

TRANSPIRATION RATE AND WATER RELATIONS OF DURUM WHEAT CULTIVARS UNDER VARYING SOIL MOISTURE CONDITIONS

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Abstract

This study investigates the physiological determinants of transpiration intensity and water exchange in durum wheat cultivars grown under contrasting soil moisture conditions. Using a comparative assessment across moisture regimes, we analyzed cultivar-specific responses in transpiration activity and indicators of plant water status. The results show pronounced genotypic differences: transpiration and water-exchange traits varied with both soil moisture level and inherent biological characteristics of the cultivars. Drought-tolerant cultivars maintained a more stable water balance and moderated transpiration under reduced moisture, indicating adaptive regulation of water use. These findings provide a basis for selecting durum wheat with improved water-use efficiency and for optimizing irrigation strategies in water-limited environments.

Keywords: Durum wheat; transpiration intensity; cultivars; moisture levels; water exchange; stress tolerance.

Introduction

Agricultural production suffers substantial losses each year due to severe droughts. Drought stress markedly affects plant physiological processes and subsequently reduces yield. It induces a suite of physiological and molecular changes in plants, many of which facilitate adaptation to unfavorable environments. Acting both directly and indirectly on plant metabolism, drought alters the morpho-anatomical, physiological, and biochemical makeup of plants, thereby reducing transpiration and improving the efficiency of water use in plants. Continuous water loss via transpiration leads to leaf water deficit. In addition to oxidative damage, water deficit can trigger cell death. To mitigate the adverse effects of drought, it is first necessary to elucidate the mechanisms by which drought influences plant physiology [1].



Owing to global climate change—decreasing precipitation and increasing evaporation—widespread drought is expected to intensify across many regions. Moreover, global warming results in increasingly unpredictable precipitation patterns, leading to recurrent, prolonged drought episodes worldwide. Persistent drought profoundly influences plant development, causing growth retardation, disruption of physiological processes, and impairment of reproduction [2].

Understanding plant water exchange is critical for predicting the consequences of extreme climatic events—such as drought—on the functioning of agricultural systems and on crop growth under water-limited conditions. Drought stress hampers crop growth primarily by disturbing plant water relations and related physiological functions. Plants deploy diverse mechanisms to withstand drought stress, including increased diffusive resistance to reduce water loss, deeper root systems to enhance water uptake, and smaller leaves to limit transpiration, among others [3].

Under sufficient moisture, examining agro-morphological, biochemical, and physiological responses can improve our understanding of how crops respond and adapt to drought-prone environments. In wheat, multiple agro-morphological traits—plant height, culm length, number of fertile tillers, spike length, number of grains per spike, thousand-grain weight, and even leaf length—are affected by limited soil moisture. These traits not only influence drought tolerance but also illuminate how adaptive genotypes cope with drought through morphological adjustments [4]. Studying agro-morphological, biochemical, and physiological responses is thus closely linked to crop capacity for response and adaptation under water-deficit conditions. Several agro-morphological traits—such as plant height, spike length, grains per spike, and thousand-grain weight—are associated with drought tolerance under restricted soil moisture and reflect the ways adaptive genotypes withstand drought via morphological modification [5].

Water deficit, by lowering soil water potential, reduces the number of leaves per plant, individual leaf size, and leaf lifespan. Expansion of leaf area depends on leaf turgor, temperature, and the supply of assimilates for growth. Under drought, the reduction in leaf area is associated with slower leaf expansion due to diminished photosynthesis. The overall negative effect of water stress on plants is a decline in both fresh and dry biomass production [6].

Stomata are the sites of water loss and CO₂ uptake, and their closure is among the earliest responses to drought, leading to reduced photosynthetic rates. Stomatal closure deprives leaves of CO₂, and the assimilation of photosynthetic carbon decreases in favor of photorespiration. Based on previous literature and current knowledge of drought-induced photosynthetic responses, progressive stomatal closure accompanies increasing drought severity. Leaf water status continually interacts with stomatal conductance, and a strong relationship between leaf water potential and stomatal conductance is observed even under drought. Root-to-leaf signaling under soil drying—transmitted via the transpiration stream—also promotes stomatal closure. “Non-stomatal” mechanisms include changes in chlorophyll synthesis, functional and structural alterations of chloroplasts, and disruptions in assimilation, transport, and partitioning processes [7,8].

Drought is among the most widespread environmental stresses affecting plant growth and development and remains a major challenge for agricultural researchers and breeders. It is estimated that by 2025–2030 nearly 1.8 billion people will face absolute water scarcity, and 65% of the world’s population will live under water-stress conditions. Tolerance to water deficit is a complex trait in which multiple characteristics influence crop productivity. Drought tolerance is



often considered in two components: drought avoidance (escape) and dehydration tolerance. Avoidance encompasses deeper root systems, efficient use of available water, and adjustments in cropping conditions to exploit rainfall. Dehydration tolerance refers to a plant's capacity to withstand partial tissue dehydration and then resume growth when precipitation returns [9].

Research objects and methods

Field experiments were conducted using six durum wheat varieties: Istiqbolli, Lekurum-3, Javohir, Makuz-3, Istiqlol-25, and Istiqlol. Leaf transpiration intensity was measured in the field by rapidly weighing excised leaf segments on a torsion balance over 3 minutes; the mean value was calculated from 4–5 replicates and expressed as the amount of water evaporated (mg) per 1 g fresh leaf mass per hour. This approach is considered convenient for eco-physiological studies under field conditions [10].

Results and discussion

Leaf transpiration intensity (rate of water vapor loss) was measured across varieties, soil-moisture levels, and times of day (08:00–10:00; 12:00–14:00; 16:00–18:00) to track dynamics during the flowering phase.

- **Istiqbolli.** Morning (08:00–10:00) transpiration at 70% soil moisture was 90.5 mg/m²/min; with decreasing moisture it declined to 87.7 (60%), 84.4 (50%), and 80.6 (40%). At midday (12:00–14:00) the values were 84.3, 80.6, 77.5, 72.0, respectively; in the evening (16:00–18:00) 89.5, 87.3, 83.6, 82.8. Transpiration was higher in early morning and evening and somewhat reduced at midday, suggesting a water-saving strategy that becomes more pronounced under deficit.
- **Lekurum-3.** Morning values were 73.7 (70%), 70.1 (60%), 66.4 (50%), 62.2 (40%); midday values rose to 96.7, 94.4, 90.2, 88.0; evening values were 79.2, 75.8, 72.4, 69.5. The markedly higher midday transpiration indicates greater water loss during heat, pointing to weaker drought resilience in this variety.
- **Javohir.** Morning transpiration: 85.4 (70%), 82.8 (60%), 79.4 (50%), 75.9 (40%). Midday: 87.4, 83.7, 80.1, 80.8. Evening: 86.0, 83.2, 81.5, 81.5. Transpiration remained nearly stable across day periods, indicating a moderate, adaptive strategy with limited sensitivity to temperature/time.
- **Makuz-3.** Morning values decreased from 75.5 to 65.9 with declining moisture. Midday: 88.7, 85.6, 82.4, 81.5; evening: 84.7, 82.0, 80.1, 78.5. Like Lekurum-3, midday rates were high and evening loss remained appreciable, limiting water conservation; thus, drought tolerance appears relatively weak.
- **Istiqlol-25.** Morning: 92.6 (70%), 90.4 (60%), 88.3 (50%), 85.1 (40%). Midday: 87.1, 83.6, 80.4, 78.4. Evening: 90.6, 88.3, 86.6, 84.3. Transpiration was consistently high across periods but declined gradually with increasing deficit; evening rates remained elevated—suggesting active water exchange with some capacity for adjustment to stress.
- **Istiqlol.** Morning: 81.1, 77.5, 74.5, 70.8 (for 70%, 60%, 50%, 40%). Midday: 85.6, 82.3, 78.1, 81.5. Evening: 82.0, 80.1, 78.5, 78.5. Overall moderate transpiration with intermediate sensitivity to temperature; as moisture decreased, rates declined steadily but less sharply than in other varieties, indicating average tolerance.

Across time periods, most varieties exhibited higher transpiration in morning and evening, with midday depressions in some (Istiqbolli, Javohir) and midday peaks in others (Lekurum-3, Makuz-



3), reflecting divergent responses to heat and light. While transpiration intensity signals active water exchange, high rates under deficit can be detrimental—especially during hot midday hours. A balanced diurnal profile—higher in morning/evening and lower at midday—favors water conservation; this pattern was most evident in Istiqbolli and Javohir.

Conclusions

By variety, Istiqlol-25 exhibited the highest transpiration activity and, under water deficit, reduced transpiration gradually; it can thus be regarded as a cultivar with active yet adaptable water exchange. Istiqbolli and Javohir effectively regulate transpiration—depressing midday rates—which indicates a water-saving mechanism. In contrast, Lekurum-3 and Makuz-3 showed excessively high midday transpiration, leading to substantial water loss under deficit; their water-conservation strategy appears insufficient, making them more vulnerable to drought. Overall, the data show that cultivar differences in transpiration activity and water-exchange characteristics vary with soil moisture level and intrinsic biological traits.

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