IOCBI 2026 Conference

The 1st International Online Conference on Biology

10–12 February 2026 | Online

SCHOOL OF AGRICULTURE
UNIVERSITY OF IOANNINA

MDPI

Toward Sustainable Kiwi Cultivation: Growth and Metabolic Insights from a Case Study of the Application of Amino Acid and Organic-Based Biostimulants

Vasileios Papantzikos

Department of Agriculture, University of Ioannina, Arta Campus, 47100, Greece

INTRODUCTION

Kiwi is an economically important cultivar for Greece, as the country has been ranked fourth in kiwi exports worldwide in 2020 [1]. However, climate change has posed significant challenges to kiwi cultivation, as water requirements are much higher, and intense drought periods can cause abiotic stresses, which usually lead to reduced growth [2,3]. The use of humic and fulvic acid (HF), and glycine-betaine-proline (GBP) biostimulants could be an alternative to limit the harsh abiotic stress conditions, as it has been observed in several works [4]. This study aims to investigate the effect of an HF and a GBP biostimulant on *Actinidia deliciosa* var. "Hayward" growth by evaluating some metabolic and physiological properties.

METHODS

Two biostimulant treatments and a control (C) (where no biostimulant was applied) were arranged; i) GBP treatment (Application of a glycine–betaine 80%, proline 10%, antioxidants, bioflavonoids and ellagic acid 0.5% *w/w* biostimulant): Fitomaat (Futureco Bioscience), and ii) HF treatment (Application of a humic & fulvic acid-based (>25% *w/w*) biostimulant): Blackjack Bio (Sofbey). The total chlorophyll content (TCHL), total phenolic content (TPC), Proline, and leaf area were recorded.

RESULTS & DISCUSSION

Leaf area (Picture 1) was higher in the GBP treatment (3943.17±211.26 cm^2), with a statistically significant difference compared to the control (3484.01±354.19 cm^2) and HF (3943.17±211.26 cm^2) (Figure 1i). Exogenous proline application has been observed to improve leaf area, as well as to increase leaf water content [5]. The results of this experiment are in agreement with other studies in which a positive effect of GBP substances on the increase in leaf number [6] and leaf area [7,8] has been observed. The overall picture of TPC in kiwi leaves did not show great variations.

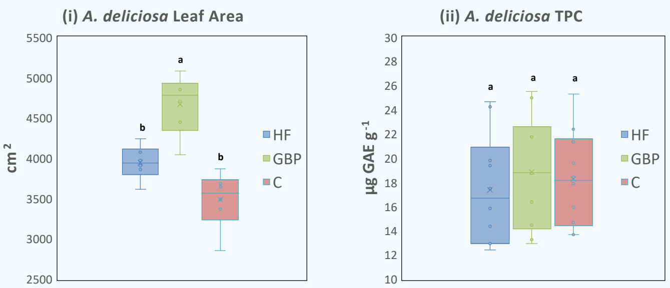

Figure 1. Variation of leaf area (cm^2 ± SD) (i), and total phenolic content (mg GAE g^{-1} ± SD) (ii) of *A. deliciosa* leaves. Different letters between treatments indicate significant differences according to the Bonferroni test (p≤0.05).

Picture 1. Representative photographs of *A. deliciosa* var. "Hayward" leaf area of the treatments: i) C, ii) GBP, iii) HF. The leaf area was analyzed at the end of each experimental season with the Image J software.

There was no statistically significant difference between the treatments, except for some samplings, mainly in the first experimental season. Although the TCP was increased in the GBP treatment (18.86±4.61 mg GAE g^{-1}) (Figure 1ii). In other studies, a continuous statistically significant difference in TCP is observed in the treatments that applied GBP [9,10], which in this experiment was not observed for both consecutive years.

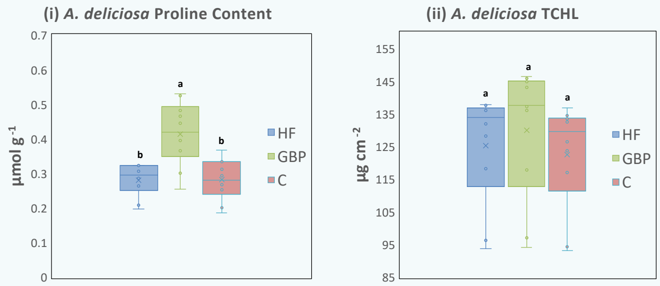

Figure 2. Variation of proline content (μmol g^{-1} ± SD) (i), and total chlorophyll content (μg cm^{-2} ± SD) (ii) of *A. deliciosa* leaves. Different letters between treatments indicate significant differences according to the Bonferroni test (p≤0.05).

Higher values of proline, were observed for both consecutive years in the GBP treatment (0.41±0.09 μmol g^{-1}), with a statistically significant difference from both the C (0.28±0.06 μmol g^{-1}) and the HF (0.28±0.05 μmol g^{-1}) (Figure 2i). These results are in agreement with the work of Delfani et al. 2023, where the exogenous addition of GBP substances significantly increased proline levels in orange trees [11]. The restoration of osmotic dysfunctions can be achieved by the addition of GBP agents, a fact that has been observed in other works [12, 13]. Several studies confirm that TCHL enhancement in plant tissues occurs after the addition of GBP biostimulants [14, 15, 16]. However, in this experiment, no statistically higher TCHL was observed in the GBP treatment for two consecutive seasons (Figure 2ii). Although the higher THCL was noted in GBP treatment (130.12±19.97 μg cm^{-2}), this is relevant in other studies as well [17, 18]. Gernard et al. 1991 mention the protective role of Glycine-betaine for chloroplasts from oxidative stress and may act like cytokinin to enhance TCHL [19].

CONCLUSIONS

The addition of biostimulants promises a certain recovery of plant metabolism in stress conditions. In this experiment, this recovery was observed by the increase of leaf area and proline levels in the GBP treatment, presenting statistically significant differences for two consecutive years in kiwifruit cultivation.

RESOURSES

1. Sharma, K.; Kumar, R.; Kumar, A. Himalayan Horticulture Produce Supply Chain Disruptions and Sustainable Business Solution—A Case Study on Kiwi Fruit in Uttarakhand. Horticulturae 2022, 8, doi:10.3390/HORTICULTURAE8111018.
2. Lötter, J. de V. Ecological Factors Influencing The Commercial Production Of Kiwifruit (Actinidia Deliciosa). Acta Hortic 1990, 65–78, doi:10.17660/ACTAHORTIC.1990.282.6.
3. Li, Z.; Bai, D.; Zhong, Y.; Abid, M.; Qi, X.; Hu, C.; Fang, J. Physiological Responses of Two Contrasting Kiwifruit (Actinidia Spp.) Rootstocks against Waterlogging Stress. Plants 2021, Vol. 10, Page 2586 2021, 10, 2586, doi:10.3390/PLANTS10122586.
4. Dutta, S.K. Dataset on Effect of Biostimulants on Growth and Rooting of Kiwifruit (Actinidia Deliciosa) Cuttings: From Morphological and Gene Regulation Approach. Data Brief 2024, 54, 110538, doi:10.1016/J.DIB.2024.110538.
5. Ntanos, E.; Tsafouros, A.; Denaxa, N.K.; Kosta, A.; Bouchagier, P.; Roussos, P.A. Mitigation of High Solar Irradiance and Heat Stress in Kiwifruit during Summer via the Use of Alleviating Products with Different Modes of Action—Part 1 Effects on Leaf Physiology and Biochemistry. Agriculture 2022, Vol. 12, Page 2121 2022, 12, 2121, doi:10.3390/AGRICULTURE12122121.
6. Osman, H.S. Enhancing Antioxidant–Yield Relationship of Pea Plant under Drought at Different Growth Stages by Exogenously Applied Glycine Betaine and Proline. Annals of Agricultural Sciences 2015, 60, 389–402, doi:10.1016/J.AOAS.2015.10.004.
7. Islam, S.; Parrey, Z.A.; Shah, S.H.; Mohammad, F. Glycine Betaine Mediated Changes in Growth, Photosynthetic Efficiency, Antioxidant System, Yield and Quality of Mustard. Sci Hortic 2021, 285, 110170, doi:10.1016/J.SCIENTA.2021.110170.
8. Sakr, M.T.; El-Sarkassy, N.M.; Fuller, M.P. Osmoregulators Proline and Glycine Betaine Counteract Salinity Stress in Canola. Agron Sustain Dev 2012, 32, 747–754, doi:10.1007/S13593-011-0076-3/TABLES/2.
9. Serapicos, M.; Afonso, S.; Gonçalves, B.; Silva, A.P. Exogenous Application of Glycine Betaine on Sweet Cherry Tree (Prunus Avium L.): Effects on Tree Physiology and Leaf Properties. Plants 2022, 11, 3470, doi:10.3390/PLANTS11243470/S1.
10. Molaei, S.; Rabiei, V.; Soleimani, A.; Razavi, F. Exogenous Application of Glycine Betaine Increases the Chilling Tolerance of Pomegranate Fruits Cv. Malase Saveh during Cold Storage. J Food Process Preserv 2021, 45, e15315, doi:10.1111/JFPP.15315.
11. Delfani, K.; Asadi, M.; Golein, B.; Babakhani, B.; Razeghi Jadid, R. Foliar Application of Glycine Betaine Affects Morpho-Physiological, Biochemical and Fruit Quality Traits of Thomson Navel Orange Under Deficit Irrigation. J Plant Growth Regul 2023, 42, 2867–2883, doi:10.1007/S00344-022-10753-8/FIGURES/4.
12. Zhang, Y.; Jin, P.; Huang, Y.; Shan, T.; Wang, L.; Li, Y.; Zheng, Y. Effect of Hot Water Combined with Glycine Betaine Alleviates Chilling Injury in Cold-Stored Loquat Fruit. Postharvest Biol Technol 2016, 118, 141–147, doi:10.1016/J.POSTHARVBIO.2016.04.010.
13. Jain, P.; Pandey, B.; Singh, P.; Singh, R.; Singh, S.P.; Sonkar, S.; Gupta, R.; Rathore, S.S.; Singh, A.K. Plant Performance and Defensive Role of Glycine Betaine under Environmental Stress. Plant Performance Under Environmental Stress: Hormones, Biostimulants and Sustainable Plant Growth Management 2021, 225–248, doi:10.1007/978-3-030-78521-5_9/TABLES/1.
14. Athar, H.U.R.; Zafar, Z.U.; Ashraf, M. Glycinebetaine Improved Photosynthesis in Canola under Salt Stress: Evaluation of Chlorophyll Fluorescence Parameters as Potential Indicators. J Agron Crop Sci 2015, 201, 428–442, doi:10.1111/JAC.12120.
15. Cha-Um, S.; Kirdmanee, C. Effect of Glycinebetaine on Proline, Water Use, and Photosynthetic Efficiencies, and Growth of Rice Seedlings under Salt Stress. Turkish Journal of Agriculture and Forestry 2010, 34, 517–527, doi:10.3906/tar-0906-34.
16. Oukarroum, A.; El Madidi, S.; Strasser, R.J. Exogenous Glycine Betaine and Proline Play a Protective Role in Heat-Stressed Barley Leaves (Hordeum Vulgare L.): A Chlorophyll a Fluorescence Study. Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology 2012, 146, 1037–1043, doi:10.1080/11263504.2012.697493.
17. Farhat, F.; Arfan, M.; Wang, X.; Tariq, A.; Kamran, M.; Tabassum, H.N.; Tariq, I.; Mora-Poblete, F.; Iqbal, R.; El-Sabrout, A.M.; et al. The Impact of Bio-Stimulants on Cd-Stressed Wheat (Triticum Aestivum L.): Insights Into Growth, Chlorophyll Fluorescence, Cd Accumulation, and Osmolyte Regulation. Front Plant Sci 2022, 13, 850567, doi:10.3389/FPLS.2022.850567/BIBTEX.
18. Shafiq, S.; Akram, N.A.; Ashraf, M.; García-Caparrós, P.; Ali, O.M.; Abdel Latef, A.A.H. Influence of Glycine Betaine (Natural and Synthetic) on Growth, Metabolism and Yield Production of Drought-Stressed Maize (Zea Mays L.) Plants. Plants 2021, Vol. 10, Page 2540 2021, 10, 2540, doi:10.3390/PLANTS10112540.
19. Genard, H.; Le Saos, J.; Billard, J.-P.; Tremolieres, A.; Boucaud, J. Effect of Salinity on Lipid Composition, Glycine Betaine Content and Photosynthetic Activity in Chloroplasts of Suaeda Maritima. Plant physiology and biochemistry (Paris) 1991, 29, 421–427.