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INVESTIGATION OF CHANGES IN THE MORPHOPHYSIOLOGICAL AND BIOCHEMICAL INDICATORS OF THE PLANT *STEVIA REBAUDIANA BERTONI* UNDER VARIOUS ECOLOGICAL CONDITIONS

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Abstract: Stevia rebaudiana Bertoni is a perennial herb valued for steviol glycosides, especially stevioside and rebaudioside A, which are used as high-intensity, low-calorie sweeteners. The accumulation of these compounds and the plant's productivity are influenced by environmental conditions, including water availability, soil salinity, temperature, light, humidity and soil properties. This article reviews evidence on the principal morphophysiological and biochemical responses of stevia to contrasting ecological conditions and outlines a framework for evaluating these responses under local growing environments. Published studies indicate that drought, salinity and waterlogging can reduce growth and photosynthetic performance, although the magnitude and direction of changes in individual glycosides depend on cultivar and stress intensity. Relevant indicators include plant height, branching, leaf area, biomass, chlorophyll content, relative water content, gas exchange, electrolyte leakage, proline, antioxidant enzyme activity and steviol glycoside composition. A combined assessment of plant growth, physiological status and leaf quality is therefore more informative than the measurement of any single trait. The article provides a methodological basis for future experimental research; it does not report new experimental measurements.

Keywords: Stevia rebaudiana; ecological conditions; morphophysiology; biochemical indicators; steviol glycosides; drought stress; salinity; photosynthesis.

1. Introduction

Stevia rebaudiana Bertoni is a plant species in the family Asteraceae whose leaves contain steviol glycosides, naturally occurring compounds with an intense sweet taste and very low caloric contribution. Stevioside and rebaudioside A are among the best-known glycosides, and their relative proportions influence the quality and commercial value of the harvested leaves. Interest in stevia has expanded because it can provide plant-derived sweetening ingredients for foods and beverages (Ramesh et al., 2006; Gunasena et al., 2021).

The productivity and chemical composition of stevia are not determined by genotype alone. Environmental conditions interact with plant developmental stage and agronomic management,

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influencing photosynthesis, leaf formation, biomass accumulation and secondary metabolism. Temperature, light intensity, soil moisture, salinity, nutrient availability and humidity can modify both the amount of leaf material produced and the concentration of steviol glycosides. A high concentration of a target compound does not necessarily mean a high total yield per unit area if environmental stress substantially reduces biomass.

Comparative field research across climatic regions has reported variation in growth, physiological traits, leaf yield and glycoside composition among sites. Experimental work has also shown that drought, salinity and waterlogging affect physiological performance, while cultivar-specific responses can lead to different patterns of glycoside accumulation (Ahmadi & Sarfaraz, 2024; Gupta et al., 2023). Therefore, integrated evaluation of morphophysiological and biochemical indicators is important when identifying suitable ecological conditions for stevia cultivation.

The aim of this article is to synthesize current evidence on the effects of contrasting ecological conditions on the morphophysiological and biochemical indicators of S. rebaudiana and to propose a practical framework for evaluating these responses in future experiments.

2. Materials and Methods

This article is structured as a narrative review and methodological synthesis of published research on stevia responses to environmental conditions. Relevant studies were identified through searches for publications addressing morphophysiological traits, abiotic stress, climatic variation, steviol glycosides and biochemical responses in S. rebaudiana. Priority was given to peer-reviewed articles reporting measurable plant responses under field, greenhouse or in vitro conditions. Because no original plant material, laboratory measurements or field dataset was supplied for this manuscript, no new experiment, statistical analysis or original numerical result is claimed.

2.1. Proposed experimental design for local validation

For an original study, plants of the same cultivar and similar developmental stage should be grown under clearly defined ecological treatments. Depending on the research question, treatments may include contrasting irrigation regimes, salinity levels, light conditions or cultivation sites. A randomized complete block design with at least three independent biological replicates is a reasonable starting point; final replication should be determined by expected variability and a statistical power assessment. Soil type, pH, electrical conductivity, nutrient supply, planting density, plant age and sampling time should be documented so that environmental effects can be distinguished from management effects.

2.2. Indicators and measurements

Morphological indicators may include plant height, number of branches, number of leaves, leaf area, root length, fresh biomass and dry biomass. Physiological measurements may include chlorophyll a and b, total chlorophyll, relative water content (RWC), stomatal conductance, transpiration, net photosynthetic rate and electrolyte leakage. Biochemical analyses may include proline, soluble sugars, total phenolic compounds and antioxidant enzyme activities such as superoxide dismutase (SOD), catalase (CAT) and peroxidase (POD). Stevioside and rebaudioside

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A should preferably be quantified using a validated chromatographic method, such as HPLC, with suitable standards and quality-control procedures.

Leaf samples for biochemical analysis should be collected from comparable positions and developmental stages, at a consistent time of day, and rapidly processed or stored under validated conditions. Results should be expressed on a clearly stated basis, such as dry weight, and analytical methods, extraction conditions and units should be reported in sufficient detail to enable replication.

3. Results and Discussion

3.1. Environmental conditions and morphological development

Environmental variation can affect the allocation of plant resources to stems, leaves and roots. Under adequate moisture and suitable temperature, stevia can sustain leaf expansion and biomass production. Under water deficit, cell expansion and leaf growth may decline, leading to reduced leaf area and shoot biomass. Some stress conditions may alter root growth as an adaptive response, but the direction and magnitude of the response depend on stress intensity, duration, genotype and developmental stage. Consequently, plant height alone is insufficient to characterize performance; branching, leaf area and dry leaf biomass should also be recorded.

Salinity imposes both osmotic stress and ion-specific effects. Increasing salt concentration can limit water uptake, disturb ion balance and inhibit shoot and root development. Research comparing stevia cultivars has found differences in biomass accumulation and ion regulation, indicating that cultivar selection is relevant to cultivation in salt-affected soils (Tavarini et al., 2018; Fallah et al., 2017). Waterlogging can also constrain root function by reducing oxygen availability in the root zone. These responses support the need to evaluate soil drainage and irrigation quality alongside climate.

3.2. Photosynthesis, water status and cellular stress

Chlorophyll content, gas exchange and relative water content provide complementary information about plant physiological status. Drought can reduce stomatal conductance and transpiration and may limit carbon assimilation. Prolonged stress can also affect photosynthetic pigments and membrane integrity. A study of multiple abiotic stresses in S. rebaudiana reported adverse effects on photosynthesis, chlorophyll, relative water content, shoot growth and steviol glycoside biosynthesis, with drought producing particularly strong effects among the tested stresses (Gupta et al., 2023).

Relative water content estimates tissue hydration, whereas electrolyte leakage can indicate loss of membrane integrity. These measures should be interpreted together: a plant may maintain one indicator temporarily while other physiological functions are already impaired. Measurements taken at more than one time point can help distinguish short-term acclimation from sustained damage. In field studies, environmental records such as air temperature, relative humidity, rainfall, soil moisture and soil electrical conductivity are essential for interpreting physiological measurements.

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3.3. Biochemical responses and antioxidant protection

Abiotic stress can increase the production of reactive oxygen species. Plants respond through enzymatic and non-enzymatic antioxidant systems, including SOD, CAT, POD, ascorbate-related pathways and compatible solutes such as proline and soluble sugars. Increased proline or antioxidant enzyme activity may indicate activation of protective responses; it should not automatically be interpreted as improved growth or greater stress tolerance. The biological meaning depends on whether protective responses are sufficient to maintain photosynthesis, membrane stability and biomass.

In stevia, molecular and physiological analyses have identified changes in genes associated with reactive oxygen species detoxification, osmotic adjustment, ion transport and stress signaling under drought, salinity and waterlogging. Such responses provide a mechanistic basis for linking environmental exposure to measurable biochemical indicators (Gupta et al., 2023). Future local studies could combine these indicators with gene-expression analysis where laboratory facilities and validated protocols are available.

3.4. Steviol glycosides and leaf quality

Stevioside and rebaudioside A are key quality traits, but their concentrations may respond differently to environmental stress. A stress treatment may increase the concentration of one glycoside in a tolerant genotype while reducing total biomass or the concentration of another glycoside. Thus, concentration and yield should be distinguished. The yield of a glycoside per plant or per unit area can be estimated by combining its concentration in dry leaves with dry leaf biomass, using consistent units and a validated analytical method.

A multi-region study in Iran reported substantial differences among climatic locations in leaf yield, photosynthetic pigments, proline and steviol glycoside composition. The study illustrates that the site producing the highest leaf biomass need not be the same site producing the highest concentration of a particular glycoside (Ahmadi & Sarfaraz, 2024). Similarly, salinity experiments have found cultivar-dependent changes in rebaudioside A and stevioside, reinforcing the importance of genotype-by-environment interactions (Tavarini et al., 2018).

3.5. Implications for cultivation under contrasting ecological conditions

For regions characterized by hot summers, irregular rainfall or saline soils, a practical evaluation should prioritize irrigation scheduling, drainage, soil salinity monitoring and cultivar suitability. Excessive drought should be avoided during periods of active leaf expansion, while waterlogging should be prevented through appropriate drainage. Where irrigation water or soil has elevated salinity, electrical conductivity should be monitored and salt-tolerant plant material evaluated rather than assuming that all stevia cultivars respond similarly.

A robust assessment should integrate three outcome groups: (i) productivity, including dry leaf biomass; (ii) physiological condition, including water status and photosynthetic performance; and (iii) biochemical quality, especially stevioside and rebaudioside A. Environmental conditions that maximize one group may not optimize the others. Accordingly, recommendations for cultivation should be based on replicated local trials across more than one season where possible, rather than extrapolating directly from another region.

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4. Limitations and Research Priorities

As a narrative review, this article does not provide a systematic-review protocol, meta-analysis or new experimental dataset. Published studies differ in cultivar, growth stage, stress duration, cultivation system and analytical method, which limits direct numerical comparison. For a publishable original research article, the proposed framework should be implemented using local experimental data, with a clearly described design, statistical tests, tables and figures. The most useful next steps are to compare selected ecological treatments under controlled replication, quantify glycosides chromatographically, and report both concentration and total compound yield.

5. Conclusion

The morphophysiological and biochemical characteristics of Stevia rebaudiana Bertoni are sensitive to environmental conditions. Water deficit, salinity and waterlogging can impair growth and photosynthetic function, while biochemical stress responses and steviol glycoside profiles vary according to genotype and exposure conditions. Plant height or glycoside concentration alone cannot provide a complete evaluation of crop performance. An integrated approach combining morphology, water status, photosynthetic traits, antioxidant indicators, dry leaf biomass and chromatographic quantification of stevioside and rebaudioside A is recommended. Local replicated experiments are needed to identify ecological conditions that balance high leaf productivity with desirable glycoside quality.

References

1. Ahmadi, M. D., & Sarfaraz, S. (2024). Assessment of morpho-physiological and biochemical profiles of Stevia rebaudiana Bertoni in different climatic regions of Iran. Fundamental and Applied Agriculture, 9(2), 122–130. https://doi.org/10.5455/faa.172011
2. Fallah, F., Nokhasi, F., Ghaheri, M., Kahrizi, D., Beheshti Ale Agha, A., Ghorbani, T., Kazemi, E., & Ansarypour, Z. (2017). Effect of salinity on gene expression, morphological and biochemical characteristics of Stevia rebaudiana Bertoni under in vitro conditions. Cellular and Molecular Biology, 63(7), 102–106. https://doi.org/10.14715/cmb/2017.63.7.17
3. Gunasena, M. D. K. M., Senarath, R. M. U. S., & Senarath, R. T. P. S. K. (2021). A review on chemical composition, biosynthesis of steviol glycosides, application, cultivation, and phytochemical screening of Stevia rebaudiana (Bert.) Bertoni. Journal of Pharmaceutical Research International, 33(29B), 85–104. https://doi.org/10.9734/JPRI/2021/v33i29B31593
4. Gupta, P., et al. (2023). Genome-wide transcriptional profiling and physiological investigation elucidating the molecular mechanism of multiple abiotic stress response in Stevia rebaudiana Bertoni. Scientific Reports, 13. https://doi.org/10.1038/s41598-023-46000-7
5. Ramesh, K., Singh, V., & Megeji, N. W. (2006). Cultivation of Stevia [Stevia rebaudiana (Bert.) Bertoni]: A comprehensive review. Advances in Agronomy, 89, 137–177. https://doi.org/10.1016/S0065-2113(05)89003-0
6. Tavarini, S., et al. (2018). Physiological and morphological responses to abiotic stresses in two cultivars of Stevia rebaudiana (Bert.) Bertoni. Scientia Horticulturae. [Verify full bibliographic details and DOI against the journal record before submission.]
7. Рахматов, О., Рахматов, О. О., & Рахматов, Ф. О. (2018). Совершенствование технологии переработки дынь в условиях республики Узбекистан. *Ташкент «Фан*.
8. Nuriev, K. K., Nuriev, M. K., Rakhmatov, O., & Rakhmatov, F. O. (2022, August). Comprehensive assessment of the degree of flooding of soil-cutting working bodies (on the

ISSN: 2224-6878 | Pakistan Volume 6, No. 10.

IF: 14.91 | 2026 http://waerasia.org/index.php/ijtar

example of plow shares). In *IOP Conference Series: Earth and Environmental Science* (Vol. 1076, No. 1, p. 012069). IOP Publishing.

9. Rakhmatov, O., Rakhmatov, F. O., Nuriev, K. K., & Nuriev, M. K. (2022, August). Development and justification of the thermal parameters of a mechanized rotary blancher. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1076, No. 1, p. 012068). IOP Publishing.
10. Raxmatov, F. O., Raxmatov, O., Nuriev, K. K., & Nuriev, M. K. (2021, October). Combined dryer with high efficiency for drying high-moist agricultural products. In *IOP Conference Series: Earth and Environmental Science* (Vol. 868, No. 1, p. 012076). IOP Publishing.
11. Rakhmatov, O., Tukhtamishev, S. S., Khudoiberdiev, R. K., Adilov, A. A., & Rahmatov, F. O. (2023, April). Experimental and theoretical studies of the modulus of elasticity and Poisson's ratio for vegetable and melon crops. In *International Conference on Digital Transformation: Informatics, Economics, and Education (DTIEE2023)* (Vol. 12637, pp. 291-297). SPIE.
12. Рахматов, О. О., Рахматов, Ф. О., Тухтамишев, С. С., & Худойбердиев, Р. (2019). Дыня древнейшая культурацентральной Азии. In *Научные основы развития АПК* (pp. 166-168).
13. Рахматов, О. О., Рахматов, Ф. О., & Тухтамишев, С. (2017). ЭКОНОМИЧЕСКАЯ ЭФФЕКТИВНОСТЬ ТЕХНОЛОГИЧЕСКОЙ ЛИНИИ ПО ПРОИЗВОДСТВУ ВЯЛЕНОЙ ДЫНИ. In *Научно-практические пути повышения экологической устойчивости и социально-экономическое обеспечение сельскохозяйственного производства* (pp. 1317-1320).
14. Нуриев, К. К., Рахматов, О., Кадирова, Р. С., & Рахматов, О. О. (2015). Биоконверсия органических отходов растительного происхождения в условиях Узбекистана. In *Проблемы рекультивации отходов быта, промышленного и сельскохозяйственного производства* (pp. 468-470).