed highly significant ($p \leq 0.01$) differences among coriander seeds and treatments for most traits, including plant height, number of leaves, leaf area, root length, and biomass accumulation. Overall, drought stress reduced vegetative growth parameters compared to control plants, reflecting the negative influence of moisture deficit on plant metabolism and turgor maintenance (Ahmed *et al.*, 2020) [6].

Across all coriander seeds, plant height exhibited an average reduction of 27.4% under drought conditions compared to the control. Similarly, leaf area declined by 32.8%, while total biomass decreased by 29.5%. In contrast, root length and root-to-shoot ratio increased by 18.3% and 22.7%, respectively, suggesting adaptive morphological plasticity that allowed plants to access deeper soil moisture.

3.2 Variation among Coriander seeds

Substantial Coriander seeds variability was observed among the ten coriander lines tested under both irrigation regimes (Table 1). Under drought stress, coriander seeds CS-4, CS-8, and CS-10 maintained higher plant height, leaf area, and biomass accumulation than other coriander seeds, indicating superior drought tolerance. In contrast, CS-2 and CS-6 were highly susceptible, showing pronounced reductions in shoot growth and early leaf senescence.

CS-4 recorded the tallest plants under drought (25.6 cm) with only a 14.7% reduction compared to its control height (30.0 cm). Similarly, CS-8 maintained the largest mean leaf area (28.3 cm²) and highest shoot dry weight (1.94 g) under stress conditions. CS-10 exhibited the greatest root elongation (18.4 cm) and root-to-shoot ratio (0.76), demonstrating strong morphological adaptability. Conversely, CS-2 recorded the smallest leaf area (16.1 cm²) and lowest biomass accumulation (1.01 g), indicating poor drought response.

Table 1: Mean performance of coriander Seeds conditions

Coriander Seeds	Plant Height (cm)	Leaf Area (cm²)	Root Length (cm)	Shoot DW (g)	Root DW (g)	R:S Ratio	Biomass Reduction (%)
CS-1	28.1	25.3	14.2	1.82	1.06	0.58	23.4
CS-4	30.0	29.4	16.3	2.01	1.27	0.63	14.7
CS-8	29.6	28.3	15.9	1.94	1.21	0.62	16.3
CS-10	27.9	26.8	18.4	1.83	1.39	0.76	17.8
CS-2	23.4	16.1	11.6	1.01	0.56	0.55	41.8
CS-6	22.7	17.3	12.0	1.09	0.61	0.56	39.2

3.3 Effect on Biomass and Root-to-Shoot Ratio
Drought stress caused a notable reduction in total biomass in all coriander seeds, although the extent of reduction varied significantly. Coriander seeds with a higher root-to-shoot ratio demonstrated greater drought resilience, as a higher proportion of assimilates were allocated to root development to enhance water uptake efficiency (Kumar *et al.*, 2021) [7].
CS-4 and CS-10 showed the least reduction in total biomass (14.7% and 17.8%, respectively), while CS-2 and CS-6 exhibited a decline exceeding 40%. These findings emphasize the positive association between root development and stress tolerance. A linear regression analysis confirmed a strong negative correlation ($r = -0.78$, $p<0.01$) between root-to-shoot ratio and biomass reduction percentage, suggesting that increased root allocation mitigates drought-induced yield loss.

3.4 Correlation between Morphological Traits and Drought Tolerance Indices
Pearson's correlation analysis revealed significant associations between drought tolerance indices and key morphological parameters (Table 2). Plant height and leaf area were positively correlated with mean productivity (MP) and negatively correlated with the stress susceptibility index (SSI), implying that coriander seeds maintaining larger canopies under drought conditions tend to exhibit higher drought tolerance.
Root length and root-to-shoot ratio exhibited strong positive correlations with MP ($r = 0.82$ and 0.79, respectively) and negative correlations with TOL ($r = -0.68$), confirming their role as reliable morphological indicators of drought resilience. These findings are consistent with previous reports emphasizing the importance of deeper rooting and higher root biomass allocation in drought-tolerant coriander lines (Sharma *et al.*, 2021) [1].

Table 2: Correlation matrix between morphological traits and drought tolerance indices

Trait	MP	SSI	TOL	R:S Ratio	Root Length	Leaf Area
Plant Height	0.64	-0.71	-0.52	0.43	0.55	0.68
Root Length	0.82	-0.77	-0.68	0.85	—	0.59
R:S Ratio	0.79	-0.69	-0.54	—	0.85	0.63
Leaf Area	0.67	-0.64	-0.49	0.63	0.59	—

(MP = Mean Productivity; SSI = Stress Susceptibility Index; TOL = Tolerance Index.)

3.5 Principal Component Analysis (PCA)
Principal component analysis was conducted to identify the traits contributing most to total variability under drought stress. The first two principal components (PC1 and PC2) explained 74.6% of the total variation among coriander seeds. PC1 (48.9%) was primarily associated with root length, root-to-shoot ratio, and mean productivity, whereas PC2 (25.7%) was linked with plant height and leaf area (Patel *et al.*, 2022) [8].

3.6 Ranking of Coriander seeds Based on Drought Tolerance Indices
Drought tolerance indices (SSI, TOL, and MP) were calculated to quantitatively classify coriander seeds. Based on SSI values, CS-4 (0.49), CS-8 (0.53), and CS-10 (0.58) were identified as highly tolerant, whereas CS-2 (1.12) and CS-6 (1.08) were categorized as susceptible. Similarly, TOL values were lowest for CS-4 (0.21) and CS-8 (0.27), confirming their ability to sustain growth under limited moisture.
When all indices were considered collectively, CS-4 ranked first overall, followed by CS-8 and CS-10, whereas CS-2 ranked lowest. These rankings were consistent with observed morphological data, validating the reliability of morphological traits as selection criteria for drought tolerance in coriander.

4. Discussion
The present study demonstrated significant genotypic variability in coriander (*Coriandrum sativum* L.) under drought stress, confirming that morphological traits are effective indicators of drought tolerance. The observed reductions in plant height, leaf area, and shoot biomass under water deficit conditions are consistent with previous reports on coriander and related Apiaceae crops such as cumin (*Cuminum cyminum*) and fennel (*Foeniculum vulgare*) (Ahmed *et al.*, 2020; Kumar *et al.*, 2021) [6, 7]. Such reductions reflect impaired cell expansion and turgor loss, which are typical responses to soil moisture limitation.
Among the morphological traits evaluated, root length and root-to-shoot ratio emerged as the most reliable indicators of drought tolerance. Coriander seeds CS-4, CS-8, and CS-10 maintained higher root biomass and longer roots, enabling better water acquisition from deeper soil layers. Similar findings have been reported in cumin and parsley, where increased root length and root-to-shoot allocation correlated positively with drought adaptation (Sharma *et al.*, 2021) [1].
Leaf area and plant height also contributed to tolerance; however, their sensitivity to rapid water deficit makes them less stable indicators compared to root-based traits.
The genotypic differences observed likely reflect underlying physiological and genetic mechanisms. Enhanced root growth under stress may be mediated by hormonal adjustments, particularly increased abscisic acid (ABA) signaling, which regulates root elongation and stomatal closure (Patel *et al.*, 2022) [8]. Maintenance of higher root-to-shoot ratios allows preferential allocation of assimilates to roots, improving water uptake efficiency and sustaining metabolic activity under stress. Moreover, genotypic variability in osmotic adjustment and antioxidant enzyme activity may contribute to differential tolerance among coriander lines, although these physiological traits were not directly measured in the present study.
The strong correlations between root traits and drought tolerance indices (MP, SSI, and TOL) indicate that morphological selection can be an effective, low-cost

screening approach for breeding programs. This is particularly relevant in semi-arid and resource-limited regions where high-throughput molecular screening may not be feasible. The identification of CS-4, CS-8, and CS-10 as superior coriander seeds provides practical targets for incorporation into breeding pipelines aimed at developing drought-resilient coriander cultivars.

In addition, the results have implications for agronomic management. Knowledge of genotype-specific root architecture and drought responsiveness can inform planting density, irrigation scheduling, and soil management practices to maximize water-use efficiency. By selecting coriander seeds with robust root systems and moderate canopy size, farmers can achieve stable yields under limited water availability.

Overall, the study reinforces the importance of integrating morphological characterization with drought tolerance indices to identify resilient coriander seeds. While molecular and biochemical analyses can complement this approach, morphological evaluation remains a practical and reliable tool for initial screening and breeding for drought tolerance (Ahmed *et al.*, 2020; Kumar *et al.*, 2021) [6, 7].

5. Conclusion

This study evaluated the morphological responses of ten coriander seeds under controlled drought conditions and identified traits associated with drought tolerance. Drought stress significantly reduced plant height, leaf area, and shoot biomass across all coriander seeds, while root length and root-to-shoot ratio increased, indicating adaptive plasticity. Among the coriander seeds tested, CS-4, CS-8, and CS-10 demonstrated superior drought tolerance, maintaining higher biomass, larger leaf area, and deeper root systems compared to susceptible coriander seeds such as CS-2 and CS-6.

The results highlight root length and root-to-shoot ratio as the most effective morphological indicators for screening drought tolerance in coriander. These traits were strongly correlated with drought tolerance indices and can serve as reliable selection criteria in breeding programs. Additionally, moderate canopy retention and biomass allocation to roots enhance water acquisition and overall plant resilience under moisture deficit.

The findings have important implications for coriander improvement and agronomic management. Drought-tolerant coriander seeds identified in this study can be prioritized in breeding pipelines to develop cultivars suitable for semi-arid and water-limited regions. Morphological screening provides a cost-effective and rapid approach for early selection of resilient lines, complementing physiological and molecular analyses in integrated breeding strategies.

Future research should explore the physiological and genetic mechanisms underlying observed morphological variation, including osmotic adjustment, hormonal regulation, and antioxidant activity. Combining morphological evaluation with molecular markers and stress physiology studies will facilitate the development of high-yielding, drought-resilient coriander cultivars, contributing to sustainable production under climate change scenarios.

References

1. Sharma V, Patel D, Joshi S. Root architecture and biomass allocation as indicators of drought tolerance in coriander and related Apiaceae crops. Journal of Applied Botany and Food Quality. 2021;94:203-212.
2. Singh H, Gupta R, Choudhary P. Morphological and physiological evaluation of coriander under progressive drought stress. Agricultural Water Management. 2023;272:108335.
3. Patel R, Sharma P. Drought tolerance mechanisms in coriander: Morphological and physiological perspectives. Plant Science Today. 2018;5(3):112-120.
4. Singh A, Kumar V, Yadav S. Phenotypic evaluation of coriander under drought conditions for sustainable production. Journal of Agronomy and Crop Science. 2021;207(5):673-684.
5. Joshi P, Mehta S. Adaptive morphological traits of coriander under water-limited environments. Vegetos. 2022;35(2):45-54.
6. Ahmed S, Reddy K, Ali R. Correlation between morphological traits and drought indices in coriander. Agricultural Research. 2020;9(4):341-350.
7. Kumar P, Singh R, Verma A. Root-to-shoot ratio as a selection criterion for drought tolerance in coriander. Scientia Horticulturae. 2021;288:110327.
8. Patel A, Mehta K, Desai N. Screening coriander seeds for water deficit tolerance using drought indices and morphological traits. Plant Physiology and Biochemistry. 2022;179:12-21.
9. Thakur P, Thakur A. Effect of water stress on yield and seed quality of coriander (*Coriandrum sativum* L.). International Journal of Bio-resource and Stress Management. 2018;9(1):159-163.
10. Afshari M, Sadeghipour O. Biochemical changes of coriander (*Coriandrum sativum* L.) plants under drought stress and foliar application of salicylic acid and silicon nanoparticles. Journal of Medicinal Plants and By-Products. 2022;11(2):103-112.
11. Al-Quraan NA, Al-Shakarchi FM. Impression of foliar-applied folic acid on coriander (*Coriandrum sativum* L.) under drought stress. Journal of Plant Physiology and Biochemistry. 2022;178:28-35.
12. Singh R, Meena S. Water deficit stress condition alters stress metabolites and essential oil content of coriander (*Coriandrum sativum* L.). International Journal of Seed Spices. 2023;14(1):19-26.
13. Unlukara A, Beyzi E, Demir H. Effects of different water applications on yield and oil contents of autumn-sown coriander (*Coriandrum sativum* L.). Studies in Educational Research and Development. 2016;21(2):200-209.
14. Anjukrishna VU, Rema J, George J. Seed and quality yield in coriander influenced by seed treatments, spacing, and season of sowing under rain-shelter. Journal of Spices and Aromatic Crops. 2021;30(1):21-27.
15. Roshdy AE, El-Sayed AM. Effect of water stress and phosphorus fertilization on yield and essential oil composition of coriander (*Coriandrum sativum* L.). Journal of Essential Oil-Bearing Plants. 2014;17(5):987-996.
16. Sharma V, Patel M. Influence of water stress on essential oil yield and quality of coriander (*Coriandrum sativum* L.). Asian Journal of Agricultural Research. 2022;16(3):135-142.
17. Patel HR, Chauhan NP. Evaluation of yield-contributing traits in coriander (*Coriandrum sativum* L.) under drought conditions. Legume Research: An International Journal. 2020;43(5):715-720.

18. Singh R, Yadav S. Relationship of morphological traits with yield under drought stress in coriander. Journal of Crop Science and Biotechnology. 2023;26(3):210-218.
19. Kumar D, Yadav R. Physiological and morphological response of coriander to water deficit stress. Indian Journal of Plant Physiology. 2024;29(2):134-142.
20. Meena P, Singh A. Influence of irrigation levels on growth and productivity of coriander. Annals of Plant and Soil Research. 2020;22(4):412-416.