Management of Greenhouse Cucumber Production under Arid Environments: A Review

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GREENHOUSE cucumber production is considered an important tool beside open field production. The production of greenhouse cucumber in developing countries particularly in arid environments might achieve as low cost structures and almost without air conditions. These conditions have increased the constraints of cucumber production to be include more stresses beside salinity, drought and heat stress. These stresses mainly include biotic stress and abiotic stresses, which cause a high loss in the cucumber productivity. Thus, this review is an attempt to highlight the problems of greenhouse cucumber production under abiotic stress (mainly drought and salinity) and different strategies, which should be adapted against these stresses. Several studies have handled the individual stresses, which impact on greenhouse cucumber production but fewer studies have investigated the multiple or combined stresses. Salinity and drought are most common abiotic stresses under changing climate, which mainly cause a trouble in cucumber antioxidant enzyme activity and generate an oxidative stress leading to a loss in cucumber productivity. New strategies should be adapted to ameliorate or mitigate the expected damage resulting from salinity and drought-stressed cucumber.

Keywords: Abiotic stress, Climate changes, Drought, Salinity, Heat stress.

Introduction

The production of vegetables particularly cucumber in greenhouses has become an important agricultural pattern all over the world because of the growing consumption rate of vegetables and the limiting cultivated lands (Liu et al., 2020c). The long-term intensive production of greenhouse cucumber may create ecological problems due to the imbalance in soil microbial communities, increasing soil borne diseases and soil salinization, which might decline this cucumber productivity under greenhouses (Xiao et al., 2019). Therefore, the protected production of cucumber should be managed for more environmental health with a balance between the productivity and the profitability (Ali et al., 2019 a, b; Abdalla et al., 2020). This management should not only depend on the traditional agro-ecological practices but also might consider the plant biodiversity, soil quality and crop productivity or sustainable practices of the agriculture (El-Ramady et al., 2019 & 2020 and Zhao et al., 2020). The problems of cucumber production under greenhouses in developing countries during summer season (May to August) in arid zones is representing a crucial challenge how to avoid heat stress in particular the un air-conditional greenhouses.

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Received: 20/05/2020; Accepted: 27/06/2020  
DOI: 10.21608/jenvbs.2020.30729.1097  
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Cucumber (Cucumis sativus L.) is a widely cultivated vegetable crop grown in open fields and greenhouses, which belongs to the family Cucurbitaceae. The global ranking of cucumber production is following after potato, tomato and onion. The production of greenhouse cucumber is perceived as an economically important cash crop and the cultivated area is increasing worldwide (Ali et al., 2019b). High cucumber productivity has been achieved in the past decades due to the intensive input of irrigation water and mineral fertilizer particularly nitrogen causing serious environmental problems (Sun et al., 2019). These problems could be managed through the following approaches reducing reactive N-gases emissions, mitigating N-losses mainly leaching of nitrate to secure water quality, and enhancing the efficiency of resources to reduce the costs and to create higher values (Sun et al., 2019 and Cui et al., 2020).

Therefore, this review is an attempt to highlight the management of greenhouse cucumber under changing environments, which have serious impacts on cucumber productivity in the era of climate changes. The greenhouse cucumber production under abiotic stress will be mainly discussed.

**Obstacles of Greenhouse Cucumber Production**

The production of greenhouse vegetables like cucumber has developed rapidly in recent years. This production has become an effective tool in producing cucumber due to very high controllability as “high technology structures” in the developed countries (Dong et al., 2020a). It could be partially modified the climatic parameters mainly temperature and humidity to develop the growing system in greenhouse under adverse conditions (Phogat et al., 2020). In the developing countries, fewer facilities are available as “low cost structures” creating many stressful conditions in greenhouse cucumber production (Fig. 1 and 2). High-tech greenhouses, which use soilless growing media, are more expensive (5 to 10 times) than low cost soil-based greenhouses (Phogat et al., 2020). The main problems facing the greenhouse cucumber production may include soil salinization and degradation, nitrate groundwater pollution and heat stress (Cui et al., 2020). These problems have become major obstacles in greenhouse cucumber production particularly under changing climate. Climate change may include the elevated CO₂, high temperatures, increased frequency of extreme temperatures and changed rainfall patterns (Dong et al. 2020a). Atmospheric greenhouse gases (GHG) including N₂O, CO₂, and CH₄ have increased by 20, 41 and 160%, respectively, compared with those before industrial revolution (Shen et al., 2020). The agricultural production may share in these GHG with 9-14% of global net CO₂ emissions (Zarei et al., 2019). It was found that elevated CO₂ (550 μmol mol⁻¹) increased the cucumber fruit yield by 33% (Dong et al., 2020a), whereas the elevated CO₂ (1200 μmol mol⁻¹) decreased N-uptake efficiency of cucumber roots and decreased the NH₄⁺ oxidation and denitrification (Dong et al., 2020b).

The production of cucumber under greenhouse in low cost structure has many problems including energy efficient (Iddio et al., 2020), greenhouse soil degradation due to the intensive applications of fungicides (Zhang et al., 2020), soil salinization (Phogat et al., 2020), soil nutrient imbalance (Fan et al., 2020), and deterioration of soil microbial communities (Liu et al., 2020c and Zhao et al., 2020). The long-term production of greenhouse cucumber may cause a lot of problems in the structure of soil microbial community (Liu et al., 2020c). All natural resources should be sustainably managed including the energy (Taki & Yildizhan 2018 and Asgharipour et al., 2020), water conservation (Liang et al. 2018; Sun et al. 2019) and soil and protecting from pollution and degradation (Zhao et al., 2020).

Plant pathogens (i.e., bacteria, fungi, viruses and nematodes) of greenhouse cucumber are considered one of the main limiting factors during greenhouse cucumber production (Punja et al., 2019). There are several common phyto-pathogens and diseases, which can cause damage and decline in the yield of greenhouse cucumber such as fusarium wilt, powdery mildew, downy mildew and Alternaria blight (Punja et al., 2019). The most common fungal pathogens may include fusarium wilt (Fusarium oxysporum), Pythium crown and root rot (Pythium aphanidermatum), gummy stem blight (Didymella bryoniae), Botrytis grey mould (Botrytis cinerea), and powdery mildew (Podosphaera xanthii) (Punja et al. 2019). A part from pesticides, there are many other chemical and biological agents or nutrients could be applied for greenhouse cucumber control such as foliar manganese on Colletotrichum lagenarium (Eskandari et al., 2020) or on powdery mildew (Eskandari and Sharifhabib, 2019), applied Bacillus subtilis against some fungal pathogens (Punja et al., 2019), applied NiOnano-particles against cucumber mosaic virus (Derbah and Elsharkawy, 2019) and applied some nano-molecules against powdery mildew (Hafez et al., 2020).
Fig. 1. Cucumber production under greenhouse conditions faces many abiotic stresses such as general yellowing (photo 1), heat stress (photo 2), Ca-deficiency (photo 3), multi-stresses (photo 4), curly cucumber fruits due to N-deficiency (photo 5), and abortion fruits (photo 6) (all photos by authors).

The biocontrol agents (BCAs) or biological control (e.g., Trichoderma) is an important strategy could be applied in control phyto-pathogens of greenhouse cucumber (Zhang and Zhuang, 2020). More than 260 species of Trichoderma have been identified, which include about 35 established species as economic biocontrol agents due to their producing antibiotics and enzymes (Sharma et al., 2019). Due to the importance of Trichoderma, several studies have handled these useful strains, which control phyto-pathogenic fungi through their high survival under stressful conditions, high efficiency in nutrients utilization, degradation the cell walls of pathogen by secreted enzymes, and producing active antimicrobial compounds (Zhang and Zhuang, 2020). The most important strains of Trichoderma, which already published in many studies included applied T. atroviride to reduce downy mildew (Szczech et al., 2017), T. asperellum to prevent cucumber fusarium wilt (Li et al., 2019b), T. pseudokoningii to control cucumber fusarium wilt (Cong et al., 2019), T. brevicrassum to diminish cucumber disease of Rhizoctonia solani (Zhang and Zhuang, 2020). These Trichoderma strains also enhanced tolerance of cultivated cucumber to abiotic stress (Kashyap et al., 2017) such as T. harzianum, which mitigates the salinity stress (Zhang et al., 2019).
Greenhouse Cucumber Production under Abiotic Stress

The production of greenhouse cucumber has a lot of constraints limiting the growth and development of cultivated plants. These constrains include biotic and abiotic stresses, which have been handled in several investigations (Tables 1 and 2). These studies mainly focused on different stresses as an individual case and a fewer cases as multiple stresses (e.g., Liu et al. 2018). The behavior of cultivated cucumber towards these stresses and their mechanisms also has been reported and how these plants adapt their selves to be more tolerant to stress or through application of many anti-stress materials and nutrients. Under abiotic stress, cucumber plants suffer from the accumulation of large amounts of mis-folded or unfolded proteins in plant cells (Hou et al. 2020). The mode of actions including amelioration, mitigation, and compensation of greenhouse cucumber towards the negative effects of stress on plant growth also has listed in Tables 1 and 2.

<table>
<thead>
<tr>
<th>Growth details</th>
<th>Stress details</th>
<th>Response</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 3-leaf-stage treated 100 μM NaHS</td>
<td>Nitrate stress (140 mM)</td>
<td>H$_2$S has a protective role under nitrate stress by regulating antioxidant enzyme activities</td>
<td>Qi et al. (2019)</td>
</tr>
<tr>
<td>Soil amended (100 mg kg$^{-1}$) NMs (SiO$_2$, TiO$_2$, ZnS &amp; MoS$_2$)</td>
<td>Heavy metals stress: As, Pb and Cd (65.2, 182 and (3.52 mg kg$^{-1}$, resp.)</td>
<td>Studied nanomaterials (NMs) showed great potential in reducing uptake of As, Cd, Cr, Cu, Ni, Al and Pb in roots particularly MoS$_2$ NMs in Soil Cultivated Cucumber Plants</td>
<td>Song et al. (2019)</td>
</tr>
<tr>
<td>CO$_2$ enrichment (400 and 800 μmol mol$^{-1}$)</td>
<td>Drought stress via polyethylene glycol: 5 and 10%</td>
<td>CO$_2$ enrichment enhanced efficiency of photosynthetic electron transport; alleviated under drought stress toxic substances accumulation</td>
<td>Cui et al. (2019)</td>
</tr>
<tr>
<td>Nano-silica (400 mg kg$^{-1}$)</td>
<td>Water deficit (70% of ET$_c$); saline irrigation water (1.7 dS m$^{-1}$)</td>
<td>Nano-silica maintain ion homeostasis, regulate osmotic balance and control opening of stomata</td>
<td>Alsaeedi et al. (2019)</td>
</tr>
<tr>
<td>Soils treated with 5 &amp; 10% industrial solid wastes</td>
<td>Saline irrigation water (4 and 8 dS m$^{-1}$)</td>
<td>Salinity decreased Zn-content and its uptake; increased the uptake of Cd, Cr, Cu, Ni, Pb by all parts of the plants</td>
<td>Taghipour and Jalali (2019).</td>
</tr>
<tr>
<td>4 commercial rootstocks were investigated</td>
<td>Salinity stress (up to 7.5 dS m$^{-1}$)</td>
<td>Grafted rootstock tolerant to salinity can decrease Ca$^{++}$ and K$^+$/Na$^+$ ratio in leaves, with high Na$^+$ and Cl$^-$ content</td>
<td>Usanmaz and Abak (2019)</td>
</tr>
<tr>
<td>Applied N-rate up to about 500 kg N ha$^{-1}$</td>
<td>Water table stress (ranged 10-77 cm)</td>
<td>Under high water table, 75% of the recommended N rate could optimize cucumber yield via drip fertigation</td>
<td>Wang et al. (2019)</td>
</tr>
<tr>
<td>CO$_2$ enrichment (400 and 800 μmol mol$^{-1}$)</td>
<td>Salt stress (80 mmol L$^{-1}$ NaCl)</td>
<td>Enriched CO$_2$ promoted K$^+$ accumulation in plants; reduced the Na$^+$ /K$^+$ ratio; maintained ion balance in plants under stress</td>
<td>Li et al. (2019a)</td>
</tr>
<tr>
<td>Foliar applied putrescine (8 mM)</td>
<td>Salt stress (75 mM NaCl)</td>
<td>Putrescine alleviated starch over-accumulation in leaves; protecting photosynthetic organs; enhancing seedling tolerance to salt stress</td>
<td>Shen et al. (2019)</td>
</tr>
<tr>
<td>Foliar applied putrescine (8 mM)</td>
<td>Salt stress (75 mM NaCl)</td>
<td>Putrescine may improve photochemical efficiency in salt stress by increasing polyamines to alter the adaptation of LHCII</td>
<td>Shu et al. (2019)</td>
</tr>
<tr>
<td>Putrescine (0.8 mM)</td>
<td>Salt stress (75 mM NaCl)</td>
<td>Putrescine regulates ion balance in NaCl-stressed cucumber</td>
<td>Yuan et al. (2019)</td>
</tr>
<tr>
<td>Putrescine (8 mM)</td>
<td>Salt stress (90 mM NaCl)</td>
<td>Exogenous putrescine alleviated photoinhibition caused by salt stress</td>
<td>Wu et al. (2019a)</td>
</tr>
<tr>
<td>Silicon 0.3 mM added as sodium silicate</td>
<td>Salt stress (75 mM NaCl)</td>
<td>Si can enhance salt-tolerance of cucumber by increasing accumulation of polyamine; decreasing oxidative damage</td>
<td>Yin et al. (2019)</td>
</tr>
<tr>
<td>Seedlings treated with Si (0.3 mM)</td>
<td>Salt stress (75 mM NaCl)</td>
<td>Silicon may increase tolerance the crop production in saline soils</td>
<td>Zhu et al. (2019)</td>
</tr>
</tbody>
</table>
### TABLE 2. Response of cucumber plants to various abiotic stresses in some published articles during 2020

<table>
<thead>
<tr>
<th>Growth details</th>
<th>Stress details</th>
<th>Response</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Foliar Si (1.5 mM), harvested at 2nd leaf</td>
<td>Nitrate stress 200 mM NO$_3^-$</td>
<td>Si could improve nitrate stress by enhancing chlorophyll synthesis and N-assimilation</td>
<td>Gou et al. (2020a)</td>
</tr>
<tr>
<td>Dopamine (up to 200 μmol L$^{-1}$)</td>
<td>Nitrate stress (500 μmol L$^{-1}$)</td>
<td>Dopamine mediated plant growth, C and N-metabolism under nitrate stress</td>
<td>Lan et al. (2020)</td>
</tr>
<tr>
<td>Gamma-amino-butyric acid (GABA) up to 40 mM for 7 d</td>
<td>Nutrient stress (Fe deficiency)</td>
<td>GABA improved tolerance to Fe-deficiency by reducing chlorosis; inhibition of growth and photosynthesis</td>
<td>Gou et al. (2020b)</td>
</tr>
<tr>
<td>CO$_2$ enrichment (400 and 800 μmol mol$^{-1}$)</td>
<td>Drought stress via polyethylene glycol: 5 and 10%</td>
<td>CO$_2$ enrichment decreased abscisic acid content; increased gibberellin and root biomass</td>
<td>Li et al. (2020a)</td>
</tr>
<tr>
<td>CO$_2$ enrichment (800 μmol mol$^{-1}$)</td>
<td>Salt stress (80 mmol·L$^{-1}$ NaCl)</td>
<td>Enriched-CO$_2$ alleviated salt stress by regulating the invertase activity in leaves</td>
<td>Li et al. (2020b)</td>
</tr>
<tr>
<td>Samples were collected from 1 to 12 h after treating</td>
<td>Salt stress (75 mM NaCl)</td>
<td>CsPNG1 genes may respond to improving plant tolerance to abiotic stresses and hormone treatments</td>
<td>Hou et al. (2020)</td>
</tr>
<tr>
<td>Foliar applied spermidine (1 mM)</td>
<td>Salt stress (100 mM NaCl)</td>
<td>Exogenous spermidine increased cucumber tolerant to salt stress by inducing accumulation of gibberellin</td>
<td>Wang et al. (2020)</td>
</tr>
<tr>
<td>Applied Ca$^{2+}$ (50 μmolL$^{-1}$) and NO (200 μmolL$^{-1}$)</td>
<td>Low temperature stress: 11 /7 °C</td>
<td>Ca$^{2+}$ shared in the NO-induced low temperature tolerant by modulating processes of PSII, carbohydrate metabolism and leaf gas exchange</td>
<td>Zhang et al. (2020b)</td>
</tr>
<tr>
<td>2-hydroxy-melatonin (up to 150 μM)</td>
<td>Cadmium stress (50 mg kg$^{-1}$ Cd)</td>
<td>Improved antioxidant activity, reduction of H$_2$O$_2$, electrolyte leakage and malondialdehyde under Cd-stress</td>
<td>Shah et al. (2020)</td>
</tr>
<tr>
<td>Foliar up to 2.5 mM NaHS and 100 μM IAA</td>
<td>Chilling stress (5 °C)</td>
<td>H$_2$S &amp; IAA alleviate harm chilling stress by preventing excessive ROS accumulation and activating enzymatic antioxidants</td>
<td>Zhang et al. (2020a)</td>
</tr>
<tr>
<td>Foliar 2.5 mM NaHS and up to 15 mM H$_2$O$_2$</td>
<td>Chilling stress (5 °C)</td>
<td>H$_2$S alleviates chilling stress by improving C-metabolism and its assimilation, photo-protection for PSII and PSI</td>
<td>Liu et al. (2020b)</td>
</tr>
<tr>
<td>Foliar 1.0 mM NaHS at 2nd leaf stage for 6 h</td>
<td>Chilling stress (5 °C)</td>
<td>Glutathione has downstream signal of H$_2$S-induced plant tolerance to chilling stress</td>
<td>Liu et al. (2020a)</td>
</tr>
</tbody>
</table>

Due to the huge differences among abiotic stresses and their mode of actions on greenhouse cucumber production, some studies have shown the beneficial effects of many anti-stresses, but others showed a deficit in particular the combined or multiple stresses. This indicates a need to understand the various perceptions of combined and multiple stresses that exist among these stresses particularly in arid zones. Drought, salinity and alkalinity stresses are common in arid climate environments (Alsaeedi et al., 2019; Bai et al., 2019; Trabelsi et al., 2019 and Jamshidi Goharrizi et al., 2020). In arid environments, continues upward water from soil surfaces and plants due to evapotranspiration may lead to concentrate and increase salt levels near soil surfaces (Amer et al., 2019). Thus, drought stress routinely may overlap with soil salinity, and these both affect plant growth and productivity together (Bai et al., 2019). The simultaneous

stress resulting from aluminum toxicity, drought and salinity on the growth of lettuce seedlings also has investigated under acidic Andisols in Chile (Silambarasan et al., 2019). Distinguished shift in molecular responses could be exhibited by combined stresses on plants compared with the same stresses independently as investigated on the combined stress of drought and bacterial pathogen (Gupta et al., 2020). More studies have been reported about the combined and individual stresses such as combined drought-flooding conditions in saline-alkaline lands (Wen et al., 2017), drought and heat stress on tomato plants (Duc et al., 2018), salinity and drought on cabbage (Sahin et al., 2018), drought and heat stress on banana (Chaudhri et al., 2019), drought on sugar beet grown in Cd-contaminated saline soil (Abd El-Mageed et al., 2019), and salinity and drought on spinach (Ibekwe et al., 2020). Therefore, there are several substances, compounds and nutrients could be applied to ameliorate different abiotic stresses on cucumber, which depends on the type of stress such as exogenous application of salicylic acid, melatonin, chitosan, putrescine, spermidine, selenium, silicon, nanoparticles, H₂S, H₂O₂, etc.

Management of Abiotic Stress in Greenhouse Cucumber

Under environmental stresses, cultivated plants have the ability to generatemany reactive compounds such as reactive oxygen species, reactive nitrogen species, and reactive carbonyl compounds (Czarnocka and Karpiński, 2018; Kapoor et al., 2019 and Nareshkumar et al., 2020). These species might play a harmful role in different plant processesunder stress leading to oxidative stress, which impacts the plant growth severely under these abiotic factors (Nareshkumar et al., 2020). Each abiotic stress has distinguished features on greenhouse cucumber and special mitigation or management. For more explanation, each individual abiotic stress will be handled in this review including the general features of the stress on cucumber and different approaches, which could be applied against this stress. Concerning the most important abiotic stresses, drought and salinity are very common worldwide and they are together considered a serious threat casing a very high loss in cucumber crop production. Globally, desertification and salinization are resulted from drought and salinity, which are in rapid increasing phenomena (Ouzounidou et al., 2016). The salinity of water and/or soil could be considered a main contribution in abiotic stress, which may constrain the greenhouse production particularly in arid and semi-arid and regions (Minhas et al., 2020). The salinity stress may depress cucumber growth and its development due to inducing water deficit. This water deficit will cause specific toxicity (mainly Na⁺, Cl⁻ and NO₃⁻) and a secondary oxidative stress (Sang et al. 2016). Under salinity stress, the water deficit in leaves will enforce plants to close the stomata, reduce the photosynthetic rates and then accelerate the oxidative stress (Hasanuzzaman et al., 2019; Mohsin et al., 2019). This oxidative stress will generate a lot of reactive oxygen species (Khodayari et al., 2018) and cause a trouble in plant antioxidant system (Kapoor et al., 2019).

It could be mitigated the oxidative stress, which results from stress and develop plant tolerance against these stresses through exogenous application of biostimulants such as plant growth hormones like gibberellin (Wang et al., 2020), trace elements like selenium (Jóźwiak and Politycka, 2019), signaling molecules (Khan et al., 2019) and organic chemicalsalso as some fungicides such as astriazole and strebullirin (Mohsin et al., 2019). Many studies have handled the mitigation and amelioration of the oxidative damage in cucumber under salinity stress through the exogenous application of several nutrients or anti-stresses such as silicon by increasing the accumulation of polyamines and decreasing oxidative damage (Yin et al., 2019; Zhu et al., 2019 and Gou et al., 2020a), nitric oxide by enhancing antioxidant enzymes (Fan et al., 2013), silica nanoparticles by balancing nutrients uptake (Alsaeedi et al., 2019), kinetin by stimulating the salt tolerance (Gurmani et al., 2018), salicylic acid by controlling endogenous salicylic acid levels or peroxidase (Kim et al., 2017 and Yousef et al., 2018), aminolevulinic acid by enhancing ascorbate-glutathione cycle (Wu et al., 2019b), some industrial solid wastes like sugar factory wastes by decreasing the health risk of heavy metals (Taghipour and Jalali, 2019), melatonin or its derived by improving the photosynthetic capacity (Wang et al., 2016; Santosh and Prianka, 2020; Shah et al., 2020 and Zhang et al., 2020c). It could be also exogenous applied polyamines including putrescine (Shen et al., 2019; Shuet et al., 2019 and Yuan et al., 2019), spermine (Yin et al., 2019) and spermidine (Wu et al., 2018 and Wang et al., 2020) as anti-stresses. The elevated CO₂ (up to 800 μmol mol⁻¹) also can promote K⁺ accumulation in cucumber plants under salt stress with reducing the Na⁺/K⁺ ratio, maintaining the
ion balance and ensuring the enzymatic activities (Li et al., 2019a, 2020b). The applied grafting on cucumber under irrigation with saline water has alleviated crop salt stress (Wang et al. 2017 and Usanmaz and Abak, 2019).

Under changing climate, drought stress has become more frequent and severe, threatening the future of crop productivity and the security of global foods (Mphande et al., 2020). The general features of drought stress on stressed cucumber plants mainly include serious problem in plant water content and its high loss rate, which impair many metabolic and physiological processes as well as the activity of antioxidants and high osmotic stress (Fan et al., 2014 and Mphande et al., 2020). For the avoidance of cucumber drought and water deficit stress, the plants should be adaptive effective strategies in this context. These effective strategies may include the applied biostimulants such as silicon to mitigate lipid peroxidation (Ouzounidou et al., 2016), nano silica by creating abalance in the uptake of nutrients (Alsaedi et al., 2019), elevated CO₂ through the regulation of phytohormone contents in cucumber roots (Li et al., 2018; Cui et al., 2019 and Li et al., 2020a), applied hydrogen peroxide by increasing the plant antioxidative defense system (Li et al., 2016; Sun et al., 2016 and Li et al., 2018), applied zeolite and hydrogel by enhanced water retention capacity (Gholamhoseini et al., 2018).

**Conclusion**

Cucumber is considered one of the most important vegetable crops worldwide ranking its global production a distinguished position among the highest five vegetable crops. This production could be performed under greenhouse or open field systems. The greenhouse cucumber production totally differs in developed and developing countries due to the available facilities. The greenhouses of low cost structures are very common in developing countries, which the cucumber production suffers from several problems or stresses. The abiotic stresses including salinity, drought, heavy metals and heat stress are common in arid environments representing a main reason in crop yield loss. There are many strategies or approaches are required to overcome these stresses such as chemical compounds (e.g., salicylic acid, melatonin, chitosan, putrescine, spermidine, H₂S, and H₂O₂), foliage application of some nutrients (e.g., selenium, silicon) and some nanomaterials or nanoparticles as well as grafting. These previous materials or nutrients have the ability to support cultivated cucumber against the abiotic stress and overcome the oxidative stress. Due to the unique of arid environments, the multiple stresses are common in these regions particularly salinity, drought and heat stresses. The general features of salinity stress are represented in causing mainly ionic toxicity, which deteriorate the physiological, morphological and biochemical processes incucmber plants. Salinity and drought stress also can reduce the photosynthesirase and increase ROS, whicthere very toxic causing cell damage including lipid peroxidation, protein denaturing and then death of plant cells. The individual stress on cucumber plants was handled in details in many studies, but the combined stresses are still in urgent need for further investigations based on the physiological, biochemical, anatomical and molecular levels.

**Acknowledgement**

The Authors thank the staff members of Physiology and Breeding of Horticultural Crops Laboratory, Dept. of Horticulture, Fac. of Agric., Kafrelsheikh University, Kafr El-Sheikh, Egypt for supporting this work.

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Woodhead Publishing,


Cucumber Plants. *Gesunde Pflanzen*, 70 (2), 75–90. doi:10.1007/s10343-017-0413-9


