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

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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.

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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 systems¹. 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 East². 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 salinization³. 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 conditions⁴. 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 use⁵ 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 materials⁶, 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 plants⁷. 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 Celsius⁸. 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 temperatures¹¹. 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 countries¹². 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 region¹³. 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 erosion¹⁶.

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 world¹⁷. 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 yield¹⁸. 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 minimum¹⁹. 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 temperatures²⁰.

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 area²¹. 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 salinity²².

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 salinization²³. 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 stress³². 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 production³³. 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 limits³⁴, 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 surroundings³⁵. 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 crop³⁶. 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 stress³⁷. 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 appropriately⁴¹. External foliar spraying of BRs increases the ability of plants to tolerate heat as well as hormones could decrease the stress and improve the yield quality where foliar spraying with vitamins (B9) decreased the calcium oxalate content in spinach plants⁴², 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°C⁴⁵.

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 content and greater biomass than non-inoculated controls. These findings suggested that Arbuscular 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 where⁴⁹ 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, they concluded that existence of different strategies, according to which the plant could repress its ethylene signaling pathway in response to bacteria. Many studies referred to the climate 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.

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