Review Article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

Environmental Stresses That Resulted from Climatic Changes and Methods of Resistance to Production of Horticultural Crops

Abdulraheem A. Obaid[1], Ahmed H. Al Mashhdany[2] and Mohammed M. Mohammed[3]*

[1,2,3]Dept. of Hort. & Landscape, College of Agri. Eng. Sciences, Univ. of Baghdad, Iraq

ABSTRACT

Studies have shown that climate changes resulting from global warming were the main reason for the disruption of agricultural and economic systems around the world, especially rising temperatures, fluctuating rainfall rates, the occurrence of prolonged droughts, and the absence of irrigation water, in addition to the rise in soil salinity to dangerous levels that threaten global food security.The countries of the Middle East considered among the countries most affected by drought, as the areas of arable sedimentary land have decreased due to lack of irrigation water and high soil salinity. These changes have imposed challenges that have forced researchers to search for ways to confront them with appropriate means, techniques, and materials that can reduce the harmful impact of these changes. Environmental stresses on various horticultural crops and finding appropriate solutions to them, such as addressing irrigation water scarcity and ensuring its sustainability by improving consumption efficiency. In addition to searching for techniques and materials, that reduces the damage of plants by the high temperature such as shading net and mulching the soil, as well importance of using materials that supports the plant's performance in resisting environmental stresses and improving production, such as using anti-transpiration agents and materials that will be stimulate the synthesis of organic compounds that regulate plant metabolism.

KEYWORDS: Climate Change, Abiotic stress, Heat stress, Drought.

***Corresponding author**

Asst. Prof. Mohammed M. Mohammed

Dept. of Hort. & Landscape,

College of Agri. Eng. Sciences,

Univ. of Baghdad, Iraq.

Email: mohammed.m@coagri.uobaghdad.edu.iq, Mob No +9647818714104

INTRODUCTION

Accelerated climate change in recent decades has had serious repercussions on the world's environmental and economic systems, and the most important of these changes is global warming resulting from the accumulation of greenhouse gases in the atmosphere, causing global temperatures to rise to rates dangerous to the sustainability of those systems[1]. In addition, there was a fluctuation in the rate of rainfall around the world, as severe droughts occurred in certain regions of the world, such as North Africa, the Mediterranean Basin, and the countries of the Middle East[2]. Climate changes and their harmful environmental impact, represented by global warming resulting from the accumulation of greenhouse gases in the upper layers of the atmosphere, are the main cause of temperatures rising above average, a significant shortage of drinking water resources and irrigation of farms, as well as the deterioration of agricultural soils because of erosion and salinization[3]. It has created challenges that agricultural producers must face because they have become major determinants of agricultural development in the region and the world. One of the most important of these changes is the fluctuation in rainfall rates in terms of quantity and time periods. Estimates have indicated a decline in the rainfall rate and this decline is expected to continue in the future in conjunction with rising temperatures and the prevalence of drier climatic conditions[4].There are previous studies that have dealt with available means, techniques, and materials that can limit the damage resulting from various environmental stresses in the region and the world, and that have attempted to find appropriate solutions that limit the harmful impact of extreme environmental conditions resulting from climate change, such as addressing the scarcity of irrigation water and researching methods for its sustainability and efficiency. Its use[5] Other studies have emphasized the importance of using materials and methods that reduce temperatures and solar radiation, such as plant shading materials and soil covering materials[6], or using agricultural products that improve the ability of plants to resist these environmental stresses, such as anti-transpiration agents that reduce the rate of water loss from plants[7]. There are studies that have tended to develop plant varieties and species that have a great ability to resist various environmental stresses, such as tolerance to extreme heat, high salinity, and drought tolerance.

CLIMATE CHANGE AND THEIR IMPACT ON CROPS PRODUCTION

The current rate of increase in temperatures for the Middle East region can be estimated at around 1.5 degrees Celsius compared to the levels recorded for the same region during the pre-industrial period, while global temperature rise rates reached 1.1 degrees Celsius, which means an annual increase rate of 0.03 degrees Celsius[8]. Recent studies have indicated the possibility of an increase in the average temperature of the region that may reach 2.2 degrees Celsius by the year

2040, with the possibility of an increase in extreme heat waves hitting the region in the future[9,10]. Studies have shown an increase in the frequency of drought since 1950 AD, as the Middle East region was exposed between 2008 and 2011 to strong drought periods that resulted in a large deficit in agricultural resources. For expected that rainfall amounts will decrease by 30% in Turkey, which is the most important country upstream of the rivers (the Tigris and Euphrates). In addition to an increase in temperatures[11]. Other studies have confirmed that climate changes and their environmental and economic repercussions constitute a clear threat to food security, especially after droughts that caused scarcity of irrigation water, exacerbated the problem of salinity, and decreased the amount of water imported into Iraq from upstream countries[12].Other sources, based on data from international institutions, indicated that a rise in temperature by one degree Celsius causes a decrease in rainfall by 4% in most parts of the region[13]. High temperature, scarcity of irrigation water, and deterioration of agricultural soil are reflections of those climate changes that have begun to negatively affect agricultural development, as they have caused significant losses in production, as a result of the decrease in agricultural areas around the main rivers in the region, which are considered the basic pillars of agricultural production in the countries of the region [14,15].One of the damages caused by high temperatures is the increased loss of water through rapid evaporation and increased rates of evapotranspiration, which negatively affect the efficiency of plants in production, and increased soil salinization and erosion[16].

ENVIRONMENTAL STRESSES AND POSSIBLE SOLUTIONS

Due to the great damage to agricultural development, studies have emphasized the importance of researching available means, techniques, and materials that can limit the damage resulting from various environmental stresses in the region and the world[17]. The scientists tried to find solutions by using Nano-fertilization to face the climatic change and environmental stress factors, where Nano-fertilizers consider a modern way to quickly grow up the yield and to decrease use the chemicals but the use of nanotechnology may be negative on human and the environment due to fast accumulation in the tissues of alive bodies which obligate the researchers to find the correct method and doses of Nano fertilizers for the different plants beside the attempt to use fertilizer environment friendly with high efficiency on growth and yield [18]. Researchers have tried to find appropriate solutions that reduce the harmful effects of climate change, such as addressing the scarcity of irrigation water, as well as the efficiency of its use and reducing water losses to a minimum [19]. Other research dealt with research into methods and techniques that attempt to reduce the damage of high temperatures to the environment and plants.There is the importance of research into the production of agricultural materials and compounds that can play a role in directing and controlling the physiological behavior of the plant, which contributes to strengthening its immunity against drought and high temperatures [20].

Irrigation Methods and Water Salinity

Using of highly efficient irrigation systems to regulate irrigation water consumption it is one of the important solutions available to farmers in order to confront the scarcity of irrigation water and ensure that there is no shortage in production area [21]. Sometimes the producer may resort to using salt water sources to meet part of the water needs in areas affected by drought, but their use will negatively affect the performance of crops in growth and production. Therefore, means that can reduce the negative impact of salinity must be considered when using salt irrigation water in Crop production .One of the methods used to reduce the harm of salinity in irrigation water is mixing high-salinity water with low-salinity irrigation water, in addition to using irrigation systems that regulate water drainage and using varieties that are resistant to high water and soil salinity[22] .

Heat stress and its Harmful Effects

There is a possibility of using protective materials to reduce the damage of environmental stresses, whether by reducing direct solar radiation, reducing temperature, and then reducing water loss from plants and soil. Using shading materials will be provides important shading to block a portion of the solar radiation when touches the plant or the soil as well lowering the temperature, while mulching the soil had benefit of reducing water evaporation, preventing and soil salinization[23].Higher than normal temperatures negatively affect many plant vital activities[24,25]. High temperatures surrounding the plant cause an increase in the respiratory rate and an increase in the consumption of energy and food manufactured by the plant, and then a slowdown in vital activities, a deficiency in building the plant’s biomass, and a decrease in the quantity and quality of the crop[26,27]. It also inhibits the process of building enzymes and their effectiveness, as well as increasing water loss through transpiration. The damage caused by heat stress at the cellular level occurs by increasing the kinetic energy of cellular molecules to levels that cause damage to the proteins and structures of cellular membranes, thus damaging chemical bonds and losing cell contents[28,29], as well as inhibiting the work of natural hormones. Responsible for the division and differentiation of plant cells such as Brassinosteroids (BRs)[30,31]. Other studies have attempted to reduce the damage resulting from higher than average temperatures by using materials sprayed on the plant that improve its resistance by reducing water loss through transpiration or increase its ability to resist thermal stress and water stress[32].Sources indicated the possibility of using manufactured protection methods to confront high temperatures and high solar radiation and reduce their harmful impact on crop growth and production[33]. Studies have proven the effectiveness of using acrylic or sun proof in reducing the intensity of solar radiation penetrating the plant, thus lowering temperatures, and slowing the rate of plant respiration. This will positively contribute to increasing the chlorophyll content of the leaves, increasing the rate of building plant biomass, and increasing the percentage of TSS in the fruits.There are studies that have focused their attention on producing and experimenting with different chemical and organic compounds to confirm their effectiveness in improving the efficiency of plants to adapt to the surrounding environment and improving growth and production . Anti-transpiration agents are substances that can be sprayed on horticultural crops, as they serve an important purpose in regulating the plant's water content within natural limits[34],by reducing water loss by transpiration. Anti-transpiration agents that can be used as sprays on leaves are classified based on the mechanism by which they work to reduce water loss. Some of them work on the basis of relative blocking of sunlight, relative closing of stomata, or formation of an insulating layer for the leaf from its external surroundings[35]. Previous studies indicated that anti-transparent have an effect in reducing the rate of plant respiration, and this effect will be positive in providing nutrients that support plant growth and development and improving the growth rate and quality of the crop[36]. References emphasized the importance of the physiological balance for plants between the processes of respiration and photosynthesis in order to obtain ideal growth, and that temperatures exceeding the maximum limits will lead to an imbalance in this balance .Using of salicylic acid sprayed on the leaves as an anti-transpiration agent has contributed to regulating the plant's physiological processes by increasing its resistance to biotic and abiotic stresses, as well as salt stress[37]. Reactive oxygen species (ROS) are produced by plants, including cucumbers, when they are exposed to heat stress conditions[38,39]. These hormones are considered important elements that improve the plant's ability to tolerate heat stress conditions, such as brassinosteroid hormones (BRs) [40]. These hormones are important in regulating plant physiological processes such as cell division, cell differentiation and development of plant organs, important vegetative photosynthesis, as well as ethylene biosynthesis, gene expression and then responding to heat stress appropriately[41].External foliar spraying of BRs increases the ability of plants to tolerate heat as well as hormons could decrease the stress and improve the yield quality where foliar spraying with vitamins (B9) decreased the calcium oxalate content in spinach plants [42] , which enhances the sustainability of production and contributes to confronting global warming by stimulating the synthesis of proline and antioxidants such as peroxides[43,44].Spraying cucumber plants with BRs has contributed to increasing the number of female flowers on the plant, and its positive effect has been shown in maintaining a good fruit set rate after temperatures rise above 35°C [45].

Microbial Applications for Enhancing Vegetable Crop Resilience Under Abiotic Stress

Microorganisms that live in the rhizosphere the narrow region of soil directly influenced by root secretions are essential for plant health. These microbes, particularly plant growth-promoting rhizobacteria (PGPR) and fungi like arbuscular mycorrhizal fungi (AMF) [46], form symbiotic relationships with plants. In exchange for carbon-rich exudates from the plant, these microorganisms offer various benefits, such as improved nutrient uptake, enhanced water absorption, and protection against diseases. Some cases about the benefits and positive effects of soil microorganisms are as follow:

Tomato and Drought Stress In a study by Zhang et al.[47], tomato plants inoculated with AMF improved drought tolerance. The inoculated plants had higher chlorophyll contentand greater biomass than non-inoculated controls. These findings suggested thatArbuscular mycorrhizal fungi (AMF) can promote plant growth and enhance plant drought tolerance with varying effect size among different fungal species.Pepper and Salinity Stress Research by Yasin et al[48]found that inoculation with halotolerant PGPR strains improved the growth of pepper plants under saline conditions.He found that(Bacillus fortis) strain SSB21 caused highest significant increase in shoot length, root length, and fresh and dry biomass production of capsicum plants grown under saline conditions. Lettuce where[49] who used PGPR bacteria mediate stress response via a reduction in ethylene production is based on the bacterial ACC deaminase enzyme, which cleavage of ACC to ammonia and α- ketobutyrate.Also,theyconcluded that existence of different strategies, according to which the plant could repress its ethylene signaling pathway in response to bacteria. Many studies refered to the ckilmate change as a critical challenge due its effects on plant growth and production[50,51].

CONCLUSION

We can conclude that climate change is a significant issue for plant production and plant diseases, creating both direct and indirect challenges for agriculture. So, adapting to these challenges by followed with some solutions such as Resilient Crop Varieties: Breeding and genetic engineering are critical for developing plant varieties that are resistant to heat, drought, and disease, Integrated Pest Management (IPM): IPM combines biological control, crop rotation, and resistant varieties to manage pests and diseases sustainably, Improved Water Management: Efficient irrigation methods like drip irrigation and soil moisture monitoring help conserve water and maintain crop health, Climate Prediction Models: Advanced climate models can help farmers anticipate weather patterns, adjust planting schedules, and mitigate losses.

ACKNOWLEDGEMENTS

The authors would like to thank all members ofthe Central Library, University of Baghdad for their assistance and providing all the necessary references.

REFERENCES

1. Paciello MC, editor. Building sustainable agriculture for food security in the Euro-Mediterranean area: challenges and policy options. *IAI*; 2015. 334 pp. https://www.iai.it/en/pubblicazioni/building-sustainable-agriculture-food-security-euro-mediterranean-area.
2. Hellal FA, El-Sayed SA, Basha DM et al. Mineral nutrient status of some Mediterranean barley varieties as affected by drought stress in Egypt. *Iraqi J. Agric. Sci.* 2020; 51:138–147. https://doi.org/10.36103/ijas.v51iSpecial.891.
3. Jawad TK, Al-Taai OT, Al-Timimi YK. Evaluation of drought in Iraq using DSI by remote sensing. *Iraqi J. Agric. Sci.* 2018; 49(6):0018-0041. https://doi.org/10.36103/ijas.v49i6.152.
4. Saadi S, Mladen T, Lazar T et al. Climate change and Mediterranean agriculture: impacts on winter wheat and tomato crop evapotranspiration, irrigation requirements and yield. *Agric. Water Manage.* 2015; 147: 103-115. https://doi.org/10.1016/j.agwat.2014.05.008.
5. Al-Wagaa EA, Muhammad M. The role of anti-transpiration agents in improving rice yield and its components under the influence of salt stress. *J. Educ. Sci. Stud.* 2020; 7: 16.
6. Obaid AA, Khalil NH, Al-Alawy HH et al. Effect of planting density, foliar spraying, and overlapping system on growth and productivity using a soilless culture system. *J. Saudi Soc. Agric. Sci.* 2022; 21: 506–510. https://doi.org/10.1016/j.jssas.2022.02.004.
7. Koteswara RG, Babu MS, Sravani V et al. A review on the influence of antitranspirants (ATs) in vegetable crops. *Int. J. Pure App. Biosci.* 2018; 6(3): 394-399.
8. Cramer W et al. Climate change and interconnected risks to sustainable development in the Mediterranean. *Nat. Clim. Chang.* 2018; 8: 972-980. https://www.nature.com/articles/s41558-018-0299-2.
9. Kuglitsch FG et al. Heat wave changes in the eastern Mediterranean since 1960. *Geophys. Res. Lett.* 2010; 37(4): L04802. https://doi.org/10.1029/2009GL041841.
10. Jacob D et al. EURO-CORDEX: new high-resolution climate change projections for European impact research. *Reg. Environ. Change.* 2014; 14(2): 563-578. https://link.springer.com/article/10.1007/s10113-013-0499-2.

11. Vautard R et al. The European climate under a 2°C global warming. *Environ. Res. Lett.* 2014; 9(3): 034006. https://doi.org/10.1088/1748-9326/9/3/034006.
12. Hakim MA, Juraimi AS, Hanafi MM et al. Effect of salt stress on morpho-physiology, vegetative growth, and yield of rice. *J. Environ. Biol.* 2014; 35(2): 317-326. http://www.jeb.co.in/journal_issues/201403_mar14/paper_03.pdf.
13. Barbagallo RN, Di Silvestro I, Patane C. Yield, physicochemical traits, antioxidant pattern, polyphenol oxidase activity, and total visual quality of field-grown processing tomato cv. Brigade as affected by water stress in Mediterranean climate. *J. Sci. Food Agric.* 2013; 93: 1449-1457. https://onlinelibrary.wiley.com/doi/abs/10.1002/jsfa.5913.
14. Fitzgerald GJ et al. Elevated atmospheric [CO2] can dramatically increase wheat yields in semi-arid environments and buffer against heat waves. *Glob. Chang. Biol.* 2016; 22: 2269-2284. https://pubmed.ncbi.nlm.nih.gov/26929390.
15. Cisneros JBE et al. Freshwater resources in climate change 2014: impacts, adaptation, and vulnerability, part A. *Rep. IPCC.* Cambridge University Press; 2014. pp. 229-269. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5Chap3_FINAL.pdf.
16. Gudmundsson L, Seneviratne SI. Anthropogenic climate change affects meteorological drought risk in Europe. *Environ. Res. Lett.* 2016; 11(4): 044005. https://iopscience.iop.org/article/10.1088/1748-9326/11/4/044005.
17. Gudmundsson L, Seneviratne SI, Zhang X. Anthropogenic climate change detected in European renewable freshwater resources. *Nat. Clim. Chang.* 2017; 7(11): 813-816. https://www.nature.com/articles/nclimate3416.
18. Mohammed MM. Disadvantages of using nanoparticles as fertilizers in Iraq. In: *IOP Conf. Ser.: Earth Environ. Sci.* 2021; 735(1): 012043. IOP Publishing.
19. Ali ND. Fertilizer technologies and their uses. *Univ. Baghdad, Min. High. Educ. Sci. Res. Iraq.* 2012.
20. Wu C, Li F, Xu H et al. The potential role of brassinosteroids (BRs) in alleviating antimony (Sb) stress in *Arabidopsis thaliana*. *Plant Physiol. Biochem.* 2019; 141: 51–59. https://doi.org/10.1016/j.plaphy.2019.05.011.
21. Herrero M, Thornton PK. Livestock and global change: emerging issues for sustainable food systems. *Proc. Natl. Acad. Sci. U.S.A.* 2013; 110: 20878-20881. https://doi.org/10.1073/pnas.1321844111.
22. Qadir SA, Khursheed MQ, Rashid TS et al. Abscisic acid accumulation and physiological indices in response to drought stress in wheat genotypes. *Iraqi J. Agric. Sci.* 2018; 2(50): 705–7012. https://doi.org/10.36103/ijas.v2i50.670.

23. Rungruksatham P, Khurnpoon L. Effect of shade net and fertilizer application on growth and quality in muskmelon (Cucumis melo L. var. reticulatus) after harvest. *Int. J. Agric. Technol.* 2016; 12(7.1):1407–1417. https://www.thaiscience.info/journals/Article/IJAT/10985315.pdf.
24. Amarasinghe RMNT, Sakimin SZ, Wahab PEM et al. Growth, physiology, and yield responses of four rock melon (Cucumis melo Var. Cantaloupensis) cultivars in elevated temperature. *Plant Arch.* 2021; 21:259–266. https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no2.040.
25. Al-Omairi AA, Al-Hilfy IHH. Reducing the heat stress on maize during spring season by using some biostimulants. *Iraqi J. Agric. Sci.* 2024; 55(3): 972-983.
26. Amarasinghe RM, Zahraa SS. Influence of brassinolides on plant physiology and yield of cantaloupe under high temperature stress. *Iraqi J. Agric. Sci.* 2022; 53(6). https://doi.org/10.36103/ijas.v53i6.
27. Prasad PVV, Jagadish SVK. Field crops and the fear of heat stress – opportunities, challenges, and future directions. *Procedia Environ. Sci.* 2015; 29:36–37. https://www.sciencedirect.com/science/article/pii/S1878029615003564.
28. Iqbal N, Fatma M, Khan NA et al. Regulatory role of proline in heat stress tolerance: modulation by salicylic acid. Elsevier Inc.; 2019. ISBN 9780128164518.
29. Kurtar ES. Modelling the effect of temperature on seed germination in some cucurbits. *Afr. J. Biotechnol.* 2010; 9:1343–1353. https://doi.org/10.5897/AJB2010.000-3016.
30. Islam MR, Feng B, Chen T et al. Role of abscisic acid in thermal acclimation of plants. *J. Plant Biol.* 2018; 61:255–264. https://doi.org/10.1007/s12374-017-0429-9.
31. Bartwal A, Mall R, Lohani P et al. Role of secondary metabolites and brassinosteroids in plant defense against environmental stresses. *J. Plant Growth Regul.* 2012; 32:216–232. https://doi.org/10.1007/s00344-012-9272-x.
32. Al-Mashhadany NJ, Al-Amery NJ. Enhancing vegetative growth by adding phosphorus, silicon, and citric acid to pepper plants cultivated in plastic greenhouses. *IOP Conf. Ser.: Earth Environ. Sci.* 2023; 1262(4):042068. https://doi.org/10.1088/1755-1315/1262/4/042068.
33. Sankhala GK, Verma P, Nandre BM et al. Effect of different shadenet on growth, flowering, yield, and quality of muskmelon (Cucumis melo L.). *Int. J. Agric. Sci.* 2019; 11(5):7950–7952.
34. El-Afifi STM, El-Sayed HA, Farid SM et al. Effect of organic fertilization, irrigation intervals, and some antitranspirants on growth and productivity of eggplant (Solanum melongina L.). *J. Plant Prod. Mansoura Univ.* 2013; 4(2):271–286.

35. Ahmed MH, Dawa KK, Abd El-Nabi HM et al. Influence of some irrigation levels and foliar application of antitranspirants on vegetative growth, leaf chemical constitutes, and seed yield of squash plants. *J. Plant Prod. Mansoura Univ.* 2019; 10(7):505–510. https://doi.org/10.21608/jpp.2019.53544.
36. Claudio DV, Clizia V, Maria TL. Application of antitranspirant to control sugar accumulation in grape berries and alcohol degree in wines obtained from thinned and unthinned vines of cv. Falanghina (Vitis vinifera L.). *Agronomy.* 2020; 10(3):345. https://doi.org/10.3390/agronomy10030345.
37. Ahammed GJ, Li X, Zhou J et al. Role of hormones in plant adaptation to heat stress. In: Plant Hormones under Challenging Environmental Factors. Springer Netherlands; 2016. 1–21. ISBN 9789401777582.
38. Yang P, Nawaz MA, Li F et al. Brassinosteroids regulate antioxidant system and protect chloroplast ultrastructure of autotoxicity-stressed cucumber (Cucumis sativus L.) seedlings. *Agronomy.* 2019; 9:1–15. https://doi.org/10.3390/agronomy9050265.
39. Fu FQ, Mao WH, Shi K et al. A role of brassinosteroids in early fruit development in cucumber. *J. Exp. Bot.* 2008; 59:2299–2308. https://doi.org/10.1093/jxb/ern093.
40. Saini S, Ishasharma, Kumar P. Versatile roles of brassinosteroid in plants in the context of its homoeostasis, signaling, and crosstalks. *Plant Biotechnol.* 2015; 6:950. https://doi.org/10.3389/fpls.2015.00950.
41. Sharma P, Jha AB, Dubey RS et al. Reactive oxygen species, oxidative damage, and antioxidative defense mechanism in plants under stressful conditions. *J. Bot.* 2012; 2012:1–26. https://doi.org/10.1155/2012/217037.
42. Al-Mharib MA, Mohammed RM. Effect of spraying with folic acid and yeast extract on growth, yield, and calcium oxalate concentration of spinach (Spinacia oleracea L.). *Appl. Ecol. Environ. Res.* 2022; 20(3):2763–2768.
43. Wahid A. Physiological implications of metabolite biosynthesis for net assimilation and heat-stress tolerance of sugarcane (Saccharum officinarum) sprouts. *J. Plant Res.* 2007; 120:219–228. https://doi.org/10.1007/s10265-006-0040-5.
44. Mazorra LM, Nunez M, Hechavarria M et al. Influence of brassinosteroids on antioxidant enzyme activity in tomato under different temperatures. *Biol. Plant.* 2002; 45:593–596.
45. Papadopoulou E, Grumet R. Brassinosteroid-induced femaleness in cucumber and its relationship to ethylene production. *HortScience.* 2005; 40(6):1763–1767. https://doi.org/10.21273/HORTSCI.40.6.1763.

46. Al-Amery NJ, Mohammed MM. Influence of adding ascorbic acid and yeast on growth, yield, and Rhizobium of snap bean (Phaseolus vulgaris L.) under saline water irrigation. *J. Agric. Vet. Sci.* 2017; 10:23–28.
47. Zhang W, Xia K, Feng Z et al. Tomato plant growth promotion and drought tolerance conferred by three arbuscular mycorrhizal fungi is mediated by lipid metabolism. *Plant Physiol. Biochem.* 2024; 208:108478.
48. Yasin NA, Akram W, Khan WU et al. Halotolerant plant-growth-promoting rhizobacteria modulate gene expression and osmolyte production to improve salinity tolerance and growth in Capsicum annuum L. *Environ. Sci. Pollut. Res.* 2018; 25:23236–23250. https://doi.org/10.1007/s11356-018-2381-8.
49. Fortt J, González M, Morales P et al. Bacterial modulation of the plant ethylene signaling pathway improves tolerance to salt stress in lettuce (Lactuca sativa L.). *Front. Sustain. Food Syst.* 2022; 6:768250. https://doi.org/10.3389/fsufs.2022.768250.
50. Dixon GR. Climate change – impact on crop growth, food production, and plant pathogens. *Can. J. Plant Pathol.* 2012; 34(3):362–379.
51. Pautasso M, Avelino J, Gurr SJ et al. Impacts of climate change on plant diseases – opinions and trends. *Eur. J. Plant Pathol.* 2012; 133:295–313.