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ASSESSING HEAT STRESS TOLERANCE IN CICER ARIETINUM L. USING LEAF FLUCTUATING ASYMMETRY IN THE CONTEXT OF CLIMATE CHANGE

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Abstract

Climate change is increasingly affecting global crop productivity, with legumes such as chickpea - Cicer arietinum L., an important food and forage crop in arid and semi-arid regions, being particularly sensitive to elevated temperatures. This study investigates the effects of heat stress on key morphometric parameters of chickpea, including leaf size, leaf asymmetry, and stem height. The leaves' fluctuating asymmetry (FA) analysis to assess phenotypic variation in leaf morphology. FA is assessed as an indicator of developmental stability and resistance to heat stress. By identifying traits associated with heat tolerance, the results obtained facilitate the selection and breeding of more resilient chickpea genotypes, ultimately supporting efforts to maintain productivity under predicted climatic stresses.

Keywords: *Cicer arietinum* L.; *heat stress; leaf; fluctuating asymmetry*

1. Introduction

Climate change poses a significant threat to global agriculture, particularly through the increasing frequency and intensity of heat stress events. Legumes, including chickpea (*Cicer arietinum* L.), are especially vulnerable to elevated temperatures during critical growth stages such as flowering and pod filling, leading to reduced yields and impaired plant development. As chickpea is a major source of protein and a key crop in arid and semi-arid regions, understanding its response to thermal stress is essential for ensuring food security under changing climatic conditions [8, 1].

One approach to assessing plant responses to environmental stressors is the analysis of fluctuating asymmetry (FA) — a measure of small, random deviations from perfect bilateral symmetry in morphological traits. FA is widely recognized as an indicator of developmental instability and has been increasingly used to evaluate the impact of abiotic stresses, including drought, pollution, and temperature extremes, on plant growth. In leaves, increased FA may reflect disturbances in developmental processes caused by environmental stressors, thus serving as a potential marker for stress sensitivity or tolerance [4, 6].

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This study investigates the effect of elevated temperature on the leaf morphology of chickpea by quantifying FA. By comparing the levels of FA in leaves under normal and high-temperature regimes, we aim to evaluate the utility of FA as a phenotypic marker of heat tolerance. The identification of genotypes with lower FA under stress conditions could contribute to the development of more resilient chickpea varieties, better suited to withstand future climate challenges [2, 3].

2. Materials and Methods

Chickpea (*Cicer arietinum* L.), a species of the genus *Cicer* L. within the *Fabaceae* (*Leguminosae*) family, was used as the biological model in this study. Seeds of *Cicer arietinum* L. were selected based on uniform size and viability and sown in pots. The soil pH was maintained at optimal levels for chickpea growth and monitored using a calibrated pH meter throughout the experimental period. Environmental conditions, including ambient temperature, relative humidity, and photoperiod, were strictly controlled to ensure reproducibility [1].

Chickpea seeds underwent cold stratification in darkness for seven days at 5 °C and 30% relative humidity. Afterward, 120 seeds were sown (40 per pot) in a 2:1 mixture of black soil and bio-mix fertilizer and grown under controlled conditions at 25 ± 2 °C during the day and 16 ± 2 °C at night. On day 30, the plants were transferred to growth chambers for heat stress treatment. In the first chamber, daytime temperature was gradually increased to 35 ± 2 °C over three days, maintained for five hours, and then reduced to optimal levels. In the second chamber, plants were exposed to sustained high temperatures (35 ± 2 °C day / 25 ± 2 °C night) for three days. Control plants were maintained at optimal conditions (25 ± 2 °C during the day / 16 ± 2 °C during the night) throughout the experiment.

Fluctuating asymmetry was assessed by detailed morphometric measurements conducted on multiple traits of both the right and left halves of the leaf blade [8, 5]. Data were processed using JavaScript-based software to calculate asymmetry indices [7].

3. Results and Discussion

The graphical data clearly illustrates a progressive decline in developmental stability of *Cicer arietinum* with increasing intensity and duration of heat stress (Fig. 1). Under control conditions, bilateral asymmetry values remain low (0.606 mm), and both dispersion (0.156) and the fluctuating asymmetry coefficient (0.022) are minimal, suggesting stable morphogenesis and effective regulation of developmental processes in the absence of thermal stress.

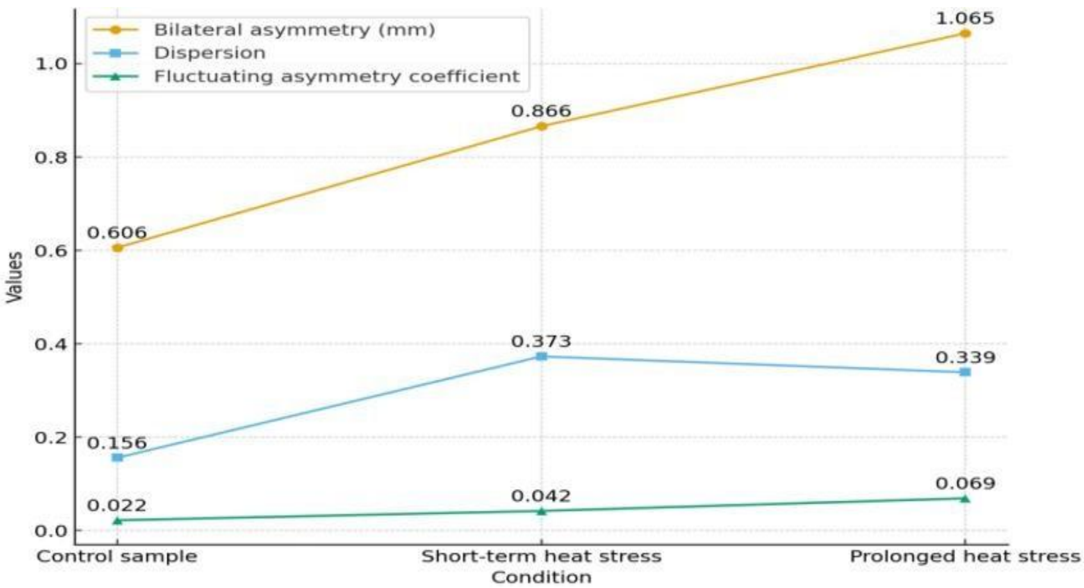

Fig. 1. Graphical representation of developmental stability changes in *Cicer arietinum* under varying temperature stress: control conditions (25 ± 2 °C during the day / 16 ± 2 °C at night), short-term heat stress (35 ± 2 °C for 5 daytime hours over three consecutive days), and prolonged heat stress (35 ± 2 °C daytime / 25 ± 2 °C nighttime for three days)

Exposure to short-term heat stress resulted in a marked increase in bilateral asymmetry (0.866 mm) and dispersion (0.373), while the fluctuating asymmetry coefficient nearly doubled (0.042). This indicates that even brief exposure to elevated temperatures disrupts developmental homeostasis, leading to measurable morphological instability.

The most pronounced effects were observed under prolonged heat stress. Bilateral asymmetry reached its maximum (1.065 mm), and the fluctuating asymmetry coefficient (0.069) tripled compared with the control, reflecting severe impairment of developmental stability. Interestingly, while dispersion decreased slightly compared with short-term stress (0 vs. 0.373), it remained substantially higher than in the control. This suggests that prolonged stress leads not only to increased asymmetry but also to altered variability patterns within the population.

Overall, the results confirm that fluctuating asymmetry and related parameters are sensitive indicators of environmental stress. The observed trends demonstrate that prolonged thermal exposure has cumulative negative effects on developmental stability, reflecting the organism’s limited adaptive capacity under conditions of sustained high temperature. These findings highlight the potential of asymmetry indices as reliable indicators for assessing plant tolerance and adaptive responses to climate-related stress factors.

4. Conclusion

The findings of this study demonstrate that elevated temperatures significantly compromise the developmental stability of *Cicer arietinum*, as evidenced by increased bilateral asymmetry, dispersion, and fluctuating asymmetry coefficients under both short-term and prolonged heat stress. While short-term exposure was sufficient to induce measurable morphological instability, prolonged stress amplified these effects, highlighting the cumulative impact of sustained thermal conditions on plant development.

These results confirm the utility of fluctuating asymmetry as a sensitive phenotypic marker for evaluating the effects of environmental stress on plants. The progressive increase in asymmetry indices with temperature stress underscores their potential application in identifying heat-tolerant chickpea genotypes. Integrating such morphological indicators into breeding programs may contribute to the development of more resilient cultivars, ensuring stable yields under future climate scenarios.

References

[1] Devi P, Jha UC, Prakash V, Kumar S, Parida SK., Paul PJ, Prasad PVV, Sharma KD, Siddique KHM. and Nayyar H. (2022). Response of physiological, reproductive function and yield traits in cultivated Chickpea (*Cicer arietinum* L.). under heat stress. Front. Plant Sci., 13: 880519. https://doi.org/10.3389/fpls.2022.880519

[2] Mamedova AO. (2009). Bioindication of environmental quality based on plant mutational and modification variability. *Cytol. Genet. 43*, 123–125. (in Russian). https://doi.org/10.3103/S009545270902008X

[3] Mammadova AO, Zafar M, Mammadova RN. (2024). Indicative and remedial properties of *Vicia faba* L. *Baku State University Journal of Life Sciences & Biology, 1(1),* 3-12. https://doi.org/10.30546/300045.2024.1.1.3

[4] Mammadova AO, Farzaliyeva NM, Mammadova RN. (2017). Environmental assessment of the tree plant leaves according to their physiological state and fluctuating asymmetry indices of morphological features, which widely spread in Baku. *Journal of Ecology of Health & Environment, 5*(1), 19–21. https://doi.org/10.18576/jehe/050103

[5] Mammadova AO, Mammadova RN. (2019). A study of bioindicative properties of *Quercus castaneifolia* C.A.Mey in naturaland urbanized sites in Azerbaijan. *Bulletin of Nizhnevartovsk State University, 2,* 71–79. https://doi.org/10.36906/2311-4444/19-2/09

[6] Mammadova RN. Mammadova AO. (2020). Investigation of the possibility to use *Quercus macranthera* Fisch. et C.A.Mey. woody plant in the management of the sustainability of the forest ecosystem. *Plant & Fungal Research, 2(2),* 30–37. https://doi.org/10.29228/plantfungalres.74

[7] Nazim R, Oqtay A. (2024). Study of Bio-ecological Indicators of Oak Species in Azerbaijan. *Proceedings of the Bulgarian Academy of Sciences, 77(10),* 1466– 1473. https://doi.org/10.7546/CRABS.2024.10.06

[8] Palmer AR, Strobeck C. (1992). Fluctuating asymmetry as a measure of developmental stability:

implications of nonnormal distributions and power of statistical tests // *Acta Zool. Fenn. 191*, 57-72.

[9] Yuvaraj M, Subramanian KS, Senthilkumar M. (2020). *Role of legumes by enhancin soil fertility and plant nutrition. IntechOpen.* https://doi.org/10.5772/intechopen.93247