ISSN: 0974-5823 Vol. 7 No. 2 February, 2022

International Journal of Mechanical Engineering

Roles of organic and bio fertilizers in improving tolerance of different plants to environmental ecosystem

Soha E. Khalil*, M.S. Gaballah, Pibars, S. K. and Mansour, H. A.

Water Relations and Field Irrigation Dept., Agriculture and Biological Institute, National Research Centre, 12322, Cairo, Egypt.

Introduction

Abiotic stress such as drought, salt, cold, and heavy metals largely influences plant crop productivity and development. Abiotic stress is a major threat to food security due to the deterioration of environment caused by human activity and constant changes of climate. To cope with abiotic stress, plants can initiate a number of physiological, molecular, and cellular changes to adapt and respond to such stresses. Better understanding of the plant responsiveness to abiotic stress will aid in both modern and traditional breeding applications towards improving stress tolerance.

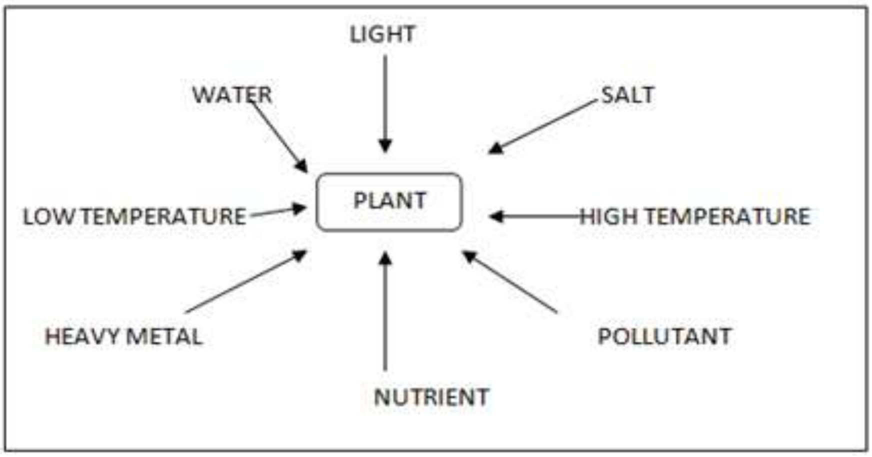

Figure 1: Some types of abiotic stress factors that affect plants life.

Drought and Salinity are two of the most serious abiotic stresses that threat different crops productivity around the world (Guo *et al.* 2014). One third of the world's population lives in areas where water is scarce (FAO 2003). Due to development of economic sectors, population growth and the competition for water resources (Laraus 2004). Drought is expected to increase in severity because of climate change, caused by increasing evaporation due to global warming. Previous assessments of historic changes in drought over the late twentieth and early twenty-first centuries illustrated that phenomena may already be happening globally (Sheffield *et al.,* 2012). Drought affects more than 10 % of arable land; leading to desertification, while salinization is rapidly increasing dramatically declining average yields of different crops. Moreover, increasing salt accumulation in the soil decreased the water potential of soil that badly affects plant tissue relative water content and plant water conductance (Munns 2002 and Soha E Khalil). Excess salts accumulation in soils causes' reduction in water potential of soil solution that causes difficulty for plants to absorb the water from soil leading to **"osmotic stress."** High salts decrease plant growth because these bulk salts stimulates the utilization of energy that the plant should use to take water from the soil solution and to improve the biochemical adjustments. This leads to reduced yield and growth of plants. Salt stress decrease the relative leaf water content, water potential, leaf water relation parameters, osmotic potential, turgor potential, and ultimately inhibited plant growth and decreased the crops fresh weight (Jabeen and Ahmad 2012).Water stress occur due to water deficit, caused by high soil salinity or drought. In case of high salinity, water exists in the soil but plants cannot uptake it, which is called **physiological drought** (Chaves *et al.*, 2003 and Soha E Khalil 2016). When water is gradually lost from a completely **saturated soil**, firstly by draining freely under the effect of gravity, and the rate of loss progressively slows down till no more water drains away, the soil is called to be at **field capacity**. Further decrease in water by uptake by plant roots or by evaporation reduces the water content of the soil, till no more loss, a stage called the **wilting point** at which roots cannot absorb water important to meet their needs, and the plants wilt and die (Nagarajan and Nagarajan, 2010, and Soha E. Khalil, 2016).

Understanding tolerance mechanism to salinity and drought is necessary to provide insights into the tolerance mechanism against these abiotic stresses at molecular, physiological, and biochemical levels. Improving tolerance of different crop plats could be happened by different ways such using bio and organic-stimulants that has been an important but largely unfulfilled aim of modern agricultural development (Rabia, Soha E. Khalil and Nadia, 2013).

Fertilizers are used to improve tolerance of most crops and soil fertility but excess use of inorganic fertilizer in agriculture causes unrecoverable environmental pollution and so many health problems. Inorganic fertilizers are known for their negative environmental effects and their high cost (Morris *et al.,*2007). The use of chemical fertilizers poses the risk of contaminating ground water, atmosphere, and air pollution. According to Chun-Li *et al.* (2014), though the practice of using pesticides and chemical fertilizers accelerates soil acidification. It also weakens the roots of plants making them susceptible to unwanted diseases. All these cause reduce in crop yields because of nutrients imbalance and soil degradation (Ojeniyi, 2000). In this regard, attempts have recently been made towards the production of high quality nutrient rich fertilizer (Bio and organic fertilizer) to ensure bio-safety (Rabia, Soha E. Khalil and Nadia, 2013). The choices of suitable fertilizer are controlled by different factors such natural conditions, locality, climate, and soil type and their suitability for crops cultivation. The leafy vegetables, cereal crops, and fruits are efficient source of basic nutrients such as phosphorus, nitrogen, potassium, and micronutrients such as magnesium, boron, calcium, and manganese. To eliminate the bad effects of chemical fertilizers on the environment, and human health, recently a new agricultural practice developed known as sustainable agriculture, ecological agriculture or organic agriculture, (Chowdhury, 2004). Organic fertilizers are primarily cost effective (Solomon, *et al.,* 2012). Organic fertilizers are the basis of soil fertility. Furthermore, bio fertilizers are non-bulky, environment friendly, cost effective that plays important role in plant nutrition (Mahajan *et al.,* 2008). Organic fertilizers are come from living or biological materials. To release the nutrient in the soil from organic fertilizers long time is needed. Organic fertilizers are different forms like: Manure which come from livestock like goats, chickens, and cows. Green manure derived from plants remains, especially different type of legumes. Compost, which obtained from agricultural waste organic material like decomposed waste, corn stalks or straw.

In addition, Bio-fertilizer considered as an alternative to chemical fertilizer to imrove crop production and soil fertility in sustainable agriculture. These biological fertilizers could act as the key role that increasing productivity and sustainability of soil protect the environment as eco-friendly for the farmers and cost effective inputs. Organic farming is one of most effective strategies that not only ensure biodiversity of soil but also food safety (Khosro and Yousef, 2012).

Bio fertilizer consists of all kinds of useful fungi and bacteria including the arbuscular mycorrhiza fungi (AMF) and plant growth promoting rhizobacteria (PGPR) which is nitrogen fixers. There are so many microorganisms living in the soil, especially in the rhizosphere of plant. A small number of these microorganisms possess a functional relationship and constitute a holistic system with plants. They have beneficial effects on plant growth. Adding beneficial microorganisms in agricultural began 60 years ago and it is now evident that these beneficial microbes can also stimulate plant tolerance to environmental stresses like water, salinity, heavy metal contamination nutrient deficiency. Biofertilizers supply the soil with all kinds of macro and micronutrients via phosphate and potassium solublization or mineralization, nitrogen fixation, secretion of antibiotics and biodegradation in the soil and release of plant growth regulating substances. Biofertilizers, when applied as soil or seed inoculants, leads to crop productivity. Bio fertilizers are compounds of living cells of different micro-organisms which able to convert nutritionally important nutrients from unavailable to available form via different biological mechanisms (Sinha *et al.,* 2014). This review aimed to express the role of organic and bio fertilizers under stress conditions. Furthermore, it reveals the potentials of organic and bio fertilizers in increasing tolerance through increasing plant growth and productivity, improve nutrient profiles, and through increasing plant tolerance to different environmental stress conditions.

Drought and Salinity have adverse effect on soil quality and productivity of different crop plants causing different morphological, physiological and biochemical changes in different crop plants (Akram *et al.*, 2002).

DROUGHT

Morphological effects of drought stress on crop plants

Drought stress is an important environmental limiting factor of plant growth and establishment. In fact, seed germination is the first stage of growth that is sensitive to water deficit. Therefore, germination of seeds, vigour and length are important for the establishment of plants. Visible symptoms of plant subject to water deficit in the vegetative stage are a decrease in plant height, leaf wilting, decrease in area and number of leaves, and delay in formation of flowers and buds (Bhatt and Srinivasa, 2005 and Soha E. Khalil and Fatma M seleem, 2019, Biswas, 2010, Mansour et al., 2019a-e, Hu et al., 2019, Abdalla et al, 2019, Jiandong, et al, 2019, Abd-Elmabod et al, 2019a-b, Tayel et al 2019a-c, Hellal et al, 2019, Mansour and Pibars 2019, Attia et al., 2019, Pibars and Mansour, 2019, Hellal et al., 2021, Gaballah, et al, 2020, Pibars et al, 2020, Mansour et al, 2020a-d; Mansour and Aljughaiman 2020). In fact, limitation in leaf growth and characters is among the earliest visible impacts of water stress because leaves are the main photosynthetic organs (Taleisnik *et al.,* 2009). Water deficit mostly reduced leaf growth and water potential and in turn, the leaf areas and leaf senescence could be observed under severe water stress conditions (Luo *et al.,*2016). According to Lonbani and Arzani (Lonbani and Arzani, 2011, Soha E. Khalil and Ashraf M. Khalil, 2015), leaf extension reduced under drought environment in order to get a balance between water absorbed by plant roots and the water status of plant tissues (Passioura, 2005). In addition, Blum (2005) recorded that a small leaf area is beneficial under water stress in order to avoid hydration. Moreover, water stress is sensed by plant roots affects roots growth and root system architecture (root length, number, spread, and length of lateral roots) (Salazar *et al.,* 2015). Roots are essential for plant productivity and functions, such as nutrient and water uptake, forming symbioses with other microorganisms in the rhizosphere. Thus, root system is important to support and stimulate plant growth during the early vegetative crop growth stage and extract water from the soil (Smith and De Smet, 2012). Drought stress reduced plant fresh and dry biomass production (Kiliç and Yağbasanlar, 2010). Yield is reduced mostly when water stress occurs during the flowering or heading phases. Drought stress can reduce 17 to 70% of grain yield (Sourour *et al.*, 2017). During maturity, the water stress resulted in about 10% reduction in yield but moderate stress during the early vegetative growth stage has mainly no clear effect on yield (Bauder, 2001).

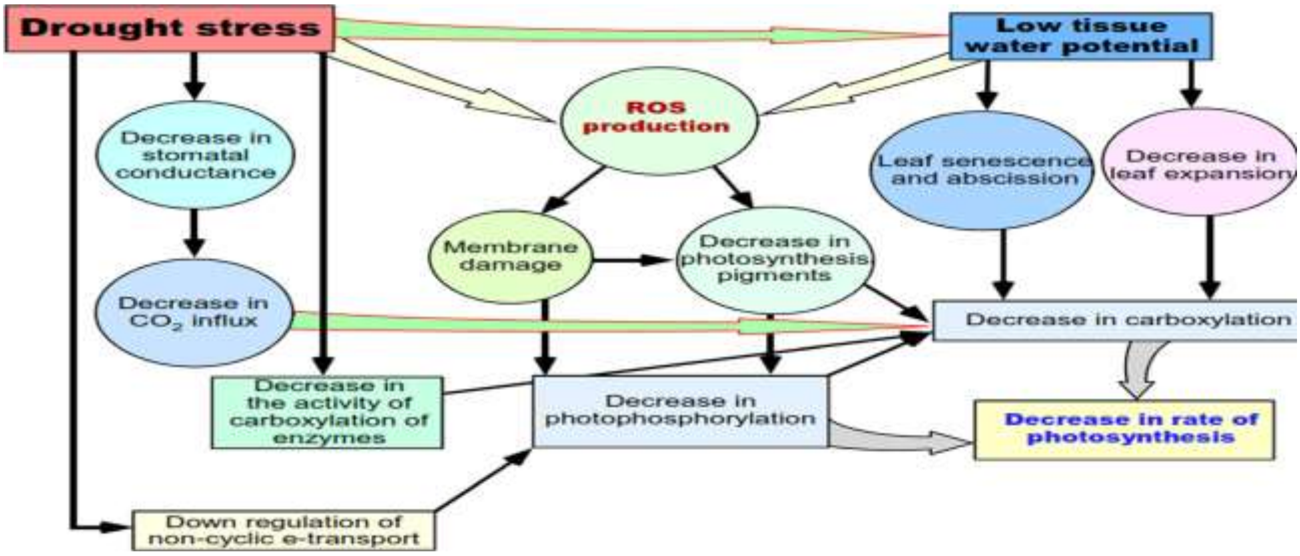

Fig. 2 Influence of drought stress on morphological, physiological and biochemical characters (Farooq *et al.*, 2015)

Physiological effects of drought stress on crop plants

Water stress also affected physiological characters of different crops (Fatma M. Seleem and Soha E. Khalil, 2018). The mainly effect of water stress is limiting photosynthesis through stomatal closure that limits CO2 uptake by leaves and prevent the transpiration water loss as result to the reduction in leaf water potential and/or turgor (Anjum *et al.*, 2003). The reduction in CO2 availability causes the photo-damage (Sourour *et al.*, 2017). Drought stress suppresses particularly photochemical efficiency of photosystem PS II by removal of external proteins, decreasing electron transport, and release of calcium and magnesium ions from their binding. Drought stress caused changes in the ratio of chlorophyll ‘a’ and ‘b’ and carotenoids. In fact, resistant cultivar to water stress had high chlorophyll content (Zlatev and Lidon, 2012). Ashraf and Foolad (2007) illustrated that drought stress reduced the concentration of chlorophyll b more than chlorophyll a. Water stress lead to the reduction of relative water content (Saeidi *et al.*, 2017). In fact, high relative water content is a resistant mechanism to drought and is related to more osmotic regulation or less elasticity of tissue cell wall (Sourour *et al.*, 2017).The osmotic adjustment is the process in which the accumulation of solutes happened by water stress to maintain turgor in tissues. Solutes accumulate contributed to osmotic adjustment in plants, include carbohydrates, organic acids, inorganic cations, free amino acids and intermediate substances contains nitrogen. Sometimes, potassium is the most abundant inorganic solute in leaf, which accumulates during water stress conditions. Osmotic adjustment depends highly on photosynthesis process to supply different cells and tissues with compatible solute. When photosynthesis is inhibited, dehydration of plant cells becomes more severe, causing in smaller solute supply for osmotic adjustment. With continued water stress, osmotic adjustment delays, but do not completely stop. Turgor maintenance and osmoregulation maintain continued root growth and efficient uptake of water from the soil. However, the accumulation of organic solutes and ions allowing osmotic adjustment in the expanding and meristematic regions, shoot growth may be still inhibited by stress conditions, because osmotic adjustment may not be sufficiently rapid to compensate for growth or due to a stress induced fall in cell turgor (Zlatev and Lidon, 2012). Similar results were obtained by Soha E. Khalil and Rabia M.M. Yousef ,2014 , Fatma M. Seleem and Soha E. Khalil, 2018 and

Soha E. Khalil and Fatma M. Seleem,2019.

Biochemical effects of drought stress on crops:

Drought induces important alterations in plant metabolism and biochemistry (Soha E Khalil and Abdel-Salam El-Noemani, 2015). Under water stress, the responses deal with the production of reactive oxygen species (ROS) that cause protein degradation, enzyme inactivation, membrane injuries and thus induce oxidative stress. Under water deficit, the accumulation of ABA plays an important role in increasing plant resistance, tolerance and response to dehydration. Stomata Closure considered as a defense mechanism against drought stress, which are functions of ABA. The ABAs amount in xylem increases under the reduction of soil moisture, which causes increase in ABA accumulation in different leaf compartments. Other effect of water stress in plants is the reduction in PM-ATPase activity. Low PM-ATPase increases the pH of the cell wall and causes the formation of abscisic acid. ABA- cannot pass through the plasma membrane and transfer toward the gourd cell by the water stream in the leaf apoplasm. Increase in accumulation of ABA around the guard cell causes stomata closure and decrease in transpiration rate that reduce water los. Under drought, plants formed glycine betaine, proline, alcohols, sugars, and accumulate organic solutes (Bray, 2001).

Moreover, accumulation of proline in plant tissues is considered as an indicator of plant tolerance to drought. In this respect, it is reported that proline content in resistant cultivars was more than in sensitive cultivar under the drought conditions. Soluble carbohydrates accumulation has also a role in osmotic regulations. Lipids, also is one of the important components of plasma membrane, which are affected by drought conditions. Glycolipids are located in chloroplasts membranes and formed more than 60% of its structure. Phospholipids are thought to be the most important structure in plasma membrane and mitochondrial lipids (Yuan and, Zhang ,2010).

SALINITY

Morphological effects of salt stress on crop plants:

Salinity causes reduction in germination rate, germination index, seedling length, germination percentage, root /shoot length ratio and seed vigor (Khodadad 2011and Soha E Khalil and Bedour H Abou Leila 2016). Salinity inhibits rapidly stems and leaves growth, whereas roots elongation may increase. Ion toxicity is the primary cause of growth reduction under salt stress (Chinnusamy, *et al.* 2005 and

Soha E. Khalil, 2016). Many researchers recorded that plant growth reduced under saline irrigation condition and the degree of growth reduction depended on environmental conditions, level of salt, type of plants and stages of growth. The first effect of salinity on plants is reduction in its growth as a result of reduced osmotic potential which inhibits absorption of water and nutrients by stressed roots (Jose *et al.,* 2017). Shoot and root growth reduction are more obvious and causes extreme, necrosis, chlorosis, and senescence of young and old leaves (Munns, 2002 and Soha E. Khalil 2016). Salinity has also been found to alter the root system morphology and decrease the plant total root length (Álvarez *et al*., 2014). A general reduction in fresh and dry weights has been recorded in most plant tissues exposed to salinity, and it is especially noticeable in the shoot system. Different researchers have revealed the reduction in fresh and dry weights to the decrease in the number of leaves or in leaf abscissions (Soha E. Khalil and Ashraf M. Khalil, 2015) . Another typical response to salt stress is a reduction in total leaf area (Jose *et al.*, 2017). The reduction in the leaf area might be considered as a resistance mechanism that minimizes the loss of water through transpiration (Ruiz-Sánchez *et al.*, 2000). Increasing salt concentration in irrigation water limiting leaf area, caused plant growth reduction, and changing the relation between root and the aerial parts. Salinity stress makes different crop plants showed drier root mass than shoot, causing increase in root to shoot ratio (Fernández-García *et al.*, 2014 and Taha B. Ali, Soha E. Khalil and Ashraf M. Khalil, 2011).

Physiological effects of salt stress on crop plants:

Photosynthesis process is the most important process in which green plants make their own food, they convert solar energy into chemical energy and produced organic compounds and oxygen by carbon dioxide fixation. Photosynthesis is adversely affected by salinity in different ways, such as the inhibition of CO_2 fixation and concentration due to stomatal closure, the reduction or destruction of photosynthetic pigments including carotenoids, chlorophyll a andchlorophyll b (Qados 2011), and damage to photosynthetic processes (photosystems I and II, and electron transport (Sudhir *et al.* 2005). The reduction in photosynthesis process due to salinity resulted from reduction in chlorophyll concentration and content. Total photosynthesis rate declined due to decrease in leaf characters such as reduction in leaf expansion and development, as well as increase in leaf abscission, increase the exposure to salinity caused, membrane disruption, complete stomatal closure, ion toxicity, become the prime factors responsible for photosynthetic inhibition. Generally, the total carotenoid and chlorophyll contents of leaves are decrease under salinity stress where the chlorosis start from oldest leaves during the salt stress conditions (Farooq *et al.,* 2015 and Taha B. Ali, Soha E. Khalil and Ashraf M. Khalil, 2011).

Salt stress suppressed the leaf water relations including relative water content percent, turgor potential, osmotic potential, water potential, water relation parameters, as well as plant growth, and plant fresh weight. Under salinity stress, water potential of the soil solution become reduced that inhibited seed germination due to sodium toxicity, which make water absorption is difficult by seeds. Moreover, the relative water content declined due to salt application, the reduction in RWC, and a loss of cell turgor limited water availability for cell elongation (Jabeen and Ahmad 2012 and Soha E. Khalil and Bedour H. Abou Leila, 2016). There are two issues:

1. In high salt concentration, plants accumulate more Cl^- and Na^+ ions in leaves than normal situation that cause decrease in leaf osmotic potentials and resulted in more negative water potentials.
2. Root hydraulic conductance reduction causes decrease in the amount of water flow from the roots to the leaves, causing water stress in the leaf tissues.

Several physiological works indicated that under stress conditions, non-structural carbohydrates including sucrose, alcohols, hexoses, and sugar accumulate in different plant tissues. However, seeds of different plants accumulated large amounts of proline and total soluble sugar for osmotic regulation in response to salt stress, which improved their water relations and the enzyme activities which regulate the process of germination. Plants also accumulate organic solutes like glycine betaine, sucrose, glutamic acid and proline (Hussain *et al.,* 2016). Accumulation of these and other organic ions increase osmotic regulation, causing increase in osmotic pressure and reduction in water potential resulting in inward diffusion of water from the surrounding media which lead to maintenance of cell turgor and cell expansion.

Biochemical effects of salt stress on crops:

Salt stress enhance the formation of reactive oxygen species ROS, like superoxide, hydroxyl radical, single oxygen radicle, and hydrogen peroxide. Salinity stress-stimulates production of ROS, which causes oxidative damages of macromolecules like DNA, lipids, and proteins, which disturb vital cellular functions of plants (Ahmad and Umar, 2012 and Soha E. Khalil, 2016). Toxic ions in salt-affected soils are usually chloride, sodium, and sulfate (Hussain *et al.*, 2016). The excessive accumulation of sodium ion (Na^+) results in ion imbalance, ion toxicity and decrease in plant water uptake also it interferes with plant metabolism, while potassium ion (K^+) accumulation can alleviate Na^+ ion toxicity by adjusting osmotic potential and through ion balance. It has been indicated that high Na^+ accumulation causes sharp reduction in K^+ and Ca^{2+} content that resulted in a sharp reduction of K^+/Na^+ ratio after treating plant with higher salinity level, which reveals greater leaves damage as compared to those in roots (Munns 2005), burning of leaves is a major symptom of salinity stress (Zhu, 2003). In salt-affected soils, high buildup of Cl^- and Na^+ ions in plant root, leads to strong nutritional imbalance in plant. This is due to antagonism of these ions with other essential mineral elements like calcium (Ca), nitrogen (N), potassium (K), magnesium (Mg), iron (Fe), phosphorus (P), manganese (Mn), copper (Cu), and zinc (Zn) (Siddiqi *et al*. 2011).

Many amino acids including proline, arginine, alanine, glycine, leucine, serine, and valine, amides (asparagines and glutamine) and the non-protein amino acids (ornithine and citrulline) accumulate in plants exposed to salt stress (Torabi *et al.*, 2010). In addition, Hussain *et al.*, (2016) indicated that the accumulation of total free amino acids higher in leaves of salt tolerant than in salt sensitive lines. The increased accumulation of soluble carbohydrates and reducing sugars in plants has been highly recorded as a response to salinity or drought stress, a significant reduction in net CO_2 fixation, concentration and assimilation rate reported as consequence to soluble carbohydrates accumulation (Murakezy *et al.*, 2003and Soha E. Khalil, 2016). Parvaiz and Satyawati (2008) recorded that when glycophytes are exposed to high salinity level, the increase in soluble sugars reached to about 50%, which increase in osmotic potential. Parida *et al.* (2002) showed that carbohydrates content such as polysaccharides like starch and mono and disaccharides like (glucose, sucrose, and fructose,) accumulate under saline conditions and play a major role in osmotic regulation, osmoprotection, carbon storage, and radical scavenging.

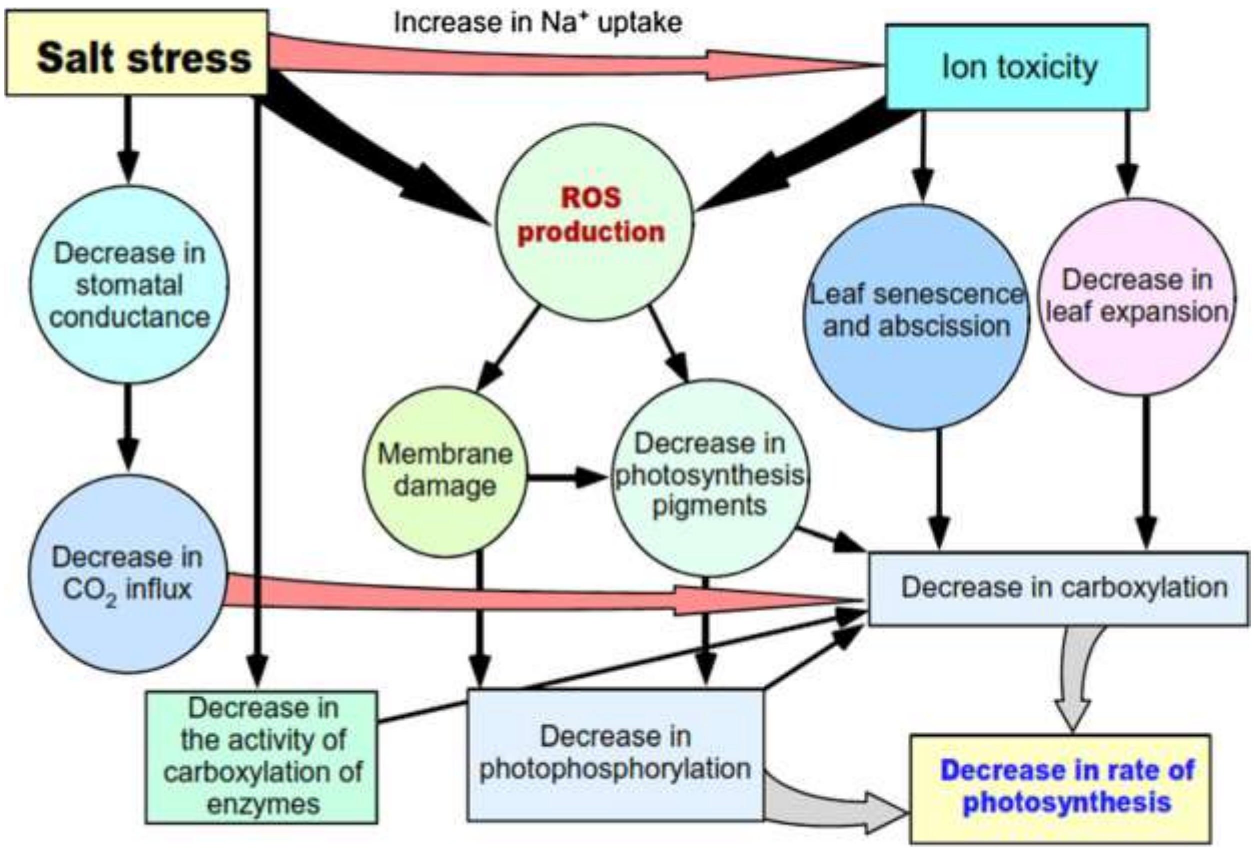

Fig. 3: Influence of salt stress on physiological and biochemical characters in plant cells. Farooq *et al.* (2015).

Stress Alleviation by using Soil Microbes or Bio fertilizers:

Production of tolerant crop plants under stress conditions can increase by different methods, including the use of soil microorganisms (biofertilizers), which seems to be effective on the increasing tolerance of different crop plants under stress conditions. Plants have complex mechanisms to tolerate abiotic stresses caused by various ecological factors, including salinity and drought. Plant associated microbe (including bacteria and fungi) in the soil alleviate the adverse effects of stresses in a more cost-effective and time sensitive manner. Research directed towards the application of bio-fertilizers in salt and drought-affected fields, which encourages commercialization of inoculants for stress resistance (Babalola, 2010 and Rabia M.M. Yousef, Soha E. Khalil and Nadia A.M. El-Said, 2013).

Types of bio-fertilizers

Bio-fertilizers are compounds composed of living cells of different types of microorganisms that are able to convert important nutritionally elements from unavailable to available form via different biological mechanisms (Vessey, 2003).There are different types of bio-fertilizers such as (Itelima *et al* ,2018):

Rhizobia: Rhizobia are symbiotic bacteria, which colonize the legume roots and fix the atmospheric nitrogen symbiotically. In symbiotic relationship, bacteria receive the products of photosynthesis process as energy source and in turn, they fix nitrogen for their host from the air.

Azospirillum and Azotobacters: These are free-living bacteria, which fix atmospheric nitrogen in cereals crops without symbiosis. Azobacter fixing atmospheric nitrogen (15-20 kg ha^{-1}) per year, it can aid in vigor germination leading to improved crop stands, in addition it produce antifungal compounds to fight against plant pathogens.

Phosphate solubilizing bacteria: Under calcareous or acidic soils, phosphorus gets fixe in soil causing plant sufferings for the need of phosphorous. Phosphobacteria able to make the unavailable phosphorus available to the plant's root through release of various organic acids like (citric acid, glutamic acid, oxalic acid, malic acid, succinic acid, , and fumaric acid) which brings the release of bound forms of phosphate.

Plant growth promoting rhizobacteria (PGPR): That kind of microbe is root colonizing bacteria, which are induce beneficial effects on plant growth and development, through direct methods by solubilizing of phosphate, fixation of atmospheric nitrogen, production of siderophores, which enhance plant growth or solubilize iron. PGPR can apply as seed coating, soil applications, and foliar sprays to improve the effectiveness that not only depends on effectiveness of the strain but also to suitable method of application.

Vesicular arbuscular mycorrhiza (VAM): VAM fungi are obligate endo-symbiosis and intercellular fungi, it probably the most abundant fungi in agricultural soils. They account reached to 5–50% of the soil biomass microbes (Somasegaran and Springer, 1994). Approximately 10–100 m mycorrhizal mycelium detected per cm root (Hari and Perumal, 2010). Many of the leguminous plants roots transmit substances to the fungi, and the fungi help in transmitting water and nutrients to the plant roots. The fungal mycelia may exceed the root lengths by 100-fold thus providing plants greater opportunity to absorb water and many important nutrients. Particularly, the less available mineral nutrients like zinc, molybdenum, phosphorus, and copper, also it helps plants to access wetter soil areas. Some VAM fungi give cottony appearance around the root system, a type of protective coat, which increase seedling tolerance to drought stress. In addition, it causing better uptake of water by plants, protection from infection by disease fungi, and protection from extreme soil acidity (Swathi, 2010 and Soha E. Khalil and Rabie M.M. Yousef, 2014).

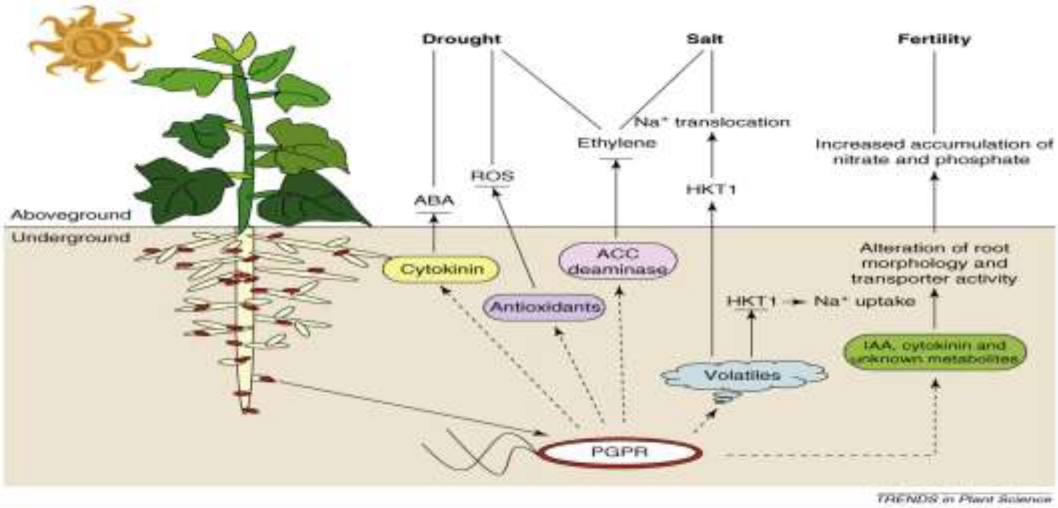

Fig 4 : Rhizosphere bacteria help plants tolerate to abiotic stress(Yang,2009).

Phytohormones are organic compounds found in very low amounts, which influence on the morphological, biochemical and physiological processes in plants; Phytohormones substances are not naturally synthesized by the plants but are synthesized exogenously by synthetic and natural means and are known as plant growth regulators. The soil microbes regulators the synthesize of the following examples directly or indirectly.

Auxins: The hormone can affect plant growth by (1) improving cellular division and cell growth, (2) stimulates root growth, (3) stimulates ethylene production, (4) expression of different plant genes and (5) differentiation of vesicular bundles, (Spaepen *et al.* 2008). The formation of plant hormones by the microorganisms is regulating by several mechanisms. Such as, the root exudates which have ability to alter the production of plant hormones by *A. brasilense*; if the production of root exudates declined and become not in suitable rate for bacterial needs and growth, the production of indole acetic acid IAA by the microorganisms increase causing the production of lateral roots and root hairs. The production of indole acetic acid IAA by *A. brasilense* stimulates the growth and development of the aerial parts in spring wheat and leaf length, compared to control plants (Spaepen *et al.*, 2008).

Cytokinin: is another important plant hormone, which is formed by different types of microorganisms, cytokinin causes activation of different cellular activities in plant body especially cell division, as well as leaf growth and senescence. The production of cytokinin by *Bacillus subtilis* induced increase in the rate of cytokinin production and the plant growth in lettuce. It can also increase plant fresh weight and growth under drought stress (Arkhipova *et al.* 2005).

Gibberellins: is the other important hormone can affect plant growth by affecting the growth and cellular activities. The hormone can affect different plant growth stages including the root growth and the floral, as well as the seed germination. Similar to the other plant hormones, like cytokinins, and auxins gibberellins can act in combination with the other plant hormones. Different *Azospirillum* species able to produce gibberellins which affecting plant growth and yield production (Spaepen *et al.,* 2009). The production of gibberellins has been also recorded in *Herbaspirillum seropedicae, Acetobacter diazotrophicus and Bacillus* spp. Gibberellins promote plant growth by enhancing the uptake of water and nutrients by plant and by increasing root growth and architecture, particularly the root hairs density (Cassán *et al.* 2014).

Ethylene: Is another plant hormone that controls different plant activities such as germination of seeds, fruit ripening, cell growth, and the senescence of flower and leaf. The hormone production increases under stress conditions; so, it is known as stress hormone (Spaepen *et al.* 2009) which badly affecting plant growth, particularly the root growth. Several research studies have revealed that PGPR can decrease the production of this stress hormone in plant. Accordingly, the level of stress hormone decreases in plant, and as a result, plant growth increases (Glick, 2015).

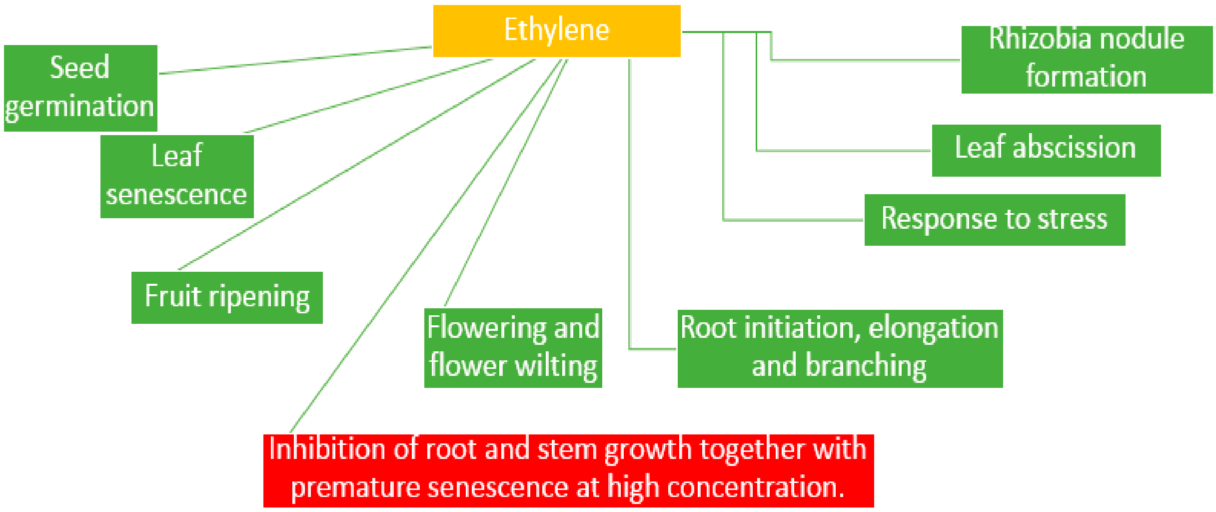

Figure 5: Ethylene hormone affects several processes in plant (Vejan *et al.*, 2016)

Production of Siderophores:

Iron considered as the bulk element that present on the earth surface. Iron is existing in the environment in the form of Fe^{3+}, which is highly insoluble form; and yet it is unavailable in the soil for plants root to solve this problem, the microorganims produced siderophores which are low molecular weight iron binding protein substances that controlled the process of chelating ferric iron from the environment. As iron is limited, the microorganisms produce the siderophores that provide plants with iron, improving plant growth and development. The siderophore-producing *Phyllobacterium* strain promotes the growth and the fruit quality of strawberries plant (Kumar *et al.,* 2010).

Production of Volatile organic compound:

Volatile organic compounds VOCs secreted by microbes are highly involved in enhancing plant growth and increase plant resistance to pathogens infections. Different bacterial species, such as Pseudomonas, Arthrobacter, Bacillus, Stenotrophomonas, and Serratia produce VOCs that affect plant development. Acetoin and 2,3-butanediol which produced by Bacillus are the best known of these compounds and are responsible for significant increases in plant growth. Some other PGPR strains produce VOCs, which mediate increases in plant disease resistance directly and/or indirectly, increase plant biomass, and improve plant tolerance to abiotic stress. Volatile organic compounds emission is produced by a most variety of soil microbes, the quantity of volatile compounds emitted differ according to microbe species (Kanchiswamy *et al.,* 2015).

Production of Enzymes:

In basis of microbe secreted protection enzymes, the mode of action called biopesticides: microbe improve plant growth characters via the control of phytopathogenic agents, mainly by the formation of metabolites, which act as antifungal and used as defense systems. The mechanism is involving the formation of hydrolytic enzymes, such as glucanase and chitinase that inhibit the growth of Phytophthoracapsici and *Rhizoctonia solani straines,* which are the most destructive crop pathogens in the earth (Vejan *et al.,* 2016).

Effect on stress tolerance:

Inoculation plants with bio-fertilizers have been known to induce abiotic stress regulation either by direct or indirect methods that increase plant tolerance to stress conditions. Root system is the major part that induced plant response to stress condition. The following mechanisms illustrate how the symbioses may help plant under stress conditions. (1) The bacteria produce cytokinin, causing an increase in production of ABA in plant. (2) Bacterial produced antioxidants that scavenge the formation of ROS or reactive oxygen species in plant. (3) The emission of volatiles compounds by which bacteria affects the translocation of Na^+ and its uptake by plant. (4) The secretion of exo-polysaccharides that improve the soil properties and fertility. (5) The bacteria can produce indol acetic acid IAA and some growth regulators, which improve root development under different conditions including stress (Yang *et al.,* 2009).

Microorganisms alleviating stress effect by the following mechanisms: (1) activation of different stress enzymes, (2) inducing systemic resistance in the host plant, and (3) formation of different metabolites such as amids, proline, amonia and polysaccharides (Yuan *et al*., 2010 and Soha E. Khalil and Rabie M.M. Yousef, 2014).

Many microbes improve ion homeostasis, photosynthetic efficiency and plant-water relations, in stressed plants; a complex network of signaling events, occurring during the plant microbe interaction and ensuing stress alleviation (Smith *et al.,* 2017). The dynamic function of PGPR in relation to phytohormonal status, water and nutrient uptake, ion transport, stomatal conductance, signal transduction proteins, carbohydrate metabolism and antioxidant enzymes, in plants is necessary to determine the induced systemic tolerance. Plant growth promoting rhizobacteria regulate stomatal opening and water potential by affecting transpiration rate and hydraulic conductivity. Marulanda *et al.* (2010) recorded on maize plants inoculated with *Bacillus megaterium an* increase in root hydraulic conductivity compared with un-inoculated plants under to salt stress conditions (2.59 dSm^{-1}). Different microbes induce phytohormone signaling and osmolyte accumulation that facilitates plants to overcome initial osmotic shock. In addition, enhanced proline synthesis in genes derived from *Bacillus subtilis* conferred salt tolerance to the plants (Chen *et al.,* 2007). Inoculation of salt tolerant *Bacillus amyloliquefaciens* on rice plants exposed to salinity (200 mM NaCl) in soil conditions and hydroponic increased plant salt tolerance and affected expression of 14 genes (Nautiyal *et al.,* 2013). The inoculation of lettuce plants with mycorrhizal fungi (*Glomus* sp.) and PGPR (*Pseudomonas* spp.) enhance the secretion of catalase enzyme under severe drought conditions, illustrating that the combination between such soil microbes can be beneficial for the ameliorating the effect of drought stress (Kohler *et al.* 2008 and Rabia M.M. Yousef, Soha E. Khalil and Nadia A.M. El-Said, 2013). Alami *et al.* (2000) indicated that rhizobium improved sunflower tolerance under water stress conditions by the production of exopolysaccharide and by improving the structure of the soil.

Under salinity stress conditions, Bacteria decrease plant salt uptake by altering root structure with extensive rhizosheaths, trapping cations in the exo-polysaccharide matrix, and regulating ion transporters. microorganisms have been known to regulate nutrient imbalance caused by the high accumulation of toxic ion such as Cl^- and Na^+ ions and increase the mineral nutrient exchange of both micro and macronutrients in plant body. Microbial induced nutrient cycling (mineralization), rhizosphere pH changes (organic acids), and metal chelation (siderophores) which improve plant nutrient availability in the soil (Lugtenberg *et al.,* 2013). Microbes help controlling ion homeostasis and keeping K^+/Na^+ ratios high in shoots by reducing Na^+ and Cl^- accumulation in leaves, increasing Na^+ exclusion by roots, and increasing the activity of high affinity K^+ transporters. Rojas- Tapias *et al.,* (2012) recorded increase in K^+ uptake and Na^+ exclusion in maize plants under salt stress conditions, when inoculation with Azotobacter strains C5 (auxin producing) and C9. Furthermore, Proline, polyphenol and Chlorophyll concentation in plant leaves increased, and treated plants with PGPR inoculum increase plant responses to stress conditions. Inoculated *Puccinellia tenuiflora* grass with *B. subtilis GB03* revealed lower Na^+ accumulation in stressed grass roots under high salt concentrations treatment (200 mM NaCl) (Niu *et al.,* 2016). Soil bacteria releasing exogenous metabolites such as hormones and enzymes, which modulate plant hormone status, and cause increase in plant tolerance. Also, metabolites and phytohormones are produced in plants cells and tissues as a response to signaling events of plants microbe interactions during stress conditions (Dodd *et al.,* 2010).

The microorganisms are able to alleviate the badly effects of stress on plant development and yield productivity by different morphological, physiological and biochemical adaptation.

Effect on plant morphological characters:

Soil microorganism can increase plant growth parameters and yield components under stress. The microorganisms such as fungi and bacteria have an ability to enter plant tissues, resulting in intercellular association with the host plant, and complete their life cycle. A large number of microbes are living in a single plant enhancing plant's growth parameters and yield production (Naveed *et al.,* 2014). The microorganisms are able to improve the host plant growth and productivity by increasing the availability of different soil mineral nutrients by using the following activities: (1) increasing the density and the length of root hairs, (2) the decrease in root diameter, and (3) the production of different biochemical substances such as phenolic compounds, flavonoids and polysacharides (Bauer and Mathesius 2004).

Bio fertilizer stimulates plant growth and productivity through different activities as improving nutrient supply by phosphorous solubilization, biological nitrogen fixation, or iron acquisition (Kuan *et al.,* 2016). In addition, it control pathogens infection, by competition and antagonism the pathogens (bio control agents) (Chowdhury *et al.,* 2015). Decrease metal toxicity and degrade organic pollutants from contaminated soils (bioremediation). In other study, Naveed *et al.* (2014) recorded the effects of *Enterobacter* sp. and *Burkholderia phytofirmans* on water content, the growth, and photosynthetic activity of two maize genotypes grown under water stress conditions. The plants were subjected to water stress for 45 days by withholding irrigation after planting during the vegetative growth stage. The bacteria were able to stimulate plant growth, fresh weight, leaf area and plant yield under drought stress by improving plant relative water content, morphological and physiological characters, compared to un-inoculated control plants. Strain *B. phytofirmans* was the more efficient strain than *Enterobacter* sp. under drought stress. It is possible to alleviate drought stress on plant growth depending on the bacterial strains and on plant genotype. Franzini *et al*. (2013) indicated that the combination between PGPR and VAMF mycorrhizal fungi are usually positively improving the growth parameters and yield productivity of legume, under drought conditions. Abdel-Rahman *et al.* (2011) studied the effects of single or combined treatment between *Bacillus subtilis* and AMF mycorrhizal fungi on the growth, yield, nutrient content and uptake and oil yield and percentage, of three different species of sweet basil under saline irrigation of 0, 1000, 2000, and 4000 mg/L. The resulted data illustrated that the highest salinity level caused significantly reduction in plant growth, yield, nutrient content and uptake of N, P, and K and oil yield and percentage of all studied species. The single inoculation of mycorrhizal fungi promotes plant growth under salinity conditions compared with bacteria and the combined inoculation intensified such a positive response. Accordingly, the authors showed that it is possible to improve sweet basil tolerance to salinity by using the single or combined treatment of AMF mycorrhizal fungi and *Bacillus subtilis*.

***Effect on plant physiological characters*:**

Beneficial microorganisms can stimulate photosynthesis, and biomass production. Seed inoculated with *B. aquimaris* strains in wheat plant under saline field conditions (5.2 dSm^{-1}) resulted in NPK and chlorohyll accumulation, higher shoot biomass, Na reduction in leaves and increase the osmotic adjustment (Upadhyay and Singh, 2015 and Rabia M.M. Yousef, Soha E. Khalil and Nadia A.M. El-Said, 2013). Jan *et al.* (2014) recorded that the utilization of organic fertilizers caused increase in chlorophyll content and the ability of wheat plant to stand stress. These results are also in accordance with the work of Badar (2014) who recorded such increase in chlorophyll concentration of sunflower plants due to addition of organic manures.

Inoculated pepper (*Capsicum annuum*) plants with *Pantoea dispersa* and *Azospirillum brasilense* under saline conditions was related to increase plant dry matter accumulation after 36 days, increase photosynthesis rate, and stomatal conductance but neither chlorophyll concentration nor photochemical efficiency of photosystem II was affected (del Amor and Cuadra-Crespo, 2012). Microbes, which exposed to osmolality fluctuations in their surrounding media accumulate large amount of osmo-protectants in their cytoplasm (Kempf and Bremer, 1998). Under such circumstances, production of osmolytes such as trehalose, proline, and glycine betaines by PGPR is faster than their host plants. The compatible solutes absorbed through stressed plant roots help in preventing cellular oxidative damage and maintaining osmotic balance under stress conditions. Combined treatment of *Phaseolus vulgaris* plant with *Paenibacillus polymyxa* and Rhizobium tropici strain modified to over express strehalose 6-phosphate gene caused increased N content, nodulation, and plant growth characters. The analysis of nodules showed up-regulation of stress resistance and tolerance genes indicating that extracellular trehalose, as an osmo-protectant can induce plant tolerance under salinity (Figueiredo *et al.,* 2008).

Chen *et al.* (2007) recorded a correlation between salinity and drought stresses and the formation of proline. The authors were reported improvement in plant growth parameters, yield compounents, osmotic regulation, and tolerance by inserted the *pro*BA gene taken from *Bacillus subtilis strain* into *Arabidopsis thaliana* plant grown under stress conditions. The inoculation of corn plants with *Rhizobium* and *Pseudomonas* increased the salt tolerance of the plant by the following mechanisms (1) decreased electrolyte leakage, (2) the increased production of proline, and (3) improved K+ uptake. Many researches recorded positive effects of proline on the cell growth under drought and salinity stresses, by the protection of the proteins and cellular membranes from damages caused by the adverse effects of the stress. Proline can scavenge the hydroxyl radical molecules or ROS formed under stress conditions by acting as a protein like molecule (Bano and Fatima 2009).

The synthesis of low molecular weights organic compounds such as amino acids (glutamate or proline), betaines (glycine betaine) and polyols (mannitol, inositol, sorbitol, or glycerol) is a common metabolic change in response to stress conditions and these compounds act as osmolytes. These solutes accumulate in the cell cytosol both outside and inside to maintain the cellular osmotic adjustment. In addition osmolytes also act as osmoprotectants by stabilizes dehydrated enzymes and preventing desiccation of membranes rather playing role in osmoregulation. They control and facilitate subcellular structures stabilization and ROS or free radical scavenging and protect plants from osmotic stress induced dehydration. Production of osmolytes or osmoprotectant is an energy-demanding process that enables plant to recover from negative effects of stress (llangumaran and Donald, 2017).

***Effect on plant biochemical characters*:**

Bio-fertilizers have considered as compounds important for reducing the negative environmental effects of chemical fertilizers and maintaining adequate plant nutrition. Bio-fertilizers have been reported to stimulate nitrate uptake by plants root. Bio-fertilizers has been also associated with the solubilization and increased uptake of phosphate (Nehra, 2011and Rabia M.M. Yousef, Soha E. Khalil and Nadia A.M. El-Said, 2013). In addition to increase in plant growth and development, some bio-fertilizers stimulate root growth and development and alter root architecture by the production of phytohormones such like indole acetic acid (IAA) (Bhattacharyya and Jha, 2012), causing increase in numbers of root tips and root surface area. The increase in root surface area of AM fungi inoculated plants might be due to the ability of AMF to produce hyphae, that are microscopic tubes colonize around plant roots and grown out into the soil further than plant root hairs. Nutrients were taken up by the hyphae to the plant that led to a very efficient uptake and mobilization of nitrogen, potassium, phosphate, magnesium, zinc, copper, boron, sulphur and other important elements that are transported to the plant. Such stimulation of roots can help plant defense against pathogens infection and can relate to increase plant tolerance against stress conditions. Given that root surfaces and tips are considered as sites of nutrient uptake, so the microbes lead to increased nutrient uptake by promoting root development. It has also been suggested that bio-fertilizers improve plant uptake of mineral ions by stimulation of the proton pump ATPase (Nehra, 2011). Beneficial microbes are able to increase the availability of nutrient content in the rhizosphere by fixing important nutrients necessary for plant growth and development. Such as, nitrogen that is needed for the formation of certain proteins and amino acids (Choudhary *et al.,* 2011).Beneficial microorganisms can also stimulate carbohydrate transport and metabolism. Plants are inoculated with *B. aquimaris* strains increased the production of reducing sugars and total soluble sugars in wheat plants under saline conditions (5.2 dSm^{-1})(Upadhyay and Singh, 2015 and Soha E. Khalil1 and Rabie M.M. Yousef , 2014).

Stress Alleviation by using organic fertilizers:

Organic fertilizers are fertilizers deriving from biological or living plant or animale materials. These fertilizers need long period of time to release the important nutrient elements in the soil. Furthermore, organic fertilizers able to increase soil fertility, they are sources of important nutrients for growing different crops and for improving the overall soil fertility and quality. The organic fertilizers increase cation and anion exchange capability, microorganism activity in soil, carbon-content and organic matter of the soil. The major advantages of organic fertilizers include improved soil water retention, soil texture, and soil resistance to erosion. Organic fertilizers protect plant from different types of diseases by enhancing plant tolerance and by meeting the plants nutritional needs. This action alleviates a serious effect of stress (Sharma and Ronak, 2017and Soha E. Khalil and Rabia M.M. Yousef, 2014).

Types of organic fertilizers

Organic fertilizers come in the different forms like:

Manure: derive from animal wastes or livestock such as chickens, goats, cows, and others. Organic manures are carbon-based substances that promote plant productivity and increase plant quality; the application of organic manure to the soil associated the soil with important properties such as water holding capacity, lower bulk density and available cation exchange capacity, as fosters beneficial microb (Sharma and Ronak, 2017).

Green manure: that driven from young plants remains or wastes, especially the remains of different legumes types.

Compost: derive from organic remains or organic waste material like corn stalks, straw, or decomposed waste. Compost produced mineralizes plant available nutrients.

Organic fertilizers contains important macro (N, P, K,) and micronutrient:

The most important macronutrient are:

Nitrogen: Mineralization process is the conversion of organic N to inorganic N form. The mineralization of organic N from organic matter is necessary for proper plant nutrition and groundwater management. Furthermore, they classified organic N into rapidly, near-term and long-term mineralizable groups. The rapid form was rapidly mineralize in few days, while near term mineralized within a weeks, on the other hand the long-term form required years to mineralize.

Phosphorus: Inorganic P is the unique form of P which plant can absorbed. Therefore, the transformation of organic p to inorganic P form through the mineralization is fundamental to maintenance adequate P level in the soil for plant growth (Bulluck *et al.,* 2002). Sharma and Ronak (2017) illustrated that some organic compounds containing P as phosphohumic complexes that could also contribute to plant nutrition and promote plant growth. Great increase observed in inorganic P than organic P concentration after application of organic matter, which reflects the mineralization of the organic material in the soil.

Micronutrients: Organic fertilizer is also a source of Zn, Mn, S and Fe as well as other micronutrients. Ojo *et al.* (2014) reported that the use of poultry manure lead to correct plant Fe and Zn deficiencies. They showed also that manure might supply micronutrients and chelating agents that increase micronutrient solubility. Furthermore, Osman and Rady (2012) indicated that the application of organic compost increased available contents of macronutrients (i.e., N, P, and K) and micronutrients (i.e., Fe, Mn, and Zn) and soil organic matter content, from 0.89–0.93% to 1.39–1.40%. A positive effect on S were also reported, they attributed their positive effects on the soil to the increase of organic matter content and bio-available nutrients.

Effect on morphological characters:

Several studies have done to alleviate the effect of abiotic stress on cellular damage and to improve different plant crops tolerance against stress, among of which the applications of organic fertilizers (Suja and Sreekumar, 2014 and Soha E. Khalil and Ashraf M. Khalil, 2015). Organic fertilizers improve different crops yield and increase its quality in ways similar to inorganic fertilizers. Organic fertilizers provide plants with nitrogen in available form, which aid plant to promote its growth without causing roots burning nor destroying beneficial the micro-organisms in the soil. The positive effect of organic fertilizers on different crops development and productivity might be due to the improvement in soil biological and physical properties. Also it may be due to the activation of different species of living organisms which release important growth regulators or phytohormones like auxin, gibberellins or cytokines also it may stimulate the plant growth and absorption of nutrients, or due to the increase in the increase in water use efficiency by different crop plants (Suja and Sreekumar, 2014). Abd El-Kader *et al.,* (2010) reported on *Abelmoschus esculentus* L. significant increases in morphological parameters such as plant height, stem diameter, number of leaves, fresh weight, branches number, leaf area / plant by adding organic composted and chicken manure at the rate of 6 m^3/ acre under drought stress conditions. Moreover, Khalil *et al.* (2012) recorded that organic fertilizers significant increase plant growth on the base of plant height, number of leaves/plant; number of branches/plant and dry weight of the aerial part of *Capsicum annuum*, L. plant under water stress conditions. Sirousmehr *et al.,* (2014) indicated that the morphologic characteristics (leaf number, plant height, stem diameter, number of lateral branch) of *Ocimum basilicum* plant were increase by application of organic fertilizers under drought stress. Also, Mukesh (2007) indicated that the application of organic matter to the soil, improve the physical properties of soil such as aeration, permeability, aggregation, and water holding capacity that promote plants growth and development especially under stress conditions. He also illustrated that plant nutrients which provided from organic substances had positive effect on the growth and productivity of the different crop either by acceleration of respiratory process with increasing hormonal growth action and cell permeability or by combination of all these processes. They are also rich in micro, macronutrients, and having plant growth promoting substances like hormones, enzymes. Wang *et al.,* (2014) revealed that application of Mixture of green organic matter to a coastal saline (EC dSm^{-1}) soil proved increase in plant growth and development. In addition, Cha-um and Kirdmanee (2011) stated that the organic matter application in paddy fields (EC 8.5–20.4 dSm^{-1}) could effectively alleviate the problem of soil salinity, also resulting in yield improvement. Similar results were obtained by Soha E. Khalil and Rabia M.M. Yousef, 2014 and Soha E. Khalil and Ashraf M. Khalil, 2015.

***Effect on plant physiological characters*:**

Under stress conditions, the reduction in chlorophyll concentration and photosynthesis rate is related to the increase in oxygen radicals in different plant cells. Free radicals cause chlorophyll pigments degradation and peroxidation. The reduction in chlorophyll accumulation under stress conditions is mainly due to the reduction in peroxidase, chlorophylls enzyme activity, and phenolic compounds, resulting in chlorophyll degradation (Ramírez, *et al.,* 2014). Salinity and drought stress, cause decrease in leaf chlorophyll b content while organic fertilizers treatment proved increase in leaf chlorophyll b content. There is a significant correlation between chlorophyll and leaf N content. Leaf chlorophyll is a good index to detect N status in plants tissues in order to determine the required amount of N fertilizer to gain high N use efficiency with maximum plant performance (Feng *et al.,* 2015). It can be supposed that the organic fertilizer can increase carotenoids and chlorophyll content by increasing the amount of N availability for the plant. Followed by the ability of this plant to absorb more sunlight and produce more assimilates and finally improving plant growth and yield. Salehi *et al,* (2016) recorded higher leaf chlorophyll concentration in vermicompost treated plants compared with control plants after water deficiency conditions. They suggest that higher photosynthetic capacity, attributed to better drought resistance of chamomile plants treated with organic fertilizers. In general, it can be supposed that the organic fertilizer can increase chlorophyll and carotenoids content by increasing the amount of N availability for plant and followed by that the ability to absorb more sunlight and produce more assimilates and finally enhancing plant growth and yield.

Accumulation of different active ions like sugars and amino acids such proline is responsible for osmotic adjustment in plant cells and tissues. Osmotic adjustments causing maintain in plant growth, control photosynthesis, turgor pressure, cell expansion as well as water flow and stomatal aperture during stress periods (K¨onigshofer and L¨oppert, 2015). Stress significantly enhanced leaf proline content, while the proline content in plants treated with organic fertilizers revealed decrease in proline content and less affected by stress conditions. It has been reported that high levels of leaf proline content able to protect plants against severe stress conditions and increase drought and salt tolerance (Cvikrov *et al.,* 2013). Salehi *et al,* (2016) indicated that vermicompost application decreased the leaf proline concentration of chamomile plants compared with non-vermicompost treatment. The results indicated also that vermicompost treatment improved chamomile drought resistance, which associate with leaf proline concentration, and increasing uptake of nutrients (N, K and P). Moreover, they indicated that the increase in leaf proline concentration might be due to change associated with tissue injury. It appears that enhancement in soil water holding capacity and decline in soil bulk density, and improvement of soil microbial liveliness (Zhang *et al.,* 2016) are due to use of organic fertilizers which can also account for stress tolerance enhances.

Leaf osmotic adjustment by organic solutes such as soluble sugar in the stressed plants cells has been previously known as a resistance mechanism to water deficit stress. The increase in stress severity led to increase in leaf soluble sugar concentration. The accumulation of soluble sugars in stressed plants tissues controlled by several factors affecting soluble sugar formation and translocation in plant leaves (Arabzadeh, 2012). Increasing the leaf soluble sugars content has been found to be correlated with improving of the relative leaf water content. Moreover, soluble sugars play important role in osmotic adjustment in different crop plants (Karimi, 2015). Salehi *et al,* (2016) reported greater sugar accumulation in leaves of plants treated with vermicompost, especially 10 t/ha, this may be due to the increase in leaf area and leaf water potential as well as reduced the chlorophyll photo oxidation activity. They added that maximum leaf soluble sugars content observed in plants treated with the highest rate of vermicompost than the other treatments under water deficiency conditions. They suggested conservation of better photosynthetic capacity, associated with more plants resistance and organic treatment which increased photosynthesis efficiency in treated plants. In accordance Soha E. Khalil and Rabia M.M. Yousef, 2014 and Soha E. Khalil and Ashraf M. Khalil, 2015 obtained similar results.

***Effect on plant biochemical characters*:**

It can be concluded that reduction in transpiration rate under stress conditions, could either due to decrease in water mass flow within the soil or N uptake by plants. In addition, it seems that the application of organic fertilizers cause increase in water retention and sustaining release of nutrients, especially N, reduces the stress effects and improves soil physicochemical properties and therefore increases the absorption of N. It has been reported that organic fertilizers application could improve N uptake by plants even under water deficit stress conditions caused by drought or salinity stress (Guo *et al.,* 2016). As a consequence of the enhanced and steady uptake of N due to organic fertilizer application, different crop plants showed greater yields than those which even received chemical fertilizers. Previous findings suggest that the presence of organic compounds in the soil increases P solubility (Gholamhoseini *et al.,* 2013). There are several factors that can lead to improve availability and absorption of P due to organic matters. (i) The application of organic compounds that rich in P can increase P content in soil; (ii) organic fertilizer decomposition helps to increase organic P in the soil and its fixation; (iii) increase in microbial activity on organic matters can increase P availability in the soil through releasing P from primary phosphorus-containing minerals. This enhances the increase in protein formation in plants treated with organic fertilizers, especially dehydrines proteins that are important to increase plant tolerance under stress conditions. It has also been stated that leaf P content affects the stomatal behavior under stress conditions, possibly by affecting the osmotic potential of guard cell or by wall stiffening that governing the stomatal movements (Aug´e, 2001). Therefore, it is not surprising if vermicompost treated plants, revealed higher growth, and performance compared to control plants, even under stressful conditions (Salehi *et al.*, 2016). On the other hand, it is widely stated that organic fertilizer application improve the physicochemical characteristics of soil and enhances nutrients uptake by different crop plants (Zhang *et al.*, 2015). The favorable effects of organic fertilizers, may be due to their potential to enhance nutrient availability, encourage microbial activity, and increase plant photosynthesis and improve water uptake by plants. Moreover, it seems that adding organic fertilizers to the soil not only increases nutrients availability directly, but also operates as a slow-release fertilizer to provide N, P and K to the plant steadily. Potassium plays important role in plant metabolism, especially when stress is the main issue. Potassium activate different enzymes involved in plant growth and development and considered as a key role in protein synthesis and stomatal movements (Evelin 2009). Therefore, it is reasonable that improved nutrient uptake NP and K by using organic fertilizers has been considered as a practical approach for amplifying resistance in different cop plants. Furthermore, Wang *et al* (2003) reported that potassium could increase the sucrose-phosphate synthase activity and the accumulation of soluble protein content in *Oryza sativa* flag leaf, also it increased the accumulation of grain protein. In relation, Salehi *et al.* (2016) stated that treated plants with 10 t/ha vermicompost showed less stress effect and induced a significant impact on chlorophyll, proline, carbohydrate and nutrient uptake in German chamomile. They also added that it could be possible with application of organic fertilizers particularly vermicompost and proper nutrient management, medicinal plant resistance to drought stress could be improved by increasing nutrient uptake. They revealed also that the exposure of arid and semi-arid region to drought, the cultivation of German chamomile could be improved by vermicompost fertilization. Also, Morard *et al*., (2011) reported that organic compounds proved improved the mineral nutrition, better efficiency of plant water uptake and grain protein and carbohydrates content of different crops. Similar findings obtained by Soha E. Khalil and Rabia M.M. Yousef, 2014 and Soha E. Khalil and Ashraf M. Khalil, 2015.

Conclusion:

Some important details related to the effects of organic fertilizers and soil microbes on plant morphological, physiological and biochemical characters have been indicated. The role of the most important organic fertilizers and soil microbes on the growth of different crop plants under stress has been presented. Accordingly, research work has indicated that organic fertilizers and the use of soil microbes including bacteria and fungi can positively affect plant characters. Some details are also available on the effect of water stress including drought and salinity on plant morphological, physiological and biochemical characters have been also

Have been illustrated. However, the other important point, which must be researched in greater details, is the interactions of bio and organic fertilizers with stress conditions. If such details are illustrated, it will be possible to produce more tolerant crop plants.

REFERENCES

1. Abdalla, A.A., Mansour, H.A., Ibrahim, H.H., Abu-Setta, R.K. 2019. Effect of the saline water, irrigation systems and soybean cultivars on vegetative growth and yield. Plant Archives, 2019, 19, pp. 2207–2218
2. Abd-Elmabod, S.K., Bakr, N., Muñoz-Rojas, Mansour, H.A., De la Rosa, D., Jones, L. 2019. Assessment of soil suitability for improvement of soil factors and agricultural management. Sustainability (Switzerland), 2019, 11(6), 1588
3. Abd-Elmabod, S.K., Mansour, H., Hussein, A.A.E.-F., De La Rosa, D., Jordán, A. Influence of irrigation water quantity on the land capability classification.Plant Archives, 2019, 19, pp. 2253–2261
4. Abdel-Rahman S, Abdel-Kader A, Khalil S, 2011. Response of three sweet basil cultivars to inoculation with Bacillus subtilis and arbuscular mycorrhizal fungi under salt stress conditions. NatSci, 9:93–111.
5. Ali, T.B., Khalil, S.E., Khalil, A.M. 2011. Magnetic treatments of Capsicum annuum L. grown under saline irrigation conditions. Journal of Applied Sciences Research, 2011, 7(11), pp. 1558–1568
6. Attia, S.S., El-Gindy, A.-G.M., Mansour, H.A., Kalil, S.E., Arafa, Y.E. 2019. Performance analysis of pressurized irrigation systems using simulation model technique. Plant Archives, 2019, 19, pp. 721–731
7. Ayyad, M.A., El-Ghareeb, R., Gaballah, M.S. 1990. Effect of protection on the phenology and primary production of some common annuals in the western coastal desert of Egypt. Journal of Arid Environments, 1990, 18(3), pp. 295–300
8. Bargaz, A., Nassar, R.M.A., Rady, M.M., Gaballah, M.S., Schmidhalter, U., Abdelhamid, M.T. 2016. Improved Salinity Tolerance by Phosphorus Fertilizer in Two Phaseolus vulgaris Recombinant Inbred Lines Contrasting in Their P-Efficiency. Journal of Agronomy and Crop Science, 2016, 202(6), pp. 497–507
9. Closed Circuit Trickle Irrigation Design: Theory and Applications, Book Chapter. 2015, pp. 61–133
10. Ebtisam, I.E., Sabreen, K.P., Abd El-Hady, M. 2015. Influence of irrigation deficit and humic acid on soil and canola growth characters and water use efficiency. International Journal of ChemTech Research, 2015, 8(6), pp. 505–513
11. El-Bassiouny, H.M.S., Allah, M.M., Rady, M.M., Gaballah, M.S., El-Sebai, T.N. 2015. Role of blue-green algae, glutathione and salicylic acid on the oxidative defense systems of wheat plant grown in saline soil. International Journal of PharmTech Research, 2015, 8(10), pp. 18–31
12. Eldardiry, E.E., Hellal, F., Mansour, H.A.A. 2015. Performance of sprinkler irrigated wheat – part II Closed Circuit Trickle Irrigation Design: Theory and Applications, Book Chapter. 2015, pp. 41–58
13. Eldardiry, E.I., Sabreen, K., Abd El Hady, M. 2012. Improving soil properties, maize yield components grown in sandy soil under irrigation testaments and humic acid application. Australian Journal of Basic and Applied Sciences, 2012, 6(7), pp. 587–593

14. El-Ghareeb, R., Ayyad, M.A., Gaballah, M.S. 1991. Effect of protection on the nutrient concentration and uptake of some Mediterranean desert annuals. Vegetatio, 1991, 96(2), pp. 113–125
15. El-Hagarey, M.E., Mehanna, H.M., Mansour, H.A.2015. Soil moisture and salinity distributions under modified sprinkler irrigation. Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp. 3–21
16. Gaballah, M.S., Mansour, H.A., Nofal, O.A. 2020. Balanced fertilization of major crops in Egypt: A review. Plant Archives, 2020, 20, pp. 2453–2458
17. Goyal, M.R., Mansour, H.A.A. 2015. Closed circuit trickle irrigation design: Theory and applications Closed Circuit Trickle Irrigation Design: Theory and Applications, Book Chapter. 2015, pp. 1–397
18. Hassan, I.F., Gaballah, M.S., El-Hoseiny, H.M., El-Sharnouby, M.E., Alam-Eldein, S.M. 2021. Deficit irrigation to enhance fruit quality of the 'african rose' plum under the egyptian semi-arid conditions. Agronomy, 2021, 11(7), 1405
19. Hellal, F., El-Sayed, S., Mansour, H., Abdel-Hady, M.2021 Effects of micronutrient mixture foliar spraying on sunflower yield under water deficit and its evaluation by aquacrop model. Agricultural Engineering International: CIGR Journal, 2021, 23(2), pp. 43–54
20. Hellal, F., Mansour, H., Abdel-Hady, M., El-Sayed, S., Abdelly, C. 2019. Assessment water productivity of barley varieties under water stress by AquaCrop model. AIMS Agriculture and Food, 2019, 4(3), pp. 501–517
21. Hu, J., Mansour, H.A., Zhang, H., Abd-Elmabod, S.K., Chang, C. 2019. Application analysis of seawater desalination and drip irrigation system based on renewable energy. Plant Archives, 2019, 19, pp. 2015–2024
22. Hussein, M.M., Pibars, S.K. 2012. Maize response to irrigation system, irrigation regimes and nitrogen levels in a sandy soil. Journal of Applied Sciences Research, 2012, 8(8), pp. 4733–4743
23. Ibrahim, A., Csúr-Varga, A., Jolánkai, M., Mansour, H., Hamed, A. 2018. Monitoring some quality attributes of different wheat varieties by infrared technology. Agricultural Engineering International: CIGR Journal, 2018, 20(1), pp. 201–210
24. Imam, H.M., Pibars, S.K. 2019. Validation of EGY-DRIP program in determining the optimum lateral length. Agricultural Engineering International: CIGR Journal, 2019, 21(4), pp. 14–23
25. Imam, H.M., Pibars, S.K., Soltan, W.M.M. 2019. Studying the hydraulic characteristics of UPVC butterfly valve by CFD technique. Plant Archives, 2019, 19, pp. 377–383
26. Islam, F.H., Abou Leila, B., Gaballah, M., El-Wakeel, H. 2019. Effect of antioxidants on citrus leaf anatomical structure grown under saline irrigation water. Plant Archives, 2019, 19, pp. 840–845
27. Jiandong, H., Hongming, Z., Mansour, H.A., ...Bin, Y., Caixia, T. 2019. Application research of renewable energy in generation electricity, water lifting and drip irrigation systems in Inner Mongolia, China. Plant Archives, 2019, 19, pp. 2002–2014
28. Khalil, S.E. 2016. Alleviating salt stress in Thymus capitatus plant using plant growth-promoting bacteria (PGPR). International Journal of ChemTech Research, 2016, 9(9), pp. 140–155
29. Khalil, S.E. 2020. Review: The effect of salt stress on some physiological and biochemical composition of some crops. Plant Archives, 2020, 20, pp. 3573–3585
30. Khalil, S.E., El-Noemani, A.A. 2012. Effect of irrigation intervals and exogenous proline application in improving tolerance of garden cress plant (Lepidium sativum L.) to water stress. Journal of Applied Sciences Research, 2012, 8(1), pp. 157–167
31. Leithy, S., Gaballah, M.S., Gomaa, A.M. 2010. Associative impact of bio-and organic fertilizers on geranium plants grown under saline conditions. Electronic Journal of Environmental, Agricultural and Food Chemistry, 2010, 9(3), pp. 617–626
32. Mansour Hani, A., Abd-Elmaboud, S.K., Saad, A. 2019. The impact of sub-surface drip irrigation and different water deficit treatments on the spatial distribution of soil moisture and salinity. Plant Archives, 2019, 19, pp. 384–392
33. Mansour Hani, A., Nofal, O.A., Gaballah, M.S., El-Nasharty, A.B. 2019. Management of two irrigation systems and algae foliar application on wheat plant growth. AIMS Agriculture and Food, 2019, 4(3), pp. 824–832
34. Mansour, H.A. 2015. Performance automatic sprinkler irrigation management for production and quality of different Egyptian wheat varities. International Journal of ChemTech Research, 2015, 8(12), pp. 226–237
35. Mansour, H.A., Abd El-Hady, M., Bralts, V.F., Engel, B.A. 2016. Performance automation controller of drip irrigation systems using saline water for wheat yield and water productivity in Egypt. Journal of Irrigation and Drainage Engineering, 2016, 142(10), 05016005
36. Mansour, H.A., Abdallah, E.F., Gaballah, M.S., Gyuricza, C. 2015. Impact of bubbler discharge and irrigation water quantity on 1-hydraulic performance evaluation and maize biomass yield. International Journal of GEOMATE, 2015, 9(2), pp. 1538–1544
37. Mansour, H.A., Abdelghani, S.S., Al-Jughaiman, A., Saad, S.S. 2020. Economic evaluation of subsurface drip irrigation pipe fitting machine. Plant Archives, 2020, 20, pp. 3565–3572
38. Mansour, H.A., Abdel-Hady, M., Eldardiry, E.I., Bralts, V.F. 2015. Performance of automatic control different localized irrigation systems and lateral lengths for:1-Emitters clogging and maize (Zea mays L.) growth and yield. International Journal of GEOMATE, 2015, 9(2), pp. 1545–1552
39. Mansour, H.A., Abd-Elmabod, S.K., Engel, B.A. 2019. Adaptation of modelling to irrigation system and water management for corn growth and yield. Plant Archives, 2019, 19, pp. 644–651
40. Mansour, H.A., Aljughaiman, A.S. 2012. Water and fertilizers use efficiency of corn crop under closed circuits of drip irrigation system. Journal of Applied Sciences Research, 2012, 8(11), pp. 5485–5493
41. Mansour, H.A., Aljughaiman, A.S. 2020. Assessment of surface and subsurface drip irrigation systems with different slopes by hydrocalc model. International Journal of GEOMATE, 2020, 19(73), pp. 91–99

42. Mansour, H.A., El Sayed Mohamed, S., Lightfoot, D.A. 2020. Molecular studies for drought tolerance in some Egyptian wheat genotypes under different irrigation systems. Open Agriculture, 2020, 5(1), pp. 280–290
43. Mansour, H.A., El-Hady, M.A., Eldardiry, E.I., Aziz, A.M. 2019. Wheat crop yield and water use as influenced by sprinkler irrigation uniformity. Plant Archives, 2019, 19, pp. 2296–2303
44. Mansour, H.A., El-Hady, M.A., Eldardiry, E.I., Essa, S.F., Eldwainy, C. 2020. Sustainable agriculture and food - Challenges and solutions: A review. Plant Archives, 2020, 20, pp. 3218–3223
45. Mansour, H.A., El-Hady, M.A., Eldardiry, E.I., Saad, S.S. 2020. Using aquacrop model to evaluate the effect of pulse drip irrigation techniques and water stress on maize water productivity. Plant Archives, 2020, 20, pp. 3232–3242
46. Mansour, H.A., Gaballah, M.S., Nofal, O.A. 2020. Evaluating the water productivity by Aquacrop model of wheat under irrigation systems and algae. Open Agriculture, 2020, 5(1), pp. 262–270
47. Mansour, H.A., Jiandong, H., Hongjuan, R., Kheiry, A.N.O., Abd-Elmabod, S.K. Influence of using automatic irrigation system and organic fertilizer treatments on faba bean water productivity. International Journal of GEOMATE, 2019, 17(62), pp. 250–259
48. Mansour, H.A., Jiandong, H., Pibars, S.K., Feng, B.H., Changmei, L. 2019. Effect of pipes installation by modified machine for subsurface drip irrigation system on maize crop yield costs. Agricultural Engineering International: CIGR Journal, 2019, 21(2), pp. 98–107
49. Mansour, H.A., Pibars, S.K., Abd El-Hady, M., Eldardiry, E.I. 2014. Effect of water management by drip irrigation automation controller system on faba bean production under water deficit. International Journal of GEOMATE, 2014, 7(2), pp. 1047–1053
50. Mansour, H.A., Pibars, S.K., Bralts, V.F.2015. The hydraulic evaluation of MTI and DIS as a localized irrigation systems and treated agricultural wastewater for potato growth and water productivity International Journal of ChemTech Research, 2015, 8(12), pp. 142–150
51. Mansour, H.A., Pibars, S.K., Gaballah, M.S., Mohammed, K.A.S. 2016. Effect of different nitrogen fertilizer levels, and wheat cultivars on yield and its components under sprinkler irrigation system management in sandy soil. International Journal of ChemTech Research, 2016, 9(9), pp. 1–9
52. Mansour, H.A., Saad, A., Ibrahim, A.A.A., El-Hagarey, M.E. 2016. Management of irrigation system: Quality performance of Egyptian wheat. Micro Irrigation Management: Technological Advances and Their Applications, 2016, pp. 279–293
53. Mansour, H.A., Sabreen Kh, P. 2019.Effect of some environmental control parameters and retention time on biogas produced from wastes of buffalo feeding.Plant Archives, 2019, 19, pp. 628–635
54. Mansour, H.A.A. 2015. Design considerations for closed circuit design of drip irrigation system
55. Mansour, H.A.A., Aljughaiman, A.S. 2015. Water and fertilizer use efficiencies for drip irrigated corn: Kingdom of Saudi Arabia. Closed Circuit Trickle Irrigation Design: Theory and Applications, Book Chapter. 2015, pp. 233–249
56. Mansour, H.A.A., El-Hady, M.A., Gyurciza, C.S. 2015. Water and fertilizer use efficiencies for drip irrigated maize. Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp. 207–218
57. Mansour, H.A.A., El-Melhem, Y. 2015. Performance of drip irrigated yellow corn: Kingdom of saudi arabia. Closed Circuit Trickle Irrigation Design: Theory and Applications, Book Chapter. 2015, pp. 219–232
58. Mansour, H.A.A., Mehanna, H.M., El-Hagarey, M.E., Hassan, A.S. Automation of mini-sprinkler and drip irrigation systems. Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp. 179–204
59. Mansour, H.A.A., Tayel, M.Y., Lightfoot, D.A., El-Gindy, A.M. 2015. Energy and water savings in drip irrigation systems. Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp. 149–178
60. Marulanda A, Azcon R, Chaumont F, Ruiz-Lozano, J M, and Aroca, R, 2010. Regulation of plasma membrane aquaporins by inoculation with a Bacillus megaterium strain in maize (Zea mays L.) plants under unstressed and salt-stressed conditions. Planta, 232, 533–543.
61. Mehanna, H.M., Abdelhamid, M.T., Pibars, S.K., El-Noemani, A.-S. 2015. SIRMOD model as a management tool for basin irrigation method in calcareous soil. International Journal of ChemTech Research, 2015, 8(10), pp. 39–44, A006
62. Mehanna, H.M., Gaballah, M.S., El-Gindy, A.M., Arafa, Y.E., Samar, A.R. 2019. Expert system for choosing the components of drip irrigation system head control unit in the egyptian market: Validation process. Plant Archives, 2019, 19, pp. 2121–2125
63. Mehanna, H.M., Pipars, S.K., El-Noemani, A.-S. 2015. Validation of SALTMED model under different water regimes and N fertilizer rates for snap bean. International Journal of ChemTech Research, 2015, 8(10), pp. 1–10, A001
64. Morard, P, Eyheraguibel B, Morard M and Silvestre J, 2011. Direct effects of humic-like substance on growth, water, and mineral nutrition of various species. J. Plant Nutr., 34(1):46-59.
65. Morris M, VA Kelly, RJ Kopicki and D Byerlee, 2007. Fertilizer Use in African Agriculture: Lessons Learned and Good Practice Guidelines. Washington, DC: The World Bank. The Rain Forest Area of Nigeria. Applied Tropical Agriculture 5:20-23.
66. Mukesh K, Sultan SS and Devi S, SK, 2007. Effect of different N sources on yield, nutrients and chlorophyll content of marigold cv pusa Narangi. Juarnal of Environment and Ecology.; 25S: Special, 4:1120-1123.
67. Munns R, 2002. Comparative physiology of salt and water stress. Plant Cell Environ., 25(2):239–250.
68. Munns R, 2005. Genes and salt tolerance: bringing them together. New Phytol, 167(3):645-663.
69. Murakezy P, Nagy Z, Duhazé C, Bouchereau A, Tuba Z, 2003. Seasonal changes in the levels of compatible osmolytes in three halophytic species of inland saline vegetation in Hungary. Journal of Plant Physiology, 160:395-401.
70. Nagarajan, S and Nagarajan S, 2010. Abiotic stress adaptation in plants. Physiological, molecular and genomic foundation (Eds. Pareek, A., Sopory, S. K., Bohnert, H. I, Govindjee). pp. 1-11. Springer, The Netherlands.

71. Nasr, G.E., Tayel, M.Y., Abdelhay, Y.B., Sabreen, K.P., Dina, S.S. 2016. Technical evaluation of a new combined implement for seedbed preparation. International Journal of ChemTech Research, 2016, 9(5), pp. 193–199
72. Nautiyal CS, Srivastava S, Chauhan PS, Seem K, Mishra A, and Sopory S K, 2013. Plant growth-promoting bacteria Bacillus amyloliquefaciens NBRISN13 modulates gene expression profile of leaf and rhizosphere community in rice during salt stress. Plant Physiol. Biochem., 66, 1-9.
73. Naveed M, Mitter B, Reichenauer TG, Wieczorek K, Sessitsch A, 2014. Increased drought stress resistance of maize through endophytic colonization by Burkholderia phytofirmans PsJN and Enterobacter sp. FD17. Environ Exp Bot, 97:30-39.
74. Nehra, B.S.V, 2011. Plant growth promoting rhizobacteria: A critical review. Life Sci. Med. Res., 21–29.
75. Niu, SQ, Li HR, Pare PW, Aziz M, Wang SM, Shi HZ, et al., 2016. Induced growth promotion and higher salt tolerance in the halophyte grass Puccinellia tenuiflora by beneficial rhizobacteria. Plant Soil, 407, 217-230.
76. Ojeniyi SO, 2002. Soil management, national resources and environment. Oke-Ado: Adeniran press. pp 24.
77. Ojeniyi, SO, 2000. Effect of goat manure on soil nutrients and okra yield in the rain forest area of Nigeria. Applied Tropical Agriculture, 5: pp 20-23.
78. Ojo JA, Olowoake AA, Obembe A, 2014. Efficacy of organo-mineral fertilizer and un-amended compost on the growth and yield of watermelon (Citrullus lanatus Thumb) in Ilorin Southern Guinea Savanna zone of Nigeria. Int J Recycl Org Waste Agric, 3:121–125.
79. Osman ASh, Rady MM, 2012. Ameliorative effects of sulphur and humic acid on the growth, antioxidant levels, and yields of pea (Pisum sativum L.) plants grown in reclaimed saline soil. J Hortic Sci Biotechnol, 87(6):626–632.
80. Parida A, Das A, Das P, 2002. NaCl stress causes changes in photosynthetic pigments, proteins, and other metabolic components in the leaves of a true mangrove, Bruguiera parviflora, in hydroponic cultures. Journal of Plant Biology, 45:28-36.
81. Parvaiz A, Satyawati S, 2008. Salt stress and phyto-biochemical responses of plants-a review. Plant Soil and Environment, 54:89-96.
82. Passioura JB, 2005. Drought and drought tolerance. Plant Growth Regul. 199 ,79–83.
83. Pibars, S.K., Eldardiry, E.I., Khalil, S.E., Abd El-Hady, M. 2015. Effect of compost tea on growth character of sunflower (Helianthus Annuus L.) under surface and subsurface drip irrigation. International Journal of ChemTech Research, 2015, 8(6), pp. 490–495
84. Pibars, S.K., Mansour, H.A. 2015. Evaluate the response of sunflower productivity to modern chemigation systems in new reclaimed lands. International Journal of ChemTech Research, 2015, 8(12), pp. 160–169
85. Pibars, S.K., Mansour, H.A. 2016. Evaluation of response sesame water productivity to modern chemigation systems in new reclaimed lands. International Journal of ChemTech Research, 2016, 9(9), pp. 10–19
86. Pibars, S.K., Mansour, H.A., Gaballah, M.S. 2020. Effect of fertilization and irrigation by mixed industrial drainage water on growth of jatropha. Plant Archives, 2020, 20, pp. 2921–2928
87. Pibars, S.K., Mansour, H.A.A., Abd El-Hady, M., Eldardiry, E.E.I. 2015. Evaluation of emitter clogging for drip irrigated snap beans. Closed Circuit Trickle Irrigation Design: Theory and Applications, Book Chapter. 2015, pp. 273–286
88. Qados AMA, 2011. Effect of salt stress on plant growth and metabolism of bean plant Vicia faba (L.). J Saudi Soc Agric Sci, 10(1):7–15.
89. Rabia M.M. Yousef, Soha E. Khalil and Nadia A.M. El-Said, 2013. Response of Echinacea purpurea L. to Irrigation water regime and bio fertilization in sandy soils. World Applied Sciences Journal, 26 (6): 771-782.
90. Sabreen Kh, P., Mansour, H.A. 2019. Effect of tillage management practices and humic acid applications on some engineering properties of peanut. Plant Archives, 2019, 19, pp. 636–643
91. Salama, D.S., Pibars, S.K., Abdelhay, Y.B., Tayel, M.Y., Nasr, G.E.-D.M. 2018. Developing a combined machine for seedbed preparation. Agricultural Engineering International: CIGR Journal, 2018, 20(1), pp. 90–94
92. Seleem, F.M., Khalil, S.E. 2018. Response of marigold (Calendula officinalis L.) Plant to irrigation water regime and exogenous application of silicon. Bioscience Research, 2018, 15(4), pp. 4322–4334
93. Soha E. Khalil and Abdel-Salam Ali El-Noemani, 2015. Effect of bio-fertilizers on growth, yield, water relations, photosynthetic pigments and carbohydrates contents of Origanum vulgare L. plants grown under water stress conditions. American-Eurasian Journal of Sustainable Agriculture, 9 (4): 60-73.
94. Soha E. Khalil and Abdel-Salam Ali El-Noemani, 2015. Effect of bio-fertilizers on growth, yield, water relations, photosynthetic pigments and carbohydrates contents of Origanum vulgare L. plants grown under water stress conditions. American-Eurasian Journal of Sustainable Agriculture, 9 (4): 60-73.
95. Soha E. Khalil and Ashraf M. Khalil, 2015. Effect of water irrigation intervals, Compost and Dry Yeast on Growth, Yield and Oil Content of Rosmarinus officinalis L. plant. American-Eurasian Journal of Sustainable Agriculture, 9 (5): 36-51.
96. Soha E. Khalil and Ashraf M. Khalil, 2015. Effect of water irrigation intervals, Compost and Dry Yeast on Growth, Yield and Oil Content of Rosmarinus officinalis L. plant. American-Eurasian Journal of Sustainable Agriculture, 9 (5): 36-51.
97. Soha E. Khalil and Bedour H. Abou Leila,2016. Effect of Magnetic treatment in improving Growth, Yield and fruit quality of Physalis pubescens plant grown under saline irrigation conditions. International Journal of ChemTech Research, 9(12): 246-258.
98. Soha E. Khalil and Bedour H. Abou Leila,2016. Effect of Magnetic treatment in improving Growth, Yield and fruit quality of Physalis pubescens plant grown under saline irrigation conditions. International Journal of ChemTech Research, 9(12): 246-258.

99. Soha E. Khalil, 2016. Alleviating salt stress in Thymus capitatus plant using plant growth-promoting bacteria (PGPR). International Journal of ChemTech Research, 9(9):140-155
100. Soha E. Khalil, 2016. Alleviating salt stress in Thymus capitatus plant using plant growth-promoting bacteria (PGPR). International Journal of ChemTech Research, 9(9):140-155
101. Soha E. Khalil1 and Rabia M.M. Yousef, 2014. Study the effect of irrigation water regime and fertilizers on growth, yield and some fruit quality of Hibiscus sabdariffa L. International Journal of Advanced Research, 2(5), 738-750.
102. Soha E. Khalil1 and Rabia M.M. Yousef, 2014. Study the effect of irrigation water regime and fertilizers on growth, yield and some fruit quality of Hibiscus sabdariffa L. International Journal of Advanced Research, 2(5), 738-750.
103. Soha E. Khalil1 and Rabie M.M. Yousef , 2014. Interaction Effects of different soil moisture levels, Arbuscular Mycorrhizal Fungi and three phosphate levels on: I- Growth, yield and photosynthetic activity of Garden Cress (Lepidium sativum L.) plant. International Journal of Advanced Research, 2(6):723-737.
104. Soha E. Khalil1 and Rabie M.M. Yousef , 2014. Interaction Effects of different soil moisture levels, Arbuscular Mycorrhizal Fungi and three phosphate levels on: I- Growth, yield and photosynthetic activity of Garden Cress (Lepidium sativum L.) plant. International Journal of Advanced Research, 2(6):723-737.
105. Soha E.Khalil and Fatma M. Seleem, 2019. Role of biochar soil amendment for alleviation of adverse effects of water stress on Dimorphotheca ecklonis plants. Bioscience Research, 16(2):1337-1353.
106. Soha E.Khalil and Fatma M. Seleem, 2019. Role of biochar soil amendment for alleviation of adverse effects of water stress on Dimorphotheca ecklonis plants. Bioscience Research, 16(2):1337-1353.
107. Tayel M.Y., Sabreen Kh.P., 2011. Effect of irrigation regimes, phosphorous level and two vica faba varities on II-yield, water and phosphorous use efficiency. Journal of Applied Sciences Research, 2011, 7(11), pp. 1518–1526
108. Tayel, M.Y, El-Gindy, A.M, Mansour, H.A. 2012. Effect of drip irrigation circuits design and lateral line length on: IV-uniformity coefficient and coefficient of variation. Journal of Applied Sciences Research, 2012, 8(5), pp. 2741–2748
109. Tayel, M.Y., El-Dardiry, E.I., Shaaban, S.M., Sabreen, K.P. 2010. Effect of injector types and irrigation and nitrogen levels on: III - cost analysis of garlic production. Journal of Applied Sciences Research, 2010, 6(7), pp. 822–829
110. Tayel, M.Y., El-Gindy, A.M., Mansour, H.A. 2012. Effect of drip irrigation circuits design and lateral line length on: III-dripper and lateral discharge. Journal of Applied Sciences Research, 2012, 8(5), pp. 2725–2731
111. Tayel, M.Y., Ismaiel, M., Shaaban, S.M., Mansour, H.A. 2016. Some techniques used to minimize fuel consumption and wheel slip in crop production growth on clay loam soil. International Journal of PharmTech Research, 2016, 9(12), pp. 792–798
112. Tayel, M.Y., Mansour, H.A., Pibars, S.K. 2019. The hydraulic evaluation of drip irrigation system by hydrocalc model under different dripper types and low quality water. Plant Archives, 2019, 19, pp. 554–561
113. Tayel, M.Y., Mansour, H.A.A., Pibars, S.K. 2015. Performance of drip irrigated soybean Closed Circuit Trickle Irrigation Design: Theory and Applications, Book Chapter. 2015, pp. 250–263
114. Tayel, M.Y., Mansour, H.A.A., Pibars, S.K. 2015. Performance of maize under bubbler irrigation system Closed Circuit Trickle Irrigation Design: Theory and Applications, Book Chapter. 2015, pp. 135–147
115. Tayel, M.Y., Mansour, H.A.A., Pibars, S.K. 2015. Performance of sprinkler irrigated wheat – part I Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp. 23–40
116. Tayel, M.Y., Pibars, S.K., Mansour, H.A. 2019.The impact of different closed drip irrigation networks and dripper type on pressure distribution along lateral lines and uniformity. Plant Archives, 2019, 19, pp. 548–553
117. Tayel, M.Y., Pibars, S.K., Mansour, H.A.A. 2015. Evaluation of emitter clogging. Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp. 287–300
118. Tayel, M.Y., Sabreen, K.P. 2011. Effect of irrigation regimes and phosphorus level on two vica faba varieties: 1- growth characters. Journal of Applied Sciences Research, 2011, 7(6), pp. 1007–1015
119. Tayel, M.Y., Shaaban, S.M., Eldardiry, E.A., Mansour, H.A. 2018. Wheat yield versus seed bed conditions. Bioscience Research, 2018, 15(3), pp. 1943–1951
120. Tayel, M.Y., Shaaban, S.M., Mansour, H.A. 2015. Effect of plowing conditions on the tractor wheel slippage and fuel consumption in sandy soil. International Journal of ChemTech Research, 2015, 8(12), pp. 151–159
121. Tayel, M.Y., Shaaban, S.M., Mansour, H.A. 2019. Impact of seedbed preparation condition on aggregates stability, yield, water productivity and fertilizers use efficiency on maize (Zea mays). Plant Archives, 2019, 19, pp. 706–710
122. Tayel, M.Y., Shaaban, S.M., Mansour, H.A., Abdallah, E.F. 2016. Response of fodder beet plants grown in a sandy soil to different plowing conditions. International Journal of ChemTech Research, 2016, 9(9), pp. 20–28
123. Yassen, A.A., Abdallah, E.F., Gaballah, M.S. 2011. Response of sunflower plants to nitrogen fertilizers and phytohormones under drainage water irrigation. Australian Journal of Basic and Applied Sciences, 2011, 5(9), pp. 801–807
124. Yassen, A.A., Abdallah, E.F., Gaballah, M.S., Zaghloul, S.M. 2018. Alleviation of salt stress on roselle plant using nano-fertilizer and organic manure. Bioscience Research, 2018, 15(3), pp. 1739–1748
125. Yousef, R.M.M., Khalil, S.E., El-Said, N.A.M. 2013. Response of Echinacea purpurea L. to irrigation water regime and biofertilization in sandy soils. World Applied Sciences Journal, 2013, 26(6), pp. 771–782