



An-Najah National University
Faculty of Graduate Studies

**EFFECT OF OSMO-REGULATORS ON
GROWTH AND PRODUCTION OF PEPPER
(*CAPSICUM ANNUUM*) UNDER SALINE
CONDITION**

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Declaration

I, the undersigned, declare that I submitted the thesis entitled:

EFFECT OF OSMO-REGULATORS ON GROWTH AND PRODUCTION OF PEPPER (*CAPSICUM ANNUUM*) UNDER SALINE CONDITION

I declare that the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

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Abstract

Abiotic stress factors are the most limiting for plant growth and production. Drought caused by water shortage is among the most impacting factor. Palestine has most of the limited renewable water resources. The agricultural sector depends on 51.5% of the total water consumption. Thus, is highly affected. Another major factor that limits productivity is high salinity mainly in arid and semi-arid region like Palestine, the deleterious impact of salinity is associated with water stress as well as nutritional imbalance. Therefore, this study was conducted to evaluate the use of DISPER as an osmoregulator on pepper growth under saline condition.

Three levels of Osmo-Regulators (DISPER Osmotic GS) with (0, 0.5, and 1 g/plant) combined with three salt concentrations (0, 100, and 200 mM) of sodium chloride were used. The experiments were conducted in Tulkarm in northern Palestine. Pepper seedlings (*Capsicum annuum*) variety (Sharbaty) were grown in a greenhouse under natural light condition during the period from 14th October, 2021 to the 22nd January, 2022. One plant was grown in each pot (30 X30cm diameter and height). Filled with a soil mixture of 2:1 sand to peatmoss. The results revealed positive effect of adding DISPER Osmotic GS on plant growth and production of pepper plants under salinity stress. DISPER Osmotic salinity levels of saline water irrigated (100, and 200 mM) saline water, the researcher obtained the best result on chlorophyll content of pepper leaves by (53.775, 41.175 mg/m³) and flower parameters by (12.500, 6.500) respectively, compared to the controller. In addition, the results showed a higher fresh weight of root (14.090, 9.250 g) and the average length of fruits (12, 6 cm) for all measurements respectively. The of DISPER Osmotic GS at 0.5 and 1 gm increased the average area of leaves (179 cm², 169.63²). As a result, DISPER application can be used to alleviate the salinity harmful effects on plant growth and development of pepper plants under saline condition.

Keywords: Osmotic GS, DISPER, Salinity irrigation levels, Saline water.

Chapter One

Introduction

In the past forty years, with increasing population growth, the demand for water increased, especially in 1950, when the world population was 2.5 billion. By 1996, the world's population had more than doubled, to 5.77 billion people. Every year an additional 100 million people are added (Population Reference Bureau, et al., 1996). Scientists have presented that in a world where population growth exceeds water and food supplies, agricultural and plant biotechnologies aimed at overcoming all severe environmental pressures must be fully implemented (De Oliveira, Mendes Alencar, and Gomes-Filho et al., 2013).

The water shortage is aggravated not only by population growth, but water management in most countries is flawed and an addition to natural disasters and environmental pollution. Geopolitical considerations also affect water policy, as in Palestine, and prevent its optimal utilization. Over 90% of the freshwater resources are used by Israel, while less than 10% is the Palestinian share (Palestinian Water Authority, 2011; Kouttab, 2013).

1.1 Saline water and the effect of irrigation on production

Water strategy and global freshwater scarcity are imposing the demand for using nonconventional water resources for irrigation and non-irrigation purposes (Salem., Yihdego., and Muhammed, et al., 2021). Ecological sustainability has led to the introduction of treated saline water for irrigation is an important tool for limited water, although plants differ in their ability to tolerate saline water. The extent of yield reduction when plants are irrigated with saline water depends on a number of soil texture including , drainage, irrigation frequency, method and time of irrigation. This requires evaluation of the suitability of water for irrigation and know the chemical composition of it (Qadir, Mansoor, et a,2017). Whereas more than 78.46% of the land area in the world is affected by salinity stress (Ashraf-Uz-Zaman, Kh, et al., 2015). However, the reuse of saline water for irrigation can have negative effects of salt on plant growth were initially associated with the osmotic stress component caused by the reduced soil water potential, thus restricting water uptake by roots (Oliveira, Alencar, et al., 2021). Thus, on global level water has a significant impact on the economy, and its scarcity of up to 20% leads to a decrease in GDP by up to 12% (Taheripour, et al., 2020). As a result, further study is

needed to reduce the negative impacts of salinity on crops. Soil salinity is a serious obstacle to food production because it prevents previously farmed land from being used. Because it has a negative impact on plant growth and development, the condition has a major impact on agricultural production, lowering crop yields by more than 20% (Purcell et al., 2012).

There are gaps in our knowledge of the effects of irrigation water quality and amount on yield and postharvest quality of pepper fruit (*Capsicum annuum L.*). In studied by Fallik, et al., (2019) to effects of water quality and quantity treatments on pepper fruits during subsequent simulated storage and shelf-life. “Total yield decreased with increasing water salinity, but export-quality yield was not significantly different in fruits irrigated with water of either 1.6 or 2.8 dS/m, but there was a 30–35% reduction in export-quality yield following use of water at 4.5 dS/m. Water quantity hardly affected either total or export-quality yield. Water quality but not quantity significantly affected fruit weight loss after 14 days at 7 °C plus three days at 20 °C; irrigation with water at 2.8 dS/m gave the least weight loss. Fruits were significantly firmer after irrigation with good-quality water than with salty water. The saltier the water, the higher was the sugar content. Vitamin C content was not affected by water quality or quantity, but water quality significantly affected antioxidant (AOX) content. The highest AOX activity was found with commercial quality water, the lowest with salty water. Pepper yield benefited by irrigation with fresh water (1.6 dS/m) and was not affected by water quantity, but post-storage fruit quality was maintained better after use of moderately-saline water (2.8 dS/m). Thus, irrigation water with salinity not exceeding 2.8 dS/m will not impair postharvest quality, although the yield will be reduced at this salinity level”.

The salinity of soil, has major causes, a problem with the wrong management of water and soil, the high rate of evaporation in addition to the low rate of rainfall (Arzani, 2008). Plants growing in saltwater soils are exposed to a variety of physiological stresses that result in nutritional imbalances, cell organelle destruction, photosynthesis, and respiration disruption (Juniper and Abbott, 1993; Evelyn et al., 2012).

“Availability of fresh surface water for irrigation is declining and saline ground water is increasingly used for irrigation”. In studied by NAGM AL DEEN, et al., (2019) “a field experiment was carried out on a sandy soil at cultivation experimental site, Agriculture

Research Center (ARC), Ministry of Agriculture and Land Reclamation during summer and winter season of 2017-2018 in Egypt, to evaluate the effect of water quality and drip irrigation management on sweet pepper (*Capsicum annuum L. cv. Top star*) plants under surface drip irrigation. The experiment consists of three treatments of water salinity (EC) with and without adding the needed leaching requirements (LR). The water salinity treatments were the control (Sc) where EC = 0.4ds/m, (S3ds/m) where EC = 3ds/m and (S5ds/m) where EC = 5ds/m, leaching requirement (LR) was applied after 2 months from transplanting. LR treatments were ScLR; S3LR and S5LR. It was found that irrigation with different salinity levels and Leaching requirement both affected the growth characteristics, yield and irrigation water productivity of sweet pepper plant. It was concluded that more salt accumulation in the root zone could lead to higher potential yield losses of sensitive and moderately sensitive crops, such as sweet peppers. Also, it was found that the higher the salinity in the irrigation water the less the plant height, the roots fresh weight, and the number of fruits per plant. As well as the higher the salinity in the irrigation water the more concentration of Na, cl, TSS and proline in fruits”.

1.2 Mitigation of the adverse impact of soil and water salinity

Salinity, which results from high salt concentrations in the soil and water, presents serious difficulties for crop production and plant development. Numerous techniques and tactics have been developed to combat the negative consequences of salt. The review will concentrate on several methods, such as soil management practices, irrigation methods, genetic and breeding techniques, and the application of chemical and biological agents.

In studies by Mohanavelu, et al., (2021) to highlight the global prevalence of salinity in irrigated areas, highlight their spatiotemporal variability and causes, document the effects of irrigation induced salinity on physicochemical properties of soil and groundwater, and discuss practical, innovative, and feasible practices and solutions to mitigate the salinity. Salinity has been a major environmental hazard of the past century since more than 25% of the total land and 33% of the irrigated land globally are affected by salinity. Adverse effects of soil salinity include inhibited crop growth, waterlogging issues, groundwater contamination, loss in soil fertility. Salinity also has an enormous impact on food security since a substantial portion of the world’s irrigated land is affected by them. Mitigating the risk of salinity while continuing to irrigate the land, for example, by growing salt-

resistant crops such as halophytes together with regular crops or creating artificial drainage appears to be the most practical solution as farmers cannot halt irrigation.

Soil management practices are essential in reducing salt stress. It has been demonstrated through research by Munns and Tester (2008) and Hameed et al. (2019) that techniques including leaching, drainage, and improving soil structure through the addition of organic matter can significantly reduce salt buildup in the root zone. Furthermore, soil amendments such as gypsum. In addition to DISPER Osmotic GS and organic matter can strengthen the soil structure and make it easier for extra salt to be washed out.

DISPER Osmotic GS's effects on soil properties, salt leaching, and plant growth under saline conditions

Disper Osmotic regulator GS Strigolactone refers to a commercial product that acts as an organic activator whose molecules regulate the process of osmosis and is designed against stress caused by increased salinity (Altemimy& Abed (2019)). It has two main functions: first, as an organic matter 47%, and sugars 9% to increase vegetative growth (Altemimy& Abed (2019)). “When the sun’s energy is used to combine CO₂ and water to form sugars, the initial high-energy product is ATP. The ATP is then used as the energy source for many other chemical reactions” (Prajapati and Modi (2012)). Moreover, it improves nutritional balance at the foliar level, increasing the quality and production of the crop as nano-fertilizers (Altemimy& Abed (2019)). As it contains soluble calcium 4.3%, calcium complex with EDTA 1.2%, and potassium 12.5% it was found to reduce foliar damage caused by salinity effect (Altemimy & Abed, 2019), Potassium is second to nitrogen in plant tissue levels with ranges of 1 to 3% by weight (Prajapati and Modi, 2012). Indeed, a review of the available literature indicated that the use of DIAPER Osmotic GS reduced salt stress in both soil and vegetation on date palm trees. The results showed an increase in the weight of the fruit flesh, its length, and weight, and a decrease in the rate of fruit dropping (Altemimy & Abed, 2019).

Practices for managing the soil are essential in reducing salt stress. It has been demonstrated through research by Munns and Tester (2008) and Hameed et al. (2019) that techniques including leaching, drainage, and improving soil structure through the addition of organic matter can significantly reduce salt buildup in the root zone. In

addition, soil amendments, including gypsum, DISPER Osmotic GS, and organic matter can strengthen the structure of the soil and make it easier for extra salt to be leached out.

DISPER Osmotic GS has demonstrated potential in the leaching of Excess Salts from the Soil. The adjustment encourages the movement of salts downward and away from the root zone, according to studies by Li et al. (2017) and Wu et al. (2020). This makes it easier for salts to be leached out of the soil, which lowers the salinity levels.

The use of DISPER Osmotic GS contributes to plant development, improves soil structure, and facilitates the leaching of salt away from the root system of plants. Plants cultivated in soil amended with DISPER Osmotic GS exhibit improved root development, nutrient uptake, and general growth performance, according to studies by Wang et al. (2018) and Liu et al. (2021). The amendment improves the environment for plant growth by reducing salt stress.

The management of salinity in water sources depends on effective irrigation techniques. Katerji et al. (2015) and Rahmati et al. (2017) have shown that drip irrigation and spray irrigation techniques are both effective at preventing salt buildup in the root zone. These methods encourage uniform water distribution and reduce plant exposure to salty water, which prevents salt buildup.

Crops can be made more tolerant to salt through genetic and breeding strategies and breeding techniques. The significance of creating salt-tolerant cultivars by conventional breeding, marker-assisted selection, and genetic engineering methods has been underlined in studies by Flowers et al. (2010) and Munns et al. (2012). By introducing genes for salt tolerance features such ion exclusion, osmotic adjustment, and antioxidant defense mechanisms. Crop damage from salt is decreased through grafting (Orosco-Alcalá et al., 2021). Utilize the genotypes of the pepper (*Capsicum annuum*) to determine how it responds to salt (Aktas, Abak, and Cakmak 2006).

using chemical additions can aid soil that is suffering from salt stress. The efficacy of additions like gypsum, lime, and sulfur in lowering soil salinity has been studied by Rengasamy (2010) and Qadir et al., (2014). These amendments function by changing the pH of the soil, increasing the availability of nutrients, and encouraging the leaching of salts from the root zone. Application of nanosilicon reduces the detrimental effects of salt

on sweet pepper plants (Tantawy et al., 2015). According to El-Afifi et al. (2017), amendments can be used to help sweet pepper plants cope with salinity stress.

Biological agents, such as mycorrhizal fungi and salt-tolerant plant growth-promoting rhizobacteria (PGPR), have demonstrated potential for enhancing plant development in saline environments. The function of PGPR and mycorrhizal associations in increasing nutrient uptake, osmotic adjustment, and antioxidant defense mechanisms in plants exposed to salinity stress has been highlighted in studies by Egamberdieva *et al.*, (2017) and Khan *et al.*, (2019). Create advantageous connections with the many bacteria and microorganisms that can be found in the roots and assist to reduce the symptoms of stress (Stolte et al., 2015). *Azospirillum brasiliense* and *Pantoea dispersa* are plant growth-promoting bacteria inoculants that have been used to increase the salinity tolerance of sweet pepper (Del Amor, and Cuadra-Crespo, 2011).

To address these salt stress, innovative technologies such as Disper Osmotic regulator GS (Gel System) have emerged as potential solution. Disper Osmotic regulator GS Strigolactone refers to a commercial product that acts as an organic activator whose molecules regulate the process of osmosis and is designed against stress caused by increased salinity (Altemimy& Abed. et al., 2019).

1.3 Vegetables production in Palestine

Ministry of Agriculture and the Palestinian Central Bureau of Statistics estimated the total area of agricultural land in Palestine at 1.21 million dunams in 2021-2022. The area of vegetables in Palestine was estimated about 202.3 thousand dunams. In Palestine, different varieties of vegetables, and fruits are grown (Nassar et al., 2007).Vegetables account for 65% of the agricultural sector's production. This is mainly the Palestinian water sector should allocate water to a crop like vegetables which brings the best return to water suppliers (Nassar et al., 2007). Estimate the average productivity of vegetables 65%, according to the Ministry of Agriculture.

In the Palestinian economic sector, the total amount of water available is estimated at about 279 Mm³/year (World Bank, 2004). From the total rate, agriculture in its two types, protected and open field, about 178 Mm³/year goes to the agricultural sector, which makes up more than 63 per cent of the country's total amount of water use (Nassar et al., 2007).

The protected irrigated area is only limited to 19.7% of the agricultural vegetable area in the West Bank. The area of open field irrigated agriculture is limited to 66.3% of the vegetable area in the West Bank (PCBS, 2022).

1.4 Production of pepper in Palestine

Pepper (*Capsicum annum*) is of the Solanaceae family, originated in South and Central America, and includes about 35 species, 30 of which are wild and 5 are domestic (Mala et al., 2021). All cultivars of the Capsicum genus contain twelve chromosomes. The fruits produced are hollow in shape and contain pungent capsaicin (Csilléry., 2006). The white flowers group has small, soft fruits, thin branches, leaves, and a slightly hairy stem (Csilléry., 2006).

Pepper has great economic importance worldwide and very popular in the market. It is consumed as a fresh food or as a dried and ground spice (González-García, 2021). Pepper is a good source of vitamins A and C and nutritional antioxidants. Levels of these compounds depend on fruit ripening, genotype, and processing (Howard et al., 1994). Pepper has biochemical and pharmacological effects, including antioxidant, anti-inflammatory, and anti-allergic natural compounds (Havesteen, 1983).

It is currently widely cultivated in the Mediterranean region (Tripodi, Pasquale, et al., 2018). Pepper crop is classified as moderately sensitive to salinity, showing a salinity threshold of 1.2 - 3.0 dS/m. (Pezo, Carolina, et al., 2020). Various investigations on the pepper plant's tolerance to salinity have been conducted. Salt stress causes yield loss in pepper crops. To optimize pepper production profitability, and ensure the most efficient use of saline water resources; there is a clear need for comprehensive information regarding crop water use of grown pepper in the horticultural system. Consequently, to maximize pepper production in saline water conditions. The study showed that the irrigation water of 4.4 dS/m resulted in a 46% decrease in the dry weight of the plant (leaves in addition to the stem) and a 25% decrease in the marketable yield. While the increase in the electrical conductivity of the irrigation water to 8.5 dS/m caused a 34% decrease in the dry weight and a 58% decrease in marketable yield (De Pascale, Stefania, et al., 2003).

In studies by Haj-Amor, et al., (2022). Allot of research has been conducted on the effects of soil salinity issue on agricultural productivity. However, limited consideration has been given to its effects soil microorganisms, soil organic carbon and greenhouse gas (GHG) emissions. This article is based on synthesis of information for many articles on these effects of soil salinity. The result show that: (a) salinity affects microbial community composition and soil enzyme activities due to changes in osmotic pressure and ion effects; (b) soil salinity reduces soil organic carbon (SOC) content; (c) soil salinity can reduction of yield crop up to 58 %; (d) even at low levels of soil salinity, can cause profound alteration in soil bio-diversity; (f) due to severe soil salinity, some soils are reaching critical desertification status; (g) innovate mitigation strategies of soil salinity need to be approached in a way that should support the United Nations Sustainable Development Goals (UN-SDGs).

1.5 Objectives of the study

The study aims to investigate the application of DISPER Osmotic GS on pepper under saline conditions. The specific objectives of the study are:

- A. To study the effects of DISPER Osmotic GS on the growth of pepper plants under saline conditions.
- B. Determine the effect of salinity on some plant growth parameters of pepper plants including stem, root, chlorophyll content-as well as on some soil parameters.

Chapter Two

Literature review

2.1 Effect of saline water on plant growth of pepper

Vegetable crops are considered one of the most susceptible crops to be affected by water salinity. To optimize pepper production, and profitability, and to ensure the most efficient use of available water resources; there is a clear need for comprehensive information regarding crop used salt water and effect of use on irrigation pepper in the horticultural system. Under saline conditions, sodium chloride is usually the most abundant salt, which strongly inhibits plant growth and productivity (Lauer, 2023) (Paridam and Das, 2005) for two reasons, the first being an osmotic effect “Osmotic pressure can be defined as the minimum pressure that must be applied to a solution to halt the flow of solvent molecules through a semipermeable membrane (osmosis). It is a colligative property and is dependent on the concentration of solute particles in the solution” and the second by the effect of an excess NaCl ion “Sodium may damage roots through direct toxicity and kill sensitive plants. High levels of sodium can destroy the aggregate structure of fine- and medium-textured soils. This decreases porosity and prevents soil from holding sufficient air and water needed for plant growth”. In addition, plants exposed to salinity stress conditions produce Activated oxygen is cytotoxic, which causes disruption of the normal metabolism process in plants (Abbaspour, 2012). As a result of this, the chemiosmotic regulatory systems of plants utilize (H⁺-) ATP-ases for the sequestration of protons to generate (H⁺) electrochemical gradients, which drive transport nutrient and secondary ion processes via H⁺-symport/antiport systems. These H⁺-ATPase pumps also adjustment pH for both intra-cellular and extra-cellular.

“Salinity as a global challenge is a very complex issue in agricultural food production. In studied by Ahmadi, et al., (2020) the growth characteristics of chili pepper (*Capsicum annuum* var. crusader) were evaluated under higher Electrical Conductivity (EC) (5 dS/m) induced by NaCl, KCl, K₂SO₄ or “All Nutrients” of Hoagland nutrient solution. The standard Hoagland solution (with EC 1.8 dS/m) was used as the control. The results showed that EC5 induced by NaCl resulted in the most negative effects on growth, yield and fruit quality parameters. Application of KCl (to induce EC5) also resulted in some reduction in growth parameters. However, application of K₂SO₄ and particularly “All Nutrients” (to induce EC5) resulted in better growth characteristics compared to plants

treated with NaCl or KCl salts. There was a significant reduction in growth and fruit quality traits including plant height, leaf SPAD value, fresh and dry weights of shoots and roots, fruit fresh yield, fruit total soluble solids (TSS) and vitamin C content by NaCl and to lesser extent by KCl. However, there was no significant reduction in these traits by “All Nutrients” and for some traits by K₂SO₄ application compared to control plants.

Most plant cells maintain cytosolic K⁺ concentrations in the range of 100–200 mM and Na⁺ values in the low mM range (1–10 mM) up to a maximum of 100 mM (Maathuis and Amtmann, 1999). In contrast, an essential cation (K⁺) for maintaining biochemical interactions of the cytoplasm, Na⁺ isn't essential for, but does facilitate, volume regulation and growth in most plants. However, at high (Na⁺) concentrations limits growth (Blumwald, 2000). The productivity of irrigated agricultural regions is generally greater than non-irrigated areas, yet irrigated crops are most susceptible to detrimental salinity effects. Therefore, genetic engineering of crop plants to improve their capacity for (Na⁺) transport and sequestration is an important goal for meeting the future food and fiber demands of a rapidly growing human population (Cushman, J. C. 2001).

Non-pungent and pungent peppers are an important crop in all world, being grown for fresh consumption, spice, medicinal purposes and ornamentation. (Zamagljen, Tien, et al., 2022). Four *Capsicum annum* L. genotypes (‘Caro F1’, ‘Berenyi F1’, ‘Somborka’ and ‘Novosadka’) were exposed to two concentration of salt stress. Result shows a significant decrease in the sugar percent in all salt stressed treatments, except for the sucrose content of the pericarp of the ‘Caro F1’ cultivar. "Salt stress had a largely negative effect on the total and individual organic acid content, although the effect differed among cultivars", and we observed using high performance liquid chromatography coupled with a mass spectro-meter, "most phenolics were identified in the pericarp (18), followed by the placenta (7) and seeds (8)". Treatment with 40 mM salt caused the highest increase in individual phenols, followed by treatment with 20 mM NaCl. The cultivar ‘Berenyi F1’ was less affected by salt stress treatment. Capsaicinoids content increased in all the cultivars.

Soil salinity also poses a severe environmental restriction limiting the availability of land for sustainable agriculture and has emerged as a serious issue for global food security (Etesami and Hassan, et al., 2021). Salinity has major causes, a problem with the wrong

management of water and soil, the high rate of evaporation in addition to the low rate of rainfall (Arzani, 2008). It is estimated that currently about 62 million hectares (20% of cultivated land worldwide) irrigated land is affected by salinity and the amount is increasing day by day, especially in arid and semi-arid regions of the world (Etesami and Noori, 2019). The effect of irrigation with salt water on the productivity and quality of pepper and to study the changes in fruit quality that occur during the maturity stages (Navarro, et ., 2010) al. The plants were grown under greenhouse conditions in perlite, using irrigation with salt water (15 and 30 mM NaCl). Fruits were harvested in three states of maturity (green, turning, and red). The results showed a linear relationship between sodium chloride concentration and a decrease in total pepper production. Despite this decrease, the marketable yield did not decrease due to the increase in the average weight of the marketable fruit. Although salinity also reduced fruit size, the number of marketable fruits was the most important reason for the decline in marketable yield.

Plants growing in saltwater soils are exposed to a variety of physiological stresses that result in nutritional imbalances, cell organelle destruction, and photosynthesis and respiration disruption (Juniper and Abbott, 1993; Evelyn et al., 2012). Moreover, research by Khan et al. (2019) and Santos et al. (2017) has shown that saltwater irrigation of pepper crops might adversely affect plant growth and physiological processes. According to (Qiu, Rangjian, et al., 2017). It has been proved that irrigation with high saline water and "leaching fraction" (LF) affect crop yield. We therefore investigated the effects of effects of irrigation water salinity (EC_{iw}) and LF on the yield, fruit quality, and ion content of hot peppers. An experiment using five levels of salinity (EC_{iw} of 0.9, 1.6, 2.7, 4.7, and $7.0 \text{ dS}\cdot\text{m}^{-1}$) and two LFs (17% and 29%) was conducted . The plants were irrigated for 120% and 140% evapotranspiration, corresponding to an LF of 0.17 and 0.29. "Results showed decreased the total fruit yield significantly with an increase in the EC_{iw} as a result of reduction both in the fresh weight of fruit and the number of fruit per plant. An increase in the EC_{iw} also led to a decrease in the total dry biomass of fruit and plant, as well as decreasing water use efficiency (WUEF). Salinity reduced the appearance of the fruit by both decreasing the length (FL) and maximum width (FMW) of the fruit. However, increased EC_{iw} also improved the taste of the hot peppers by increasing the total soluble solid (TSS) content, as well as adding to their nutritional quality with a higher content of Vitamin C (VC). Their storage quality was also improved because of an improvement in

the firmness of the fruit (F_n) as well as a reduction in the fruit water content (FWC). An increase in the LF led to an increase in the total fruit yield, total dry biomass of fruit and plant, and WUEF; it also increased the FWC and VC content, and decreased the FMW and fruit shape index (FSI)".

According to numerous research, irrigation water with excessive saline levels has a detrimental effect on the development of pepper crops. Khan et al. (2018) and Ahmed et al. (2020) conducted studies that showed pepper plants' plant height, leaf area, and shoot biomass decreased when irrigation water's saline levels increased. These results demonstrate the salt sensitivity of pepper crops and the consequent effect on their overall growth. In studies by Wahid et al. (2018) and Genc et al. (2020), the mechanisms of salt tolerance in pepper plants receiving saltwater irrigation were investigated. Osmotic adjustment, ion compartmentalization, antioxidant defense mechanisms, and compatible solute buildup are some of these mechanisms. The development of solutions to improve salt tolerance in pepper crops grown under saltwater irrigation can be aided by an understanding of these mechanisms.

In studied by Silva, et al., (2020) in a greenhouse at Federal Rural University of the Semi-Arid Region to evaluate the effects of salinity and K^+/Ca^{2+} ratios on bell pepper production. "The experimental design consisted of randomized blocks in a 5 x 4 factorial scheme with four replicates, corresponding to five K^+/Ca^{2+} ratios ($F_1 = 3.3/1$, $F_2 = 2.8/1$, $F_3 = 2.2/1$, $F_4 = 1.8/1$, and $F_5 = 1.5/1$) and four salinity levels in the nutrient solution using NaCl (1.75, 3.25, 4.75, and 6.25 dS m⁻¹). The following parameters were evaluated: the number of fruits (total, marketable and unmarketable), the mean weight of fruits (marketable and unmarketable), fruit production (total, marketable and percentage of marketable fruits) and a salinity tolerance index. Generally, nutrient solution enrichment with K^+ or Ca^{2+} did not cause significant increments in bell pepper yield. The fertigation treatments F_2 , F_3 , and F_5 led to a higher bell pepper tolerance to salinity, allowing waters with higher salt concentrations to be used without causing a reduction in the yield".

2.2. The impact of fertilizer uses on soil salinity

The accumulation of soluble salts in the soil, known as soil salinity, is a significant problem that has an impact on agricultural production all over the world. To improve crop growth and yeild, fertilizer application is a prevalent technique in modern agriculture. Sustainable agriculture is threatened by rising soil salinity, which can result from improper or excessive fertilizer use.

Although soil health management is vital for the maintenance of biodiversity and safeguarding sustainable agricultural production. The health of soil is regulated by soil properties, that is, physicochemical and biological properties. When sustainable agriculture is the global target, the troublesome effects of excessive use of fertilizers cannot be ignored. However, continuous utilization of chemical fertilizers is responsible for the decline of soil organic matter (SOM) content coupled with a decrease in the quality of agricultural soil and hardens it, reduces soil fertility, pollutes air, water, and soil, and lessens important nutrients of soil and minerals, thereby bringing hazards to environment. So, the employment of fertilizers not only increases crop productivity, but also alters soil physicochemical and biological properties research by (Pahlavi, et al, (2021).

Salinity and nutrient imbalance excessive use of fertilizers, especially nitrogen-based fertilizers, can destroy the soil's nutrient balance, which increases salinity. According to research by Ghassemi et al., (1995) and Hussain et al., (2017), excessive nitrogen fertilizer can increase the amount of nitrate ions in the soil, which can raise osmotic stress and cause soil salinity (Wang, Xiaobing, et al., 2022)

The salinity of the soil can be greatly influenced by the quality of the water used for irrigation. Applying fertilizer along with irrigation water of poor quality and a high salt content might increase salinization. According to studies by Maas and Hoffman (1977) and Qadir et al. (2008), adding fertilizers to salty irrigation water causes the salts to build up in the soil and increase salinity levels.

In some situations, incorrect fertilizer application techniques might prevent plants from absorbing nutrients, which causes an overabundance of unutilized nutrients in the soil. These wasted nutrients thus increase the salinity of the soil. According to studies by Subasinghe et al. (2015) and Rengasamy (2010), surplus nutrients like potassium and

phosphorus from fertilizers can cause soil salinity levels to rise when plants are unable to use them effectively. Additionally, saltwater irrigation can interfere with nutrient uptake and change the nutritional state of pepper plants. According to research by Rahman et al. (2019) and Jabeen et al. (2020), irrigation with saltwater can cause deficiencies in the intake of important nutrients as calcium, magnesium, potassium, phosphorus, and nitrogen. The growth and yield of plants may be adversely affected by these limitations.

Pepper plants' ion absorption and nutrient imbalances are affected by irrigation water with a high salinity level. The interference of excessive salts in the intake of vital nutrients, such as potassium and calcium, as well as the accumulation of harmful ions, such as sodium and chloride, have been the focus of research by Munns and Tester (2018) and Negro et al. (2017). These imbalances interfere with plant metabolism, nitrogen absorption, and overall nutrient status, which results in decreased pepper crop development and yield.

Nitrogen (N) is a crucial nutrient for plant growth, and its application through fertilizers is widespread. However, using nitrogen-based fertilizers excessively can result in a rise in soil salinity. According to research by Smith et al. (2018) and Johnson and Smith (2020), nitrogen fertilizer and soil salinity are positively correlated, especially when applied in large quantities. These results highlight the significance of regulating nitrogen fertilization carefully to avoid salt buildup and related salinity problems.

Phosphorus (P) is necessary for plant development and metabolism. When used at the prescribed rates, phosphorus-based fertilizers do not significantly increase soil salinity, according to research by Garcia et al. (2019). However, care should be taken when combining phosphate-rich fertilizers with salty irrigation water because this can increase salinity issues (Sharma et al., 2017).

Potassium (K) is essential for plant nutrition and aids in ion balance and osmoregulation. According to Kumar et al. (2018), moderate use of potassium-based fertilizers has no effect on soil salt levels. However, research by Jones and Brown (2019) shown that potassium ions can build up in soil as a result of excessive potassium fertilization, increasing soil salinity.

Organic fertilizers, such as compost and manure, provide a sustainable alternative to synthetic fertilizers in the face of salinity. These components strengthen soil composition and nutrient retention, possibly lowering salinity concerns. According to Li et al., 2021, organic fertilizer raised the amount of organic matter in the soil and improved its ability to exchange cations, reducing soil salinity and boosting crop yield.

Agriculture productivity is significantly challenged by salt in the soil. The use of conventional soil fertilization techniques can increase the buildup of salt. Foliar fertilization has attracted interest recently as a possible method to feed nutrients directly to plants without escalating soil salinity.

Foliar fertilization depends on supplying the plant with the necessary nutrients through spraying on the vegetative system of the plant, directly to the leaves of the plant and not through the soil, which has the ability to absorb these elements through the stomatal openings spread on the upper and lower leaf surfaces. Foliar fertilization leads to the protection of the plant and its growth properly and to get rid of the manifestations of deficiency of microelements such as yellowing of the leaves, spotting and weakness of the nodes. According to Fernández and Brown (2019), foliar fertilization depends on feeding crops with trace elements. Foliar fertilizers are effective for improving element utilization efficiency, crop yield, and quality (Niu et al. 2021). This method, which provides a viable alternative to traditional soil fertilization, which leads to limiting damage to root uptake efficiency caused by the risk of increased soil salinity.

In studies by Bajji et al. (2016) and Yildirim and Güneş (2019) aimed to investigate the effect of foliar fertilization on plant responses to salt stress. They discovered that the addition of minerals, especially potassium and calcium, to foliar fertilization, improves osmotic control and reduces oxidative damage, and according to these results, foliar fertilization is able to mitigate the negative effects of salinity and improve plant resistance to salt stress.

The concentration and composition of the nutrient solution, in addition to the type of plant, affect the effectiveness of foliar fertilization. The study by Marschner et al. (2018), which showed the importance of improving the nutrient solution and the timing of its application to the plant, in order to ensure uniform coverage of all vegetative parts and increase leaf uptake. As a result of this, the highest efficiency of nutrient absorption.

Foliar fertilization and soil management approaches can work together as part of an integrated strategy to solve soil salinity problems. Studies by Khan et al., (2020) showed that foliar fertilization and organic soil amendments worked together to improve soil structure and nutrient availability, which enhanced plant growth by reducing salt levels in the soil.

The benefit of foliar fertilization was very clear during field experiments by reducing soil salinity, increasing water use efficiency and thus improving plant nutritional status, which led to increased growth and crop yield, according to studies by Wang et al. (2021) and Li et al. (2017). These results show the potential of foliar fertilization to be a viable strategy for reducing the negative effects of soil salinity on crop yield.

2.3. Effects of techniques used to increase crops' resistance to salt water

The use of saline water to irrigate crops exposes both the soil texture and its physical properties to damage and thus affects the crop yield. In order to reduce the adverse effects on crop properties and soil quality, several techniques have been developed.

According to Li, et al., (2023) investigates the mechanism of grafting for the formation of resistant roots, whereby grafting reduces salt damage to crops (Stolte et al., 2015), also techniques grafting plant in forming beneficial relationships with different bacteria and microbes present in the roots, which help in reducing signs of salinity stress. To improve the salinity tolerance of sweet pepper (Del Amor, Cuadra-Crespo, et al., 2011), stimulatory and plant growth promoter of *Azospirillum brasilense* and *Pantoea dispersa* were used. The application of pepper genotypes (sweet pepper) improved response to salinity (Aktas et al., 2006). In addition to the application of nano silicon (Tantawy et al., 2015).

Nano-technology offers great opportunities for sustainable management of bad soils and using of saline water. The use of green nano-agrochemicals (e.g., nano-fertilizers) derived from plant bio-wastes. The impacts of nano-agrochemicals on salt tolerance mechanisms. plants under field conditions, particularly in soils with low fertility under salinity stress condition and low organic matter content, have not yet been verified. Therefore, in this study, a two-year field trial was conducted to investigate the impacts of green nano silica (GNS) application on the enhancing the salt tolerance of banana plants in arid sandy soil.

Banana plants were irrigated with fresh Nile River water ($EC = 0.53 \text{ dS m}^{-1}$) or saline groundwater ($EC = 4.12 \text{ dS m}^{-1}$) and sprayed with GNS at doses of 0 mg L^{-1} (control), 150 mg L^{-1} (GNS1), and 300 mg L^{-1} (GNS2) in spring, summer, and autumn. Spraying the saline water-irrigated plants with two amounts of GNS significantly increased the total fruit yield in the first and second year and reduced the concentrations of Na^+ in leaves compared with the control. Moreover, the foliar application of GNS1 and GNS2 improved the total sugar content in the banana fruits under salinity stress. Although the use of GNS reduced the negative effects of saline irrigation water, banana plants that were irrigated with Nile River water remained significantly better than the saline ground water. "In conclusion, the foliar application of GNS improved the productivity and quality of Williams banana fruit in sandy poor soils and enhanced their tolerance to salinity stress, which provides opportunities to expand banana cultivation using saline water in low fertile sandy arid soils" (Ding, et al., (2022).

A practical method for reducing the negative effects of salinity and enhancing the quality and productivity of pepper plants is the application of salinity treatment chemicals to the soil. In order to alleviate salt stress in both soil and plants, date palm trees are treated with DISPER Osmotic GS, a fertilizer that combines calcium, potassium, some organic matter, and free amino acids. In the dissipation treatments, the weight, length, and weight of the fruit meat all increased, and fruit dropped decreased (Altemimy & Abed. et al., 2019).

Through genetic techniques and breeding, attempts have been undertaken to create pepper cultivars that can withstand salt. The significance of discovering genetic markers linked to salt tolerance features and incorporating these qualities into breeding programs was underlined by studies by Plazas et al. (2020) and Islam et al. (2019). This strategy provides long-term answers for enhancing pepper crops' tolerance to salt and sustaining their growth while being irrigated with saline water. Environmental influences have an impact on the expression of several genes that are under control. As a result, language and growth patterns exhibit continuous quantitative variation coefficients. According to Chaim and Ben et al. (2001), salinity is one of the most significant environmental elements influencing the growth and production of pepper.

One of the most prevalent and quickly expanding abiotic pressures on the productivity of the Solanaceae family of food plants is salinity in soil and water. The most significant greenhouse plant in semi-arid areas with salty groundwater is pepper.

Pepper is the most important greenhouse plant in semi - arid regions with saline groundwater. Irrigation with brackish groundwater caused an increase in LFs and a decrease in water absorption for all used pepper cultivars, especially the 5 dS m⁻¹ and the 8 dS m⁻¹ in addition to a significant decrease in the WUE. Although it is not significantly different by 0.6 and 3 DSM⁻¹. Therefore, pepper yield can be maintained by using irrigation with brackish water up to 3 dS m⁻¹. The yield response curves of the crop irrigated with brackish water showed a lower decrease compared to the plant irrigated with the dominant sodium chloride solution. The decrease in yield is due to the higher concentration of Ca²⁺ in brackish water. Further studies are needed to know the effects of Na⁺/ Ca²⁺ on plant physiology and growth, water transport, and ion content (Baath, Gurjinder S., et al., 2020.).

Different studies were conducted to assist the inverse effect of salinity on pepper plants. Ruggiero et al., (2003) studied the effect of three different irrigation treatments (EC_w = 0.5 dS m⁻¹, 4.4, and 8.5 dS m⁻¹) on pepper plants growing under greenhouse conditions, and the results showed a decrease of 46% and 34% in the dry weight of the plant (leaves and stem), the productivity was reduced by 25% and 58% with EC of 4.4 DSM⁻¹ and 8.5 ds m⁻¹, respectively.

The growth and production of hot pepper plants were evaluated using a nutrient solution of different chemical salts (EC = 5 dS m⁻¹). Plants were harvested after four months. The results of growth variables, yield, and fruit quality are negatively influenced by salinity at (EC 5 induced by NaCl). The use of KCl also led to some decrease in the growth coefficients. While the analysis showed better growth characteristics using K₂SO₄ compared to plants treated with NaCl or KCl salts. There was a significant decrease in the other traits by NaCl and to a lesser extent by KCl (Ahmadi, & Sour, 2020).

The physiological and morphological characteristics of pepper plants grown in the greenhouse were studied under four different irrigation treatments (EC_w = 2, 4, 6, and 8 dS m⁻¹) and two resistant roots (E21R10144 and E21R10197), and one ungrafted (NG) as a control. The results showed an increase in plant height of 3.3% and 27.2% when

comparing E21R10144 with both NG and E21R10197, respectively. In addition, to the tolerance of salinity (NaCl) conditions for all morphological and physiological variables, including fruit yield. Therefore, grafting showed a promising tool for managing saline stress. (Orosco-Alcalá, Blanca E., et al 2021). Although, improving salt tolerance of vegetables by breeding is a difficult task as salt tolerance is a quantitative trait, regulated by a large number of genes. As a traditional agronomic method, grafting, which is widely practiced in vegetables, especially among members of Cucurbitaceae and Solanaceae, is a useful tool for reducing yield loss caused by salinity. In studied by Niu, et al., (2022) to uncover mechanisms by which grafting improves salt tolerance in vegetables. In this review, the effects of salt stress on vegetable crops were discussed, and the four main mechanisms by which grafting increases the salt resistance of vegetables, namely, restricting the transport of toxic ions, enhancing the antioxidant system, enhancing the stability of the photosynthetic system, and sending root signals, were discussed.

Salinity stress disrupts various physiological processes in pepper plants. Studies by Wahid et al. (2017) and Parida et al. (2019) found that saline water irrigation caused significant alterations in photosynthesis, stomatal conductance, and water use efficiency in pepper crops. These physiological disruptions can further hamper plant growth and productivity, leading to yield losses.

2.4 Uses for DISPER Osmotic GS to Reduce Salinity Stress in Plants Irrigated with Saline Water

The DISPER Osmotic GS, which is a commercial gel-based system designed to provide controlled release of nutrients to plants.

A cross-linked polymer makes up the gel matrix, which allows for delayed release over an extended period of time while holding onto water and nutrients (Silva et al., 2018). According to Zornoza et al. (2019), the gel system has a number of benefits, including increased nutrient availability, decreased nutrient loss through leaching, and decreased water requirements. whose molecules control the osmosis process and are built to withstand stress brought on by higher salinity. Utilization of the product throughout the crop's growth cycle. Granules fully dissolved in water before being added into irrigation water. Similar to this, Silva et al. (2020)'s study showed that DISPER Osmotic GS had positive effects on lettuce output.

In comparison to traditional fertigation techniques, the gel system boosted the efficiency of nitrogen uptake, leading to higher shoot biomass, improved leaf quality, and decreased nutrient losses. According to studies by Chen et al. (2020) and Zhang et al. (2021), the use of DISPER Osmotic GS increases the activity of antioxidant enzymes, lowers electrolyte leakage, and preserves the stability of cellular membranes. These results show improved osmotic control and increased salinity stress tolerance.

DISPER Osmotic GS has also demonstrated potential in minimizing the negative effects of vegetable cultivation on the environment. According to studies, nutrient runoff and leaching have significantly decreased, reducing the likelihood of water pollution (Zornoza et al., 2019). The ideals of resource conservation and precision agriculture are compatible with this sustainable strategy.

Studies have shown that Disper Osmotic GS has positive impacts on a variety of vegetable crops. For instance, Martinez-Alonso et al. (2017) found that using Disper Osmotic GS improved tomato plant growth, yield, and nutrient uptake. The continual fertilizer delivery from the gel system promoted better root formation, a greater chlorophyll content, and higher fruit yield.

According to studies by Zhang et al. (2018) and Wang et al. (2020), the use of DISPER Osmotic GS can improve osmotic adjustment in plants in salinity-related situations. The osmotic agents increase water intake and decrease water loss through transpiration to maintain cellular water balance. This mechanism enables plants to preserve turgor pressure and lessen salinity-related water stress.

In plants exposed to saline water, DISPER Osmotic GS has been demonstrated to favorably affect a number of physiological processes. The use of DISPER Osmotic GS improves photosynthetic efficiency, stomatal conductance, and chlorophyll content under salinity stress, according to studies by Chen et al. (2019) and Li et al. (2021). The growth and production of plants are improved as a result of these developments.

Liu et al.'s (2019) and Zhou et al.'s (2021) studies have shown that the use of DISPER Osmotic GS can help maintain ion homeostasis by decreasing the buildup of toxic ions like sodium (Na^+) and increasing the uptake of vital nutrients like potassium (K^+) and

calcium (Ca²⁺). This control serves to keep the right ion ratios in place and shields plants from ion-caused harm.

Due to the buildup of reactive oxygen species (ROS), plants are frequently subjected to oxidative stress caused by salinity stress. In plants exposed to saline water, DISPER Osmotic GS has been proven to improve antioxidant defense mechanisms and lessen oxidative damage. In plants treated with DISPER Osmotic GS, Wang et al. (2018) and Zhang et al. (2022) found higher levels of antioxidant components including glutathione and ascorbic acid as well as increased activity of antioxidant enzymes like superoxide dismutase (SOD) and catalase (CAT).

Under salinity-induced conditions, the use of DISPER Osmotic GS has been shown to improve crop production and yield. According to studies by Zhao et al. (2019) and Xu et al. (2020), crops treated with DISPER Osmotic GS produced higher yields, better fruit quality, and more biomass buildup than salt water-irrigated controls. These results show that DISPER Osmotic GS may be able to maintain crop productivity in salty settings.

Chapter Three

Materials and Methods

3.1 Study site and Experimental design

The experiments were conducted in a greenhouse in Tulkarm in northern Palestine. Homogenous healthy Pepper seedlings (*Capsicum annuum*) variety (Sharbaty) were obtained from Al-Junaidi nursery in Nablus, Palestine. The seedlings were grown in a greenhouse under natural light condition during the period from 14th October, 2021 until 22nd January, 2022. One plant was grown in each plastic pot (30 cm in diameter and 30 cm in height) (Appendix A.1). filled with a soil mixture of 2:1 sand to peat moss (with pH 4.61, and EC 0.37 ds/cm).

The experiment was designed as a factorial treatment (3x3) in a completely randomized design (CRD) with four replicates using three salinity levels (0, 100, and 200 mM) prepared by mixing NaCl of 0, 5.85, and 11.7 g L⁻¹ with tap water., respectively, and three DISPER Osmotic GS at amounts of D₁: 0, D₂: 0.5, and D₃: 1 g/plant. The layout of the experiment is shown in Table 1.

Table 1

Layout of a completely randomized design with three treatments, each replicated four times.

Replicates	Treatments				
	1	2	3		
1	IS ₀	IS ₁₀₀	IS ₂₀₀	1	
	D ₀	D ₀	D ₀		
2	IS ₀	IS ₁₀₀	IS ₂₀₀		
	D ₀	D ₀	D ₀		
3	IS ₀	IS ₁₀₀	IS ₂₀₀		
	D ₀	D ₀	D ₀		
4	IS ₀	IS ₁₀₀	IS ₂₀₀		
	D ₀	D ₀	D ₀		
1	IS ₀	IS ₁₀₀	IS ₂₀₀		2
	D ₁	D ₁	D ₁		
2	IS ₀	IS ₁₀₀	IS ₂₀₀		
	D ₁	D ₁	D ₁		
3	IS ₀	IS ₁₀₀	IS ₂₀₀		
	D ₁	D ₁	D ₁		
4	IS ₀	IS ₁₀₀	IS ₂₀₀		
	D ₁	D ₁	D ₁		
1	IS ₀	IS ₁₀₀	IS ₂₀₀	3	
	D ₂	D ₂	D ₂		
2	IS ₀	IS ₁₀₀	IS ₂₀₀		
	D ₂	D ₂	D ₂		
3	IS ₀	IS ₁₀₀	IS ₂₀₀		
	D ₂	D ₂	D ₂		
4	IS ₀	IS ₁₀₀	IS ₂₀₀		
	D ₂	D ₂	D ₂		

Note: IS: Ionic strength (mM NaCl), D: DISPER Osmotic GS (g).

3.2 Treatments with NaCl

Three stock solutions of NaCl (50 L each) with a concentration of (0, 100 and 200 mM) was prepared by adding 0, 5.85, and 11.7 g NaCl per L). The Ec of the stock concentrations was 1.1, 8.7, and 15.5 ds/cm respectively.

The seedlings were initially irrigated with tap water only, after 10 days, salinity treatments were applied. The irrigation process was carried out according to the needs of the plant depending on the ET₀ records of the agricultural station of An-Najah National University. In general, the irrigation intervals were approximately from 3 to 5 days.

3.3 Treatments with DISPER Osmotic GS

DISPER Osmotic GS, a commercial product was obtained from the fertilizer store in Tulkarm (Diaper Osmotic GS, Eden Modern Agriculture S.L, Spain). Three amounts of DISPER Osmotic GS 0, 0.5, and 1 g were applied. This product was applied at all growth stages. The first application was immediately after planting. The following applications of DISPER Osmotic GS were done every 7 to 15 days. Diaper Osmotic GS solution was prepared for the three quantities (0, 0.5, and 1 g) by dissolving the required amount of DISPER Osmotic GS in 50 ml of tap water, then adding to the treatment water requirement from the three concentrations of NaCl solution previously prepared, according to each treatment.

3.4 Treatments fertilizer application

A complete fertilizer of 6-6-6 NPK was applied two weeks after planting at a rate of 0.9 cm/seedling/day. For each seedling, the fertilizer was applied once per week. 5-3-8 NPK fertilizer was applied in November at a rate of 2.8 cm per seedling per day.

Another complete fertilizer of 5-3-8 NPK fertilizer, or 3.7 cm/seedling/day, was added as the size of the fruit grew weekly.

3.5 Growth parameters

3.5.1 Plant height

The height (cm) of the seedling was measured after 10 days of planting from the soil surface to the highest point in the growing apex, for each replicate, the data were recorded weekly by meter.

3.5.2 Flower number and number of fruit set

The number of flowers was recorded on November 7th , and the number of flowers was recorded for each replicated weekly but number of fertilized flower that began on November 13 was also recorded weekly.

3.5.3 Chlorophyll content

The **relative** chlorophyll content of the plant and the leaf greenness of pepper plants were taken once every two weeks using a chlorophyll meter (SPAD-502Plus Chlorophyll Scale, Konica Minolta Sensing, Inc., Japan) (Appendix A.2). For each plant, six readings from the upper leaf were taken for each replicate.

3.5.4 Yield

The harvest of the pepper fruit took place in January 22nd, 2022. The number and weight (g) of fresh fruits were recorded. The fruits were collected in a paper envelope with the treatment code and the number of the replicates were recorded. Fruits were naturally dried at room temperature 18C⁰ (Appendix A.3), and their weights were recorded.

3.5.5 Length of the fresh fruits and Measurement value display

The length (cm) of the longest fruit for each plant in each treatment was measured manually by a ruler (Appendix A.4).

3.5.6 Leaf area

After plants harvesting, 3 random leaves were selected from each treatment and their area was measured by an Area meter (Portable leaf area meter AM350, ADC Bio Scientific Ltd, UK) (Appendix A.5).

3.5.7 Plant Weight

After harvesting the fruits for each treatment, the vegetative parts of the plant were harvested by pruning shears from the closest point to the surface of the soil. The vegetative parts were kept in paper envelopes with the treatment code and replicates number written on it. Fresh weight gram (g) was taken for each treatment, then dried in oven (DRYING OVEN DIGIT, TRADE Raypa, Raypa) (Appendix A.6) at 105⁰C for 24 h, and the dry weight gram (g) was recorded by used balance meter (METTLER TOLED0, MonoBloc, Switzerland).

3.5.8 Root Weight

Simultaneously with harvesting the plants, roots were harvested, washed several times with water, and each collected in a paper envelope labeled with the handling code and the replicates number. Fresh weights gram (g) of the roots were taken by using a balance meter (METTLER TOLEDO, Mono Bloc, Switzerland). The roots were dried by using the oven (DRYING OVEN DIGIT, RAYP,) (Appendix A.6) at 105 °C for 24 hours, and the dry weight gram (g) of the roots was recorded (Appendix A.7).

3.5.9 Soil pH and Ec

Several data for the pH and electrical conductivity deciSiemens per metre (dS/m) of the soil were recorded. The first data was when planting directly and the other data every (every 7-15 days) before applying DISPER Osmotic GS to the plant. At a depth of 15 cm from the planting medium. Putted 50 g of soil sample for each replicate in a urine cup with the treatment code and the replicates number on it. Added 50 ml of distilled water for each sample to become saturated with water, stirred well, kept at room temp for overnight . Extracted saturation solution by suction pump, recorded pH (Ph55, Milwaukee Tool, America) (Appendix A.8) and electrical conductivity (Conductivity meter HI 8033, HANNA instruments, ROMANIA Europe) (Appendix A.9) were measured by Ec, Ph meter.

3.6 Statistical analysis

The experiment was designed as a factorial treatment design for both factors: salinity levels and DISPER Osmotic GS levels, the combined treatments being entirely randomized in a completely randomized design. Data analysis was done using Minitab software version.18 (2017), two-way analysis of variance was performed, followed by a mean separation of the significant components at a probability of 0.05 using the LSD test.

Chapter Four

Results and Discussion

4.1 Plant height

4.1.1 Effect of saline water irrigated on plant height

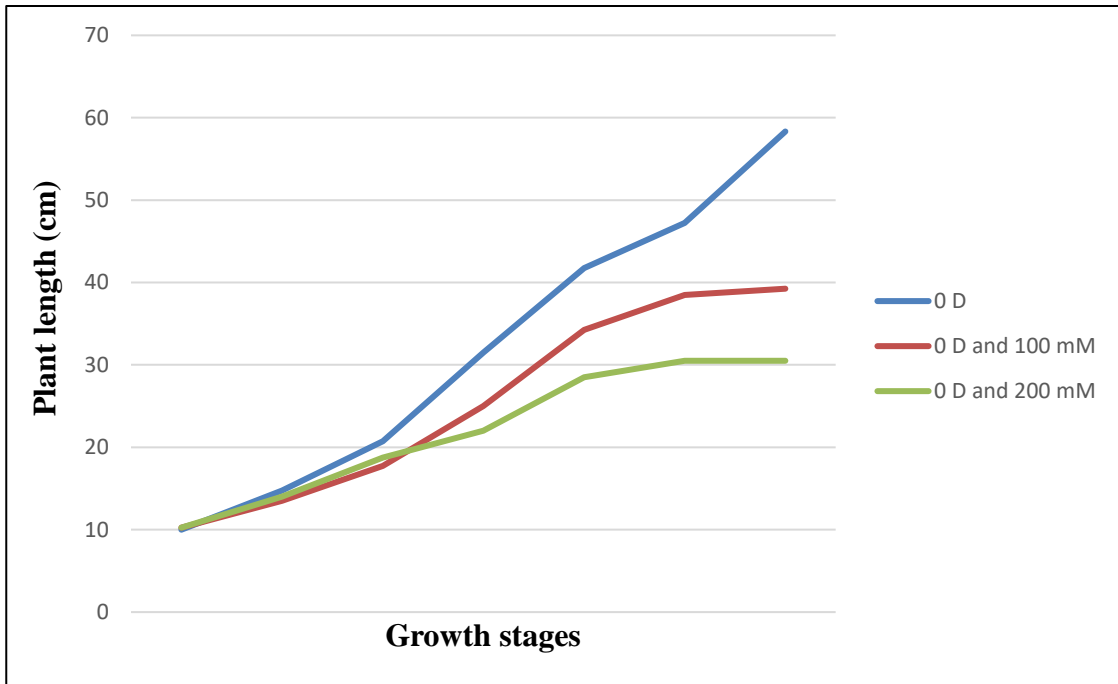
Data shows the effect of irrigation with saline water on plant length there are significant differences between three salinity levels (0, 100, and 200 mM) on plant length. ($P = 0.00$), table (2) the highest plant achieved when 0 mM (59.27cm) and 100 mM (40.08 cm), the shortest plant height was observed when using different concentrations of salt compared to the control (tap water) (Appendix A.10), . This is consistent with previous studies Cicek N, Cakirlar H (2002), shoot length decreased significantly by increasing salt treatment levels.

According to numerous research, irrigation water with excessive saline levels has a detrimental effect on the development of pepper crops. Khan et al. (2018) and Ahmed et al. (2020) conducted studies that showed decreasing plant height with rising saline levels in irrigation water. In studied by NAGM AL DEEN, et al., (2019) it was found that the higher the salinity in the irrigation water the less the plant height.

In studied by Niu, et al., (2022). “Stress imposed by saline conditions includes 2 components: (a) osmotic effect, which is caused by the increase in osmotic potential of water that decreases the ability of water uptake (b) toxicity of salt ions, especially Na^+ and Cl^- , which is harmful to the physiological processes of various plants. In the first stage, saline conditions do not substantially alter plant growth because most toxic ions are collected in the vacuoles. In this phase, both leaves and roots are inhibited, but leaves do not present salt injury symptoms. Another remarkable change is stomatal conductance. The stomata close very quickly when they detect changes in osmotic pressure (within 3 h) and rebound during a prolonged stress period (after 6–12 h). In the second stage, the cells are unable to store the toxic ions in vacuoles. As a result, their concentration in the cytoplasm increases and the activity of many enzymes is severely inhibited”.

Figure 1

The height of the pepper plants irrigated with different saline water levels (0, 100, and 200 mM)



4.1.2 Effect of different DISPER Osmotic GS amounts on plant length

Table (2) revealed that there are no significant changes in plant length across different DISPER Osmotic GS amounts ($p= 0.999$), indicating that there is no direct association between plant length and the quantity of DISPER Osmotic GS. Different DISPER Osmotic GS (0, 0.5, and 1 g) had plant lengths of 14.61cm, 15.00 cm, and 14.50 cm, respectively. (Appendix A.11).

4.1.3 Effect of different salinity levels under different DISPER Osmotic GS on plant height of pepper

The two levels of DISPER Osmotic GS used resulted in different plant height of plants under salt stress 100 mM and 200 mM. The highest results obtained with the application of 1 gram, (Table 2) ($p= 0.153$) without significant difference. Plant height under DISPER Osmotic GS 0.5 and 1 g. (Appendix A.12, A.13 and Appendix A.14, A.15).

Table 2

Effect of different levels of DISPER Osmotic GS under different salinity levels on the plant length (cm) parameters of pepper plants

DISPER Osmotic GS (g)	Plant height (cm)
0	14.61a
0.5	15.00a
1	14.50a
P-value	0.999
Salinity(mM)	
0	59.27a
100	40.08b
200	32.05c
P-value	0.00
Dis (g)* Salinity (mM)	
P-value	0.153

4.2 Chlorophyll content of leaf pepper

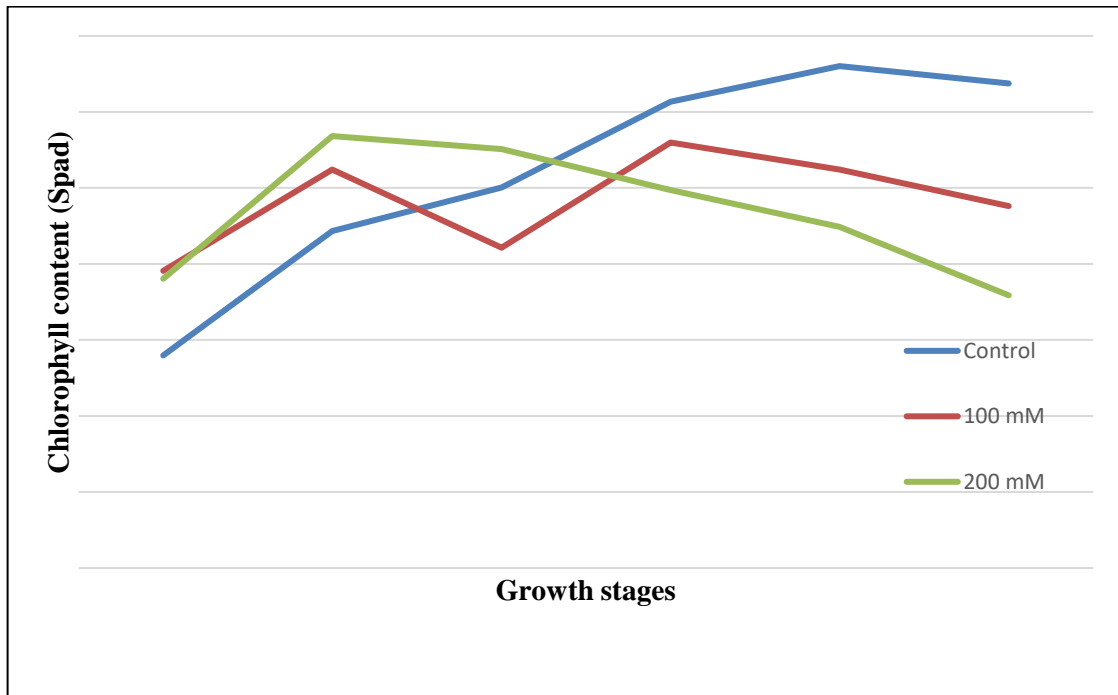
4.2.1 Effect of saline water irrigated on chlorophyll content

The data in table (3) showed that the use of saline water had a significant effect on the chlorophyll (Chll) content ($P = 0.031$) there are significant differences between saline water (0, 100, and 200 mM). Using the 100 mM saline water improved the chlorophyll content (40.09) SPAD compared to the control (37.00) SPAD. When using 200 mM, the chlorophyll content was (38.77) SPAD.

By Maeda et al. (2020), investigated the effect of salinity on photosynthesis and the distribution of photosynthates in the Japanese tomato (*Solanum lycopersicum*) Salinity did not affect the photosynthetic rate. possibly due to water use efficiency and, decreased value of control plants could be due to the stomatal closure induced by water deficit. (Figure 2).

Figure 2

Chlorophyll content of pepper plant irrigated with three saline water (0, 100, and 200)



4.2.2 Effect DISPER Osmotic GS on chlorophyll

According to the results shown in figure (2) the content of chlorophyll (Chl) were not significant different ($P = 0.313$) in pepper plants under DISPER Osmotic GS conditions; the lowest values were recorded with 1 g compared with other treatments in the growing seasons. And the best results appeared in the amount of 0.5 g.

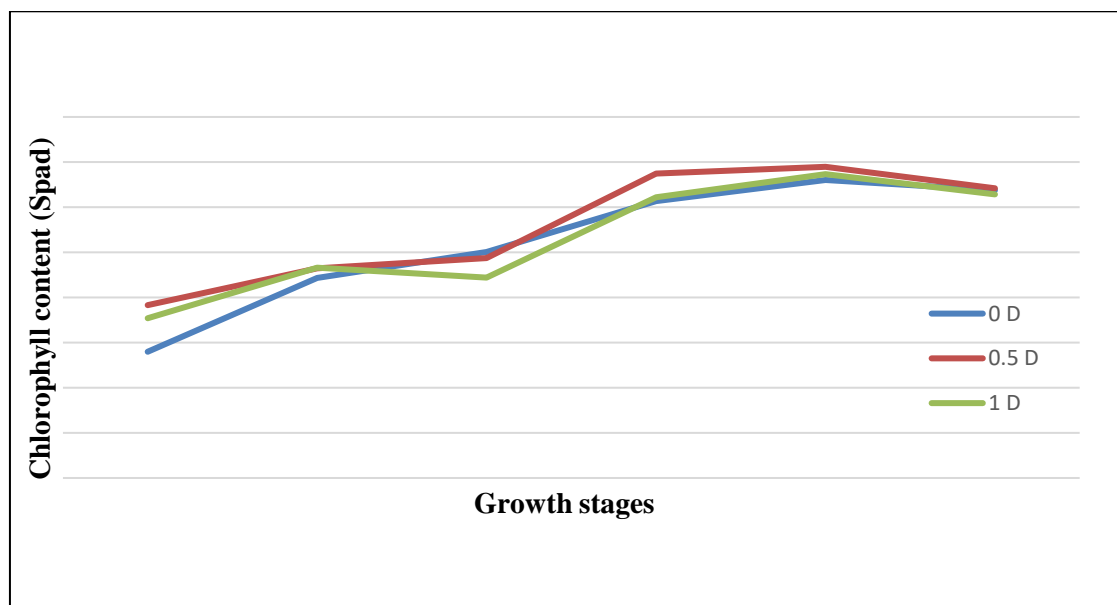
The table 4.10.1 that showed the change in the rate of soil salinity and its increase during all stages of growth. The controlled treatment was subjected to high salinity content from agricultural practices and high salinity of stock solution was preparing. Therefore, there were no changes in chlorophyll content in the leaves with a significant difference for all treatments.

“The chlorophyll synthesis in tomato plant leaves can be negatively affected by the exposure to high salt levels (Maeda et al. (2020). This may happen due to metabolic disorders which result in decreased chloroplast activity and photosynthesis, increased chlorophyllase enzyme activity, and respiration, followed by reduced chlorophyll contents Maeda et al. (2020)”.

“In general, the plants respond to the salinity stress in two phases: in the first, which lasts for days or weeks, the effect of osmotic stress is predominant, the phytohormones play an important role in regulating plant growth. For instance, abscisic acid (ABA) under saline conditions can accumulate in tomato leaves, as a response to the low soil water potential, causing stomatal closure, thus affecting the photosynthesis. In the second, of weeks to months duration, the ionic toxicity effect of leaf salt accumulation affects plant growth (Maeda et al. (2020)).

Figure 3

Chlorophyll content of pepper plant irrigated with tap water supplemented with three DISPER Osmotic GS levels



4.2.3 Effect of salinity levels and DISPER Osmotic GS on chlorophyll content of leaf pepper

Data in table (3) showed there are significant effect of salinity levels under different DISPER Osmotic GS on chlorophyll content of pepper leaves, (P-value = 0.033). As illustrated in figure (4) under salt stresses and DISPER Osmotic GS application, it is clear that plants treated with 0.5 g DISPER Osmotic GS showed increases in chlorophyll content, the highest content was observed at 200 mM, followed by 100 mM compared with control plants (Appendix A.16, A.17). Similarly, Martinez-Alonso et al. (2017), reported that the application of DISPER Osmotic GS enhanced chlorophyll content. The salt-stressed plants 200 mM with an amount of 0.5 g DISPER Osmotic GS gave lower

chlorophyll content compared to the control plants, and the same observed was in treatments with 1 g DISPER Osmotic GS (Figure 5).

Figure 4

Chlorophyll concentrations of pepper plant irrigated with three saline water (0, 100, and 200) under 0.5 g DISPER Osmotic GS amounts

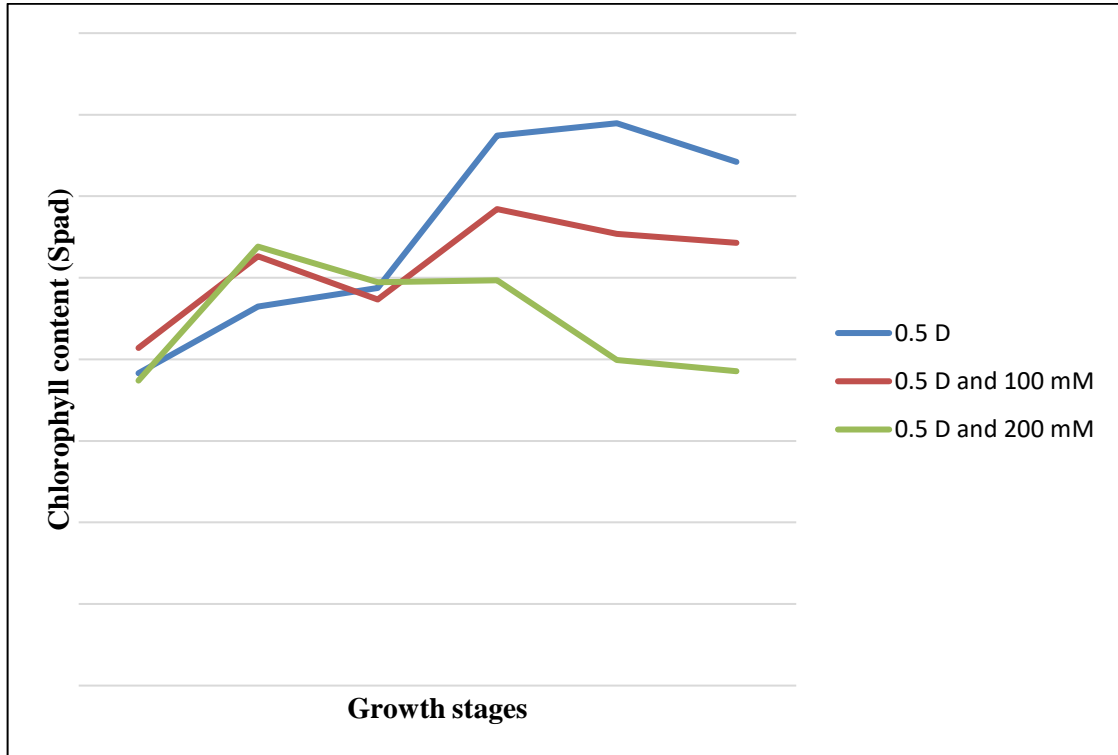


Figure 5

Chlorophyll concentrations of pepper plant irrigated with three saline water (0, 100, and 200 mM) under 1 g DISPER Osmotic GS

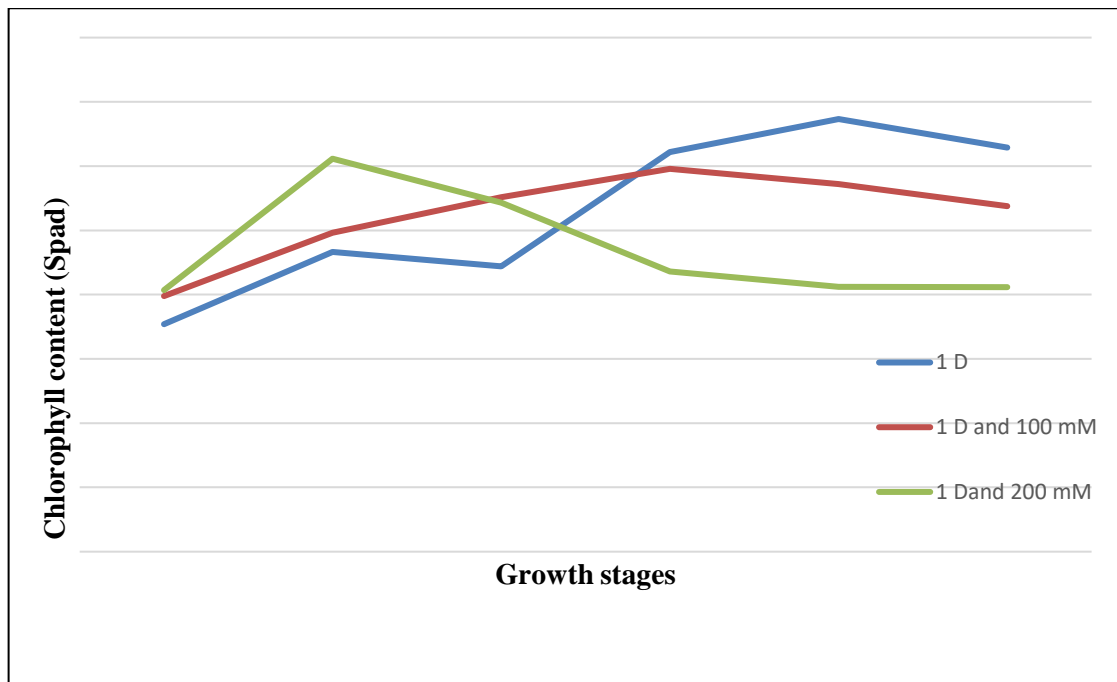


Table 3

Effect of different levels of DISPER Osmotic GS and salinity levels on the Leaves Chlorophyll parameters of pepper plants

DISPER Osmotic GS (g)	Leaves Chlorophyll (SPAD)
0	38.21a
0.5	39.03a
1	38.62a
P-value	0.313
Salinity (mM)	
0	37.00b
100	40.09a
200	38.77ab
P-value	0.031
Dis (g)* Salinity (mM)	
P-value	0.033

4.3 Flower parameters

4.3.1 Effect of saline water irrigated on number of flowers

Data in table (4) showed significant effect of using saline water ($P= 0.00$) on the number of flowers of the pepper plant after 50 days of planting. The highest number of flowers was recorded with the control, the number of flowers was (18.19) compared with that obtained with 100 mM (9.83), and the lowest number flower (5.52) when 200 mM was applied. Flowering is also delayed in salt-sensitive plants (*Sinapis arvensis*) and Arabidopsis (Stanton et al.,2000; Achard et al., 2006). Soil salinity is one of the environmental stresses that affect plant flowering. Salinity can also reduce the number of inflorescences produced (Blits and Gallagher, 1991)., “According to Shrivastava and Kumar (2015), salinity adversely affects reproductive development by inhabiting microsporogenesis and stamen filament elongation, enhancing programmed cell death in some tissue types, ovule abortion and senescence of fertilized embryos. These effects were the results of a low osmotic potential of soil solution (osmotic stress), specific ion effects (salt stress), nutritional imbalances, or a combination of these factors (Ashraf, 2004)”. (Appendix A.18)

4.3.2 Effect of different DISPER Osmotic GS on number of flower

The number of flowers increased by irrigation with DISPER Osmotic GS data in table (4). The highest number of flowers was recorded with DISPER Osmotic GS of 1 g, the number flowers was (12.66) compared with the control plant, which was (11.22) and the lowest number of flower when 0.5 g DISPER Osmotic GS was used (9.66). However, the increase in (No. F) was not significantly different compared to control treatment (P -value= 0.518), (Appendix A.19).

4.3.3 Effect of saline water irrigated under different DISPER Osmotic GS on the number of flower

The result in table (4), showed there was significant effect of using saline water irrigated with different with DISPER Osmotic GS (P -value= 0.011), as the 1 g DISPER Osmotic GS amount was used under any water concentration we applied, followed by the use of 0.5 g DISPER Osmotic GS (Figure 4, 5).

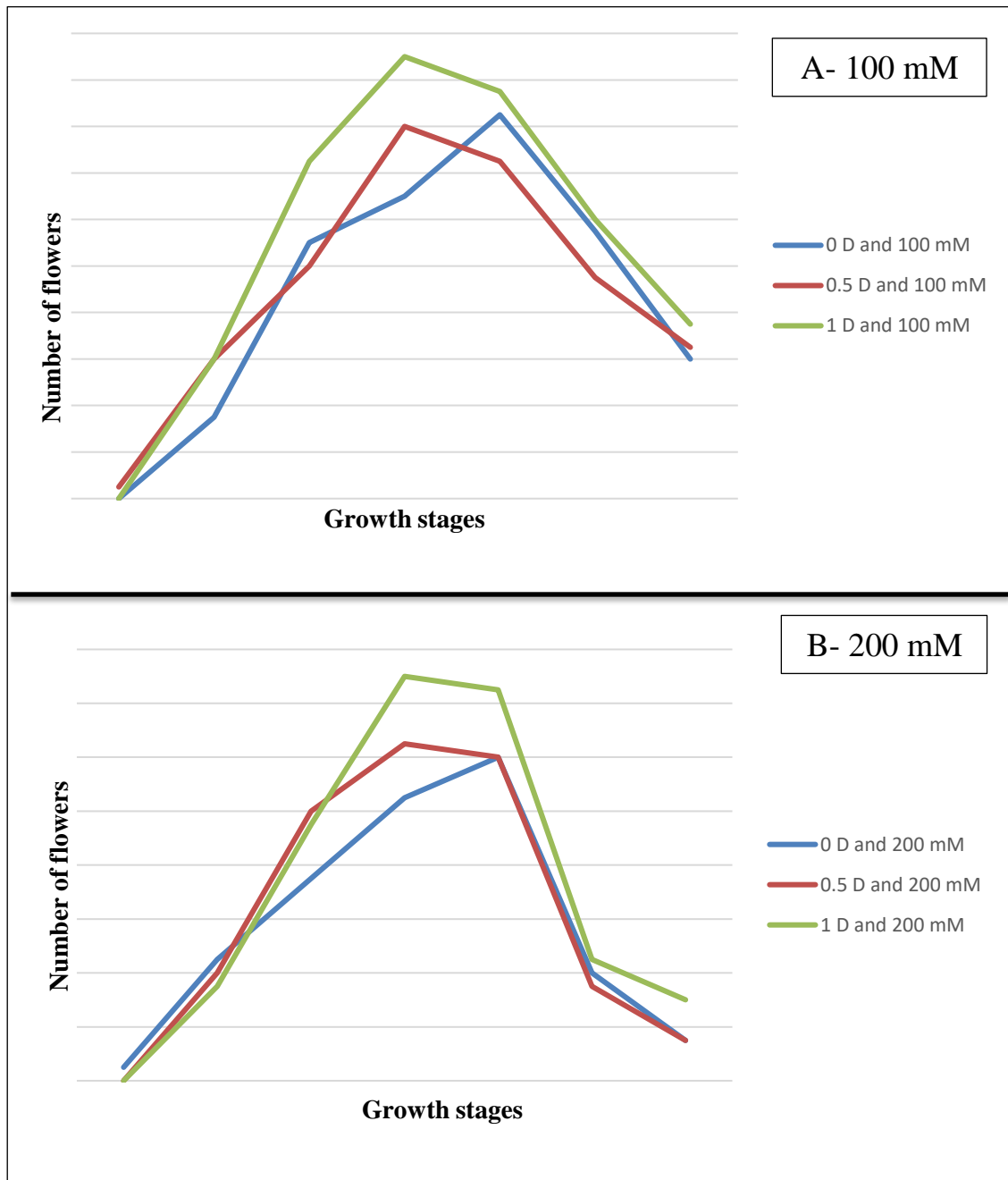
Table 4

Effect of different levels of DISPER Osmotic GS and salinity levels on the number flowers parameters on pepper plants

DISPER Osmotic GS (g)	No. of flowers
0	11.22a
0.5	9.66a
1	12.66a
P-value	0.518
Salinity (mM)	
0	18.19a
100	9.83b
200	5.52b
P-value	0.000
Dis*Salinity (mM)	
P-value	0.011

Figure 6

(No. F) Number of flowers irrigated with [A- 100 mM + (B- 200 mM) saline water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

4.4 Number of fruits

4.4.1 Effect of saline water irrigated on the number of fruits per pepper plant

In our study, salt stress also decreased fruit number, data in table (5) showed that the number of fruit after 70 days, the data exhibited significant differences ($P= 0.00$). The results (Appendix A.20) indicated that there is an effect of using saline irrigated water on the number of fruits per plant, where the highest number of fruits was obtained when under the control, the number of fruits was (1.66) compared with the 100 mM, which was (1.44). And the lowest number of fruits when use 200 mM was (0.58) (Figure 6.B).

In studied by NAGM AL DEEN, et al., (2019) it was found that the higher the salinity in the irrigation water the less the number of fruits per plant.

In other pepper cultivars, R'him et al. (2013) reported that salinity reduced the percentage of fruit set, yield and average fruit weight corroborating our results. According to report in other chili pepper cultivar Sandia by Huez-Lopez et al. (2011) who observed that the mean fruit yields decreased as soil salinity increased. In pepper crops irrigated with saltwater, research by Akhtar et al. (2018) and Javid et al. (2021) revealed decreased fruit yield, smaller fruit size, and inferior marketable fruit quality.

4.4.2 Effect of different DISPER Osmotic GS on number of fruits

Using saline water with different amounts of DISPER Osmotic GS had an effect on the number of pepper fruits at 1 g of DISPER Osmotic GS achieved the highest number of fruits at 0 mM, and 100 mM concentration of saline irrigated water (Appendix A.21, A.22, A.23), followed by 0.5 g of DISPER Osmotic GS for 100 mM , but data in table (5) showed no significant differences ($P\text{-value}= 0.584$). This result agreed with previous work of, (Altemimy & Abed. et al., 2019) who found that DISPER Osmotic GS in palm plant supports and enhance production of fruits yield.

Table 5

Effect of different levels of DISPER Osmotic GS and salinity levels on the number of fruits parameters on pepper plants

DISPER Osmotic GS (g)	No. of flowers
0	1.50a*
0.5	1.11a
1	1.08a
P-value	0.262
Salinity (mM)	
0	1.66a
100	1.44ab
200	0.58b
P-value	0.000
Dis*Salinity (mM)	
P-value	0.011

4.5 Shoots fresh and dry weight

4.5.1 Effect of saline water irrigated on fresh and dry shoot weight (g)

Data in table (6) showed that there was a significant effect of using saline irrigated water on the shoot weight for the fresh and dry plant, however, the control achieved the highest fresh and dry weight of the plant (86.31 gm) (24.32gm) respectively, compared with plant weight at 100 mM (32.56gm) (15.14gm) respectively, while the 200 mM had a negative effect on the plant height (13.34gm) (10.31gm) respectively (Table 6).

Munns et al. (2006) indicated that Irrigation with salt water inhibits plant growth for 2 reasons. First, the presence of salt in the soil structure reduces the ability of the plant to take up water; this leads to slower growth. This is the osmotic effect of salinity. Second, the excessive amounts of specific salts entering the transpiration stream will eventually injure cells in the transpiring leaves, and this may further reduce photosynthesis and growth Munns et al. (2006).

4.5.2 Effect of saline water irrigated interactions and DISPER Osmotic GS on fresh and dry shoot weight

Data in table (6) showed that DISPER Osmotic GS had no significant effect on shoot fresh and dry weight (Appendix A.24). Using saline water with different amounts of DISPER Osmotic GS had an effect on the fresh and dry shoot weight at 1 g of DISPER Osmotic GS achieved the highest fresh and dry shoot weight at 0, 100, and 200 mM concentration of saline irrigated water table (6) followed by 0.5 g of DISPER Osmotic GS for 0,100, and 200 Mm.) (Appendix A.25, A.26), . This findings was consistent with earlier research done by Martinez-Alonso et al. (2017), who discovered that using DISPER Osmotic GS improved tomato plant growth and yield. Similarly, research by (Altemimy & Abed. et al., 2019) demonstrated the benefits of DISPER Osmotic GS on palm plant

Table 6

Effect of different levels of DISPER Osmotic GS and salinity on fresh and dry plant parameters of pepper plants

Dis	Wt. of dry plant (g)	Wt. of fresh plant (g)
0	9.69a	74.09a
0.5	9.73a	85.52a
1	9.49a	85.52a
Salinity (mM)		
0	15.23a	86.31a
100	8.50b	32.56b
200	5.18c	13.34c

4.6 Fruit fresh weight

4.6.1 Effect of saline water irrigated on fruit fresh and dry weight

The influence of salinity on the fresh and dry weight of pepper fruit is shown in (Table 7), with the highest weight of fruits achieved by the control plant (86.31 gm), followed 100 mM (32.56 gm) and the lowest weight of the fruits was when using 200 mM (13.34gm). These results are in agreement with (Günes, Aydin, Ali, and Mehmet. et al.,1996). Under saline conditions, the plants fail to maintain the required balance of organic and inorganic constituents leading to suppressed growth and fruit yield.

Table 7

Effect of different levels of DISPER Osmotic GS and salinity on fresh and dry weight of pepper plants

Dis	Wt. of dry plant (g)	Wt. of fresh plant (g)
0	17.76a	45.43a
0.5	17.30a	45.58a
1	17.74a	45.59a
Salinity mM		
0	24.32a	81.60a
100	15.14b	35.44b
200	10.31c	19.57c

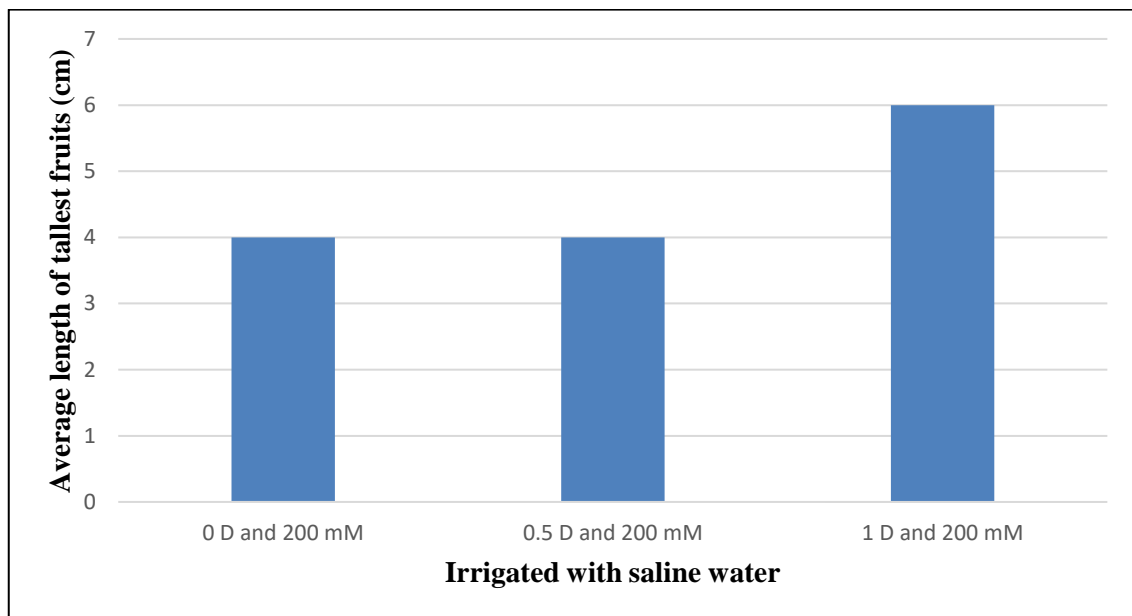
4.6.2 Effect of saline water irrigated interactions and DISPER Osmotic GS on fresh and dry fruit weight

Table (7) showed that adding 0.5 g DISPER Osmotic GS under different concentration of saline water irrigated gave the highest fruit weight The fruit fresh weight was (91.375, and 10.355 gm) when 0, and 100 mM concentration of salinity, respectively (Appendix A.27, A.29). . however, (Appendix A.28) shows that adding 1 g of DISPER Osmotic GS with 200 mM and the control gave similar significant weight. There was a significant relationship between the water deficit and cell size in plant tissues. This result is in agreement with the findings of (Altemimy & Abed. et al., 2019) who found that DISPER Osmotic GS in palm plant increase in the weight of the fruit flesh and a decrease in the rate of fruit dropping in the dissipation treatments.

There was positive correlation between salinity and DISPER Osmotic GS on the average length of tallest fruits, the highest reading was obtained under control and 100 mM salinity (Figure 7) compared to 200 mM (Appendix A.33, A.34). The effects of DISPER Osmotic GS on tomato plants enhanced fruit yield in a study by Mrtinez-Alonso et al. (2017).

Figure 7

Average length of tallest fruits irrigated with 200 mM saline water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

4.7 Root fresh weight

4.7.1 Effect of saline water irrigated on root fresh and dry weight

The result shows (figure 8) that using saline water irrigation has negative effects on root growth. The root fresh weight under the control was 21.48 g. However, under 100 mM irrigated saline water the root weight was (12.80 g). The minimum weight of the roots was (8.07 g) when 200 mM was used. As reported by (De Pascale, Stefania, et al. 2003). Root density proportionally decreased at in-creasing salt concentration in the irrigation water.

This conclusion is consistent with research by Akram et al. (2018) and Bayuelo-Jiménez et al. (2019), which shown that pepper crops can be negatively impacted by irrigation with saline water on a number of growth metrics, including root development. These

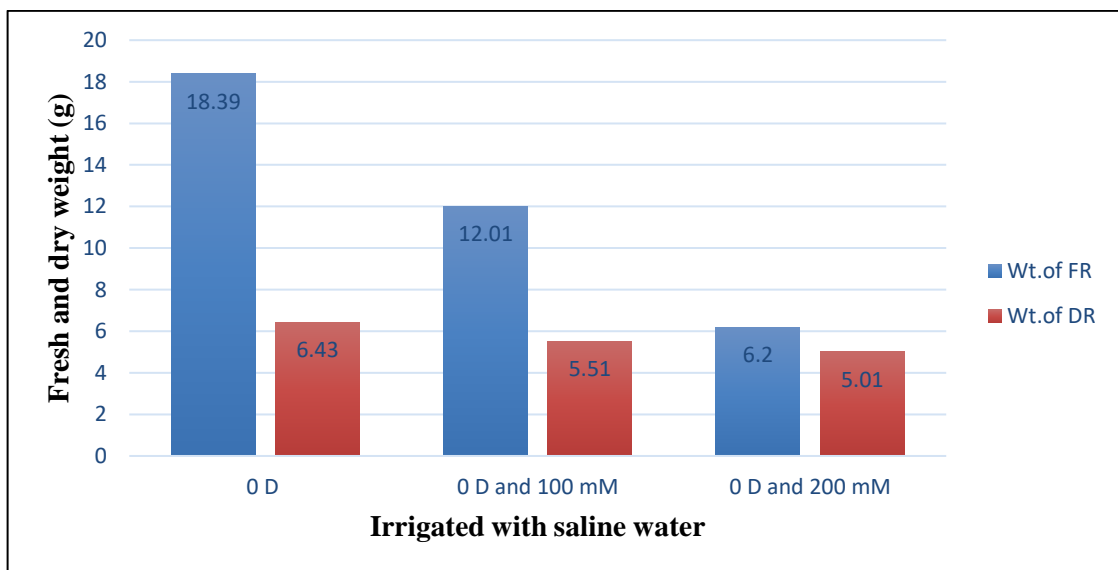
effects are frequently dose-dependent, with higher salt levels causing more drastic growth inhibitions.

In studied by NAGM AL DEEN, et al., (2019) it was found that the higher the salinity in the irrigation water the less the roots fresh weight.

As stated by Huez-Lopez et al. (2011), suppression of plant growth under saline conditions may either be due to the decreasing availability of water or to the increasing toxicity of sodium and chloride associated with increasing salinity, the decreased root and shoot dry weights was apparently due to the accumulation of salts in the soil, which increase the osmotic pressure of the soil solution and greatly decreases the availability of water to the roots.

Figure 8

Fresh and dry weight for root irrigated with three saline water (0, 100, and 200 mM)



4.7.2 Effect of saline water irrigated interactions DISPER Osmotic GS on fresh and dry root weight

The result shows that adding 1 g DISPER Osmotic GS under different concentration of saline water levels gave the highest root weight The root fresh weight was (25.80 g) when 0 mM better than treatment without DISPER Osmotic GS, root fresh weight was (18.39 g) (Appendix A.30, A.31, A.32).

The root fresh weight was (14.90, 9.25 g) with 100, and 200 mM salinity combined with 1 g DISPER Osmotic GS, respectively. Adding 1 g of DISPER Osmotic GS. It has been previously reported in (Altemimy & Abed. et al., 2019) who found DISPER Osmotic GS is fertilizer that contains calcium, potassium, some organic matter, and free amino acids on date palm trees to reduce salt stress in both soil and plant. Martinez-Alonso et al. (2017) reported that the gel system offered a constant supply of nutrients, which promoted root development. (Appendix A.31, A.33)

4.8 Length and average area of leave

4.8.1 Effect of saline water irrigated interactions DISPER Osmotic GS on length and average area of leave

The effect of different levels of DISPER Osmotic GS application under different salinity on plant growth and development of pepper plants is shown in Table (8). The results showed no significant effect of DISPER Osmotic GS application on the studied parameters expect for the length of leave which was reduced from 189.73 cm to 169.63 cm. In contrast, (Fig 4.8.1) show average area of leaves irrigated with tap water under three DISPER Osmotic GS levels, 0.5 g DISPER Osmotic GS levels followed by 1 g gave best result than the control.

Figure 10 show average area of leaves irrigated with 100 mM saline water under three DISPER Osmotic GS levels, under 0.5 g DISPER Osmotic GS better result than with 1 g was observed., Silva et al.'s (2020) study established the advantages of DISPER Osmotic GS for lettuce production. Comparing the gel system to traditional fertigation techniques, the gel system increased fertilizer uptake efficiency, improved leaf quality, and decreased nutrient losses. A number of growth indices, including leaf area, can be adversely impacted when pepper crops are irrigated with saline water, according to studies by Akram et al. (2018) and Bayuelo-Jiménez et al. (2019). “The harmful effects of salinity on leaf area, and leaf length also increase with the salt concentration rise, according to the studies performed by Maeda et al. (2020)”.

Table 8

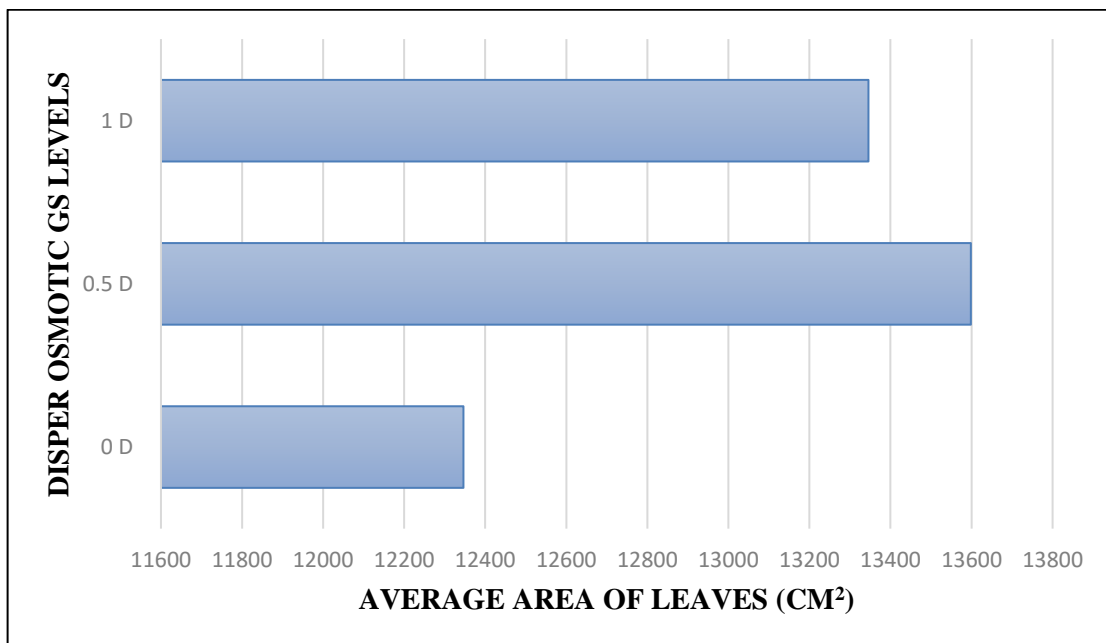
Effect of different levels of DISPER Osmotic GS and salinity on length of leave parameters of pepper plants

Dis	Wt. of dry plant (g)
0	189.73a
0.5	179.76ab
1	169.63b

Salinity mM	Wt. of dry plant (g)
0	181.389a
100	178.033a
200	

Figure 9

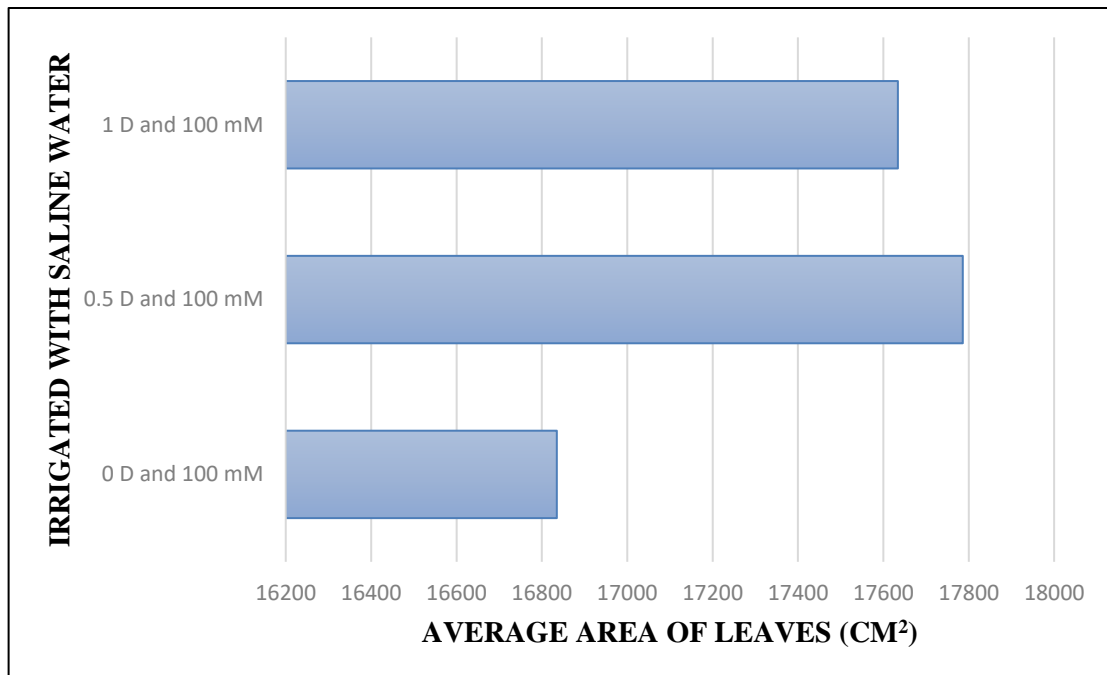
Average area of leaves irrigated with tap water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1.

Figure 10

Average area of leaves irrigated with 100 mM saline water under three DISPER Osmotic GS levels



Note. Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

4.10 Electrical conductivity (Ec) of irrigation water

4.10.1 Effect of saline water irrigated interactions and DISPER Osmotic GS on electrical conductivity (Ec) of irrigation water

The table (9). shows the change in the salinity level during all stages of growth. As a result of adding fertilizer, the controlled treatment was subjected to high salinity concentration from (1.1 to 4.7mS/m) and the change of Ec became more after added DISPER Osmotic GS with fertilizer from (1.1 to 5.00 mS/m). Therefore, there were no changes in most parameters.” Irrigation water typically contains some salts, which eventually build up, leading to salinization related losses in productivity for up to half of the areas under irrigation (Seckler et al., 1998; Flowers and Yeo, 1995)”.

The literature study reveals a nuanced interaction between fertilizer application and soil salinity. While excessive phosphorus, potassium, and nitrogen fertilization have been linked to higher salt levels, organic fertilizers present a possible alternative for reducing

salinity hazards. To reduce salinity-induced soil deterioration and encourage sustainable agriculture, proper fertilizer management is crucial. This includes using the best application rates and irrigation techniques (Abrol et al., 2018).

Several tactics have been proposed to reduce the detrimental impact of fertilizer use on soil salinity. Among these is the use of precision farming methods to adjust fertilizer application rates based on soil properties and crop needs (Abrol et al., 2018). Additionally, by providing water and nutrients directly to plant roots, effective irrigation techniques like drip irrigation or fertigation can reduce salt accumulation (Rengasamy et al., 2015).

Table 9

Electrical conductivity (Ec) of irrigation water at different fertilizing stages for each treatment

Treatment	EC(mS/m) initial	EC (mS/m) 6-6-6	EC (mS/m) 5-3-8 2.8	EC (mS/m) 5-3-8 3.7
Tap water		2.44	3.87	4.7
Tap water + 0.5 DISPER	1.1	4.03	3.98	3.78
Tap water + 1 DISPER		5.22	4.17	5.00
100 Mm		7.04	7.31	8.06
100 mM + 0.5 DISPER	8.7	6.65	7.03	7.1
100 mM + 1 DISPER		7.22	6.84	7.19
200 Mm		11.07	11.59	12.27
200 mM + 0.5 DISPER	15.5	9.07	9.84	10.13
200 mM + 1 DISPER		10.65	10.16	11.16

4.11 Conclusion

In this experiment different amounts of DISPER Osmotic GS were used to improve plant growth and production of pepper plants under saline stress condition. The results clarified that adding DISPER Osmotic GS at 1 gm per plant under three levels of saline water irrigated (0, 100, and 200 mM) exhibited the best result on chlorophyll content of pepper leaves and flower parameters compared to the control group , in addition the results

showed a best but non significant fresh weight of root and average length of tallest fruits when used 1 g DISPER Osmotic GS under different concentration of salinity levels. The application of 0.5 g DISPER Osmotic GS has promote average area of leaves. Therefore, DISPER Osmotic GS helps to alleviate salinity stress effect .

4.12 Recommendations

According to the results obtained, using DIAPER as soil management procedures on pepper showed indicator of positive response under saline conduction for some growth parameters. Therefore, we recommend conducting more research using saline soil from a field with salty soil or preparing saline solutions with lower salt concentrations than used in the current study, and thus the effect of DISPER Osmotic GS might be more clear results are more accurate of saline using DISPER Osmotic GS.

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Appendices

Appendix A

Figures

Figure A.1

Pepper seedlings on the first day of planting



Figure A.2

Chlorophyll meter, source:(photo : Lama Omar)



Figure A.3

Naturally dried in room temperature, (photo: Lama Omar)



Figure A.4

Ruler



Source: Researcher.

Figure A.5

Area meter AM350



Source: Researcher.

Figure A.6

Oven



Source: Researcher.

Figure A.7

Dry root



Source: Researcher.

Figure A.8

Ph meter



Figure A.9

Ec meter



Source: Researcher.

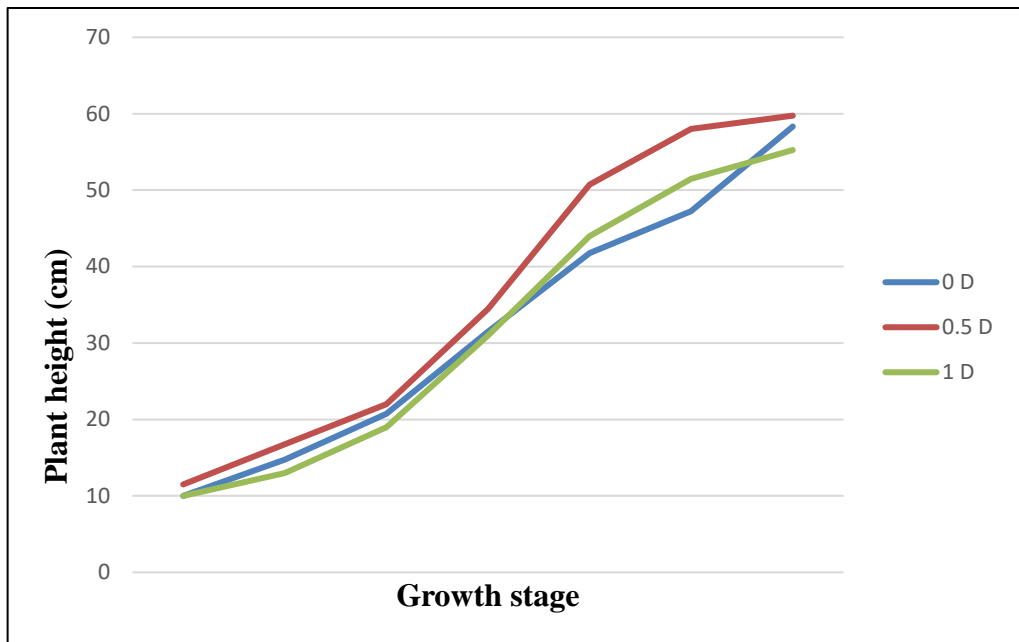
Figure A.10

Height of pepper plant irrigated with three saline water (0, 100, and 200 mM)



Figure A.11

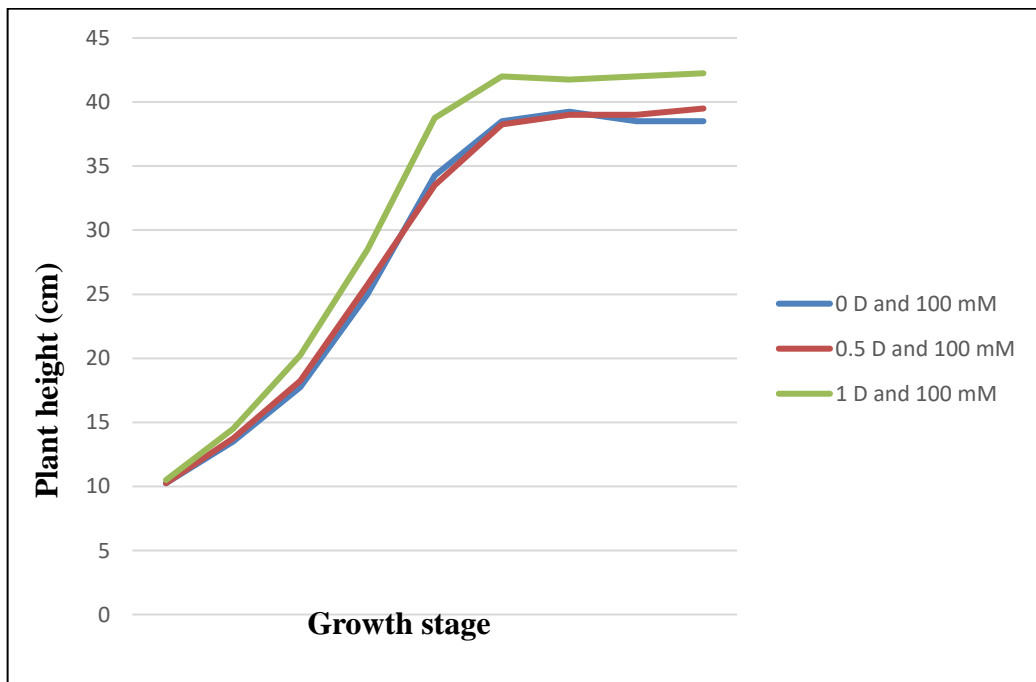
Height of pepper plant irrigated with tap water supplemented with three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.12

Height of pepper plant irrigated with 100 mM saline water under three amounts of DISPER Osmotic GS



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1g.

Figure A.13

Height of pepper plant irrigated with 100 mM saline water under three amounts of DISPER Osmotic GS



Note. Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.14

DISPER Osmotic GS. Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g

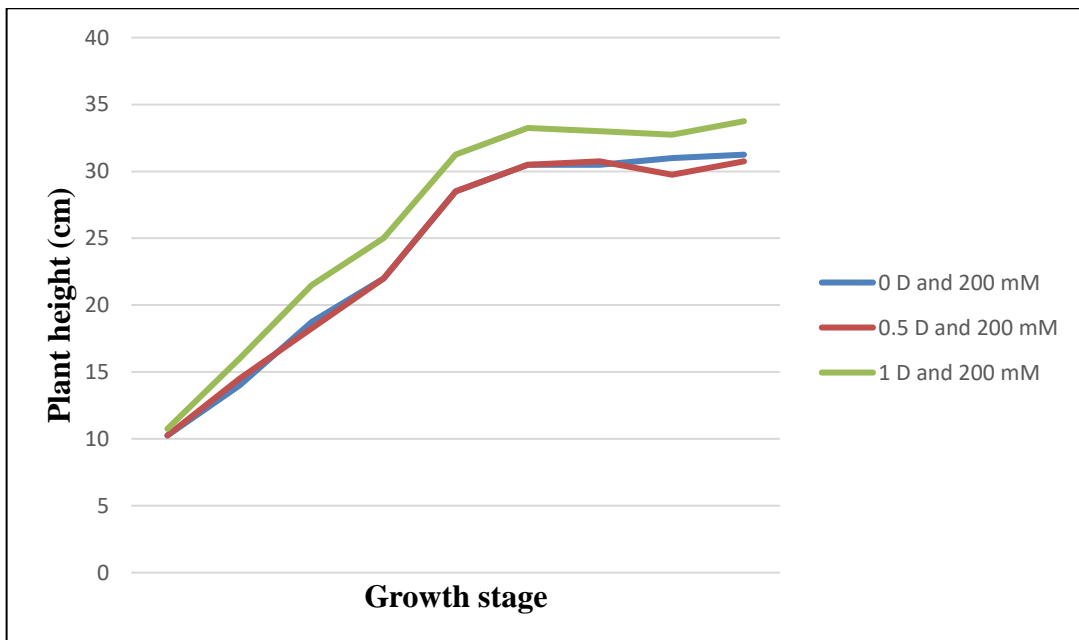


Figure A.15

Height of pepper plant irrigated with 200 mM saline water under three amounts of DISPER Osmotic GS



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.16

Chlorophyll concentrations of pepper plant irrigated with 200 mM saline water under three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g

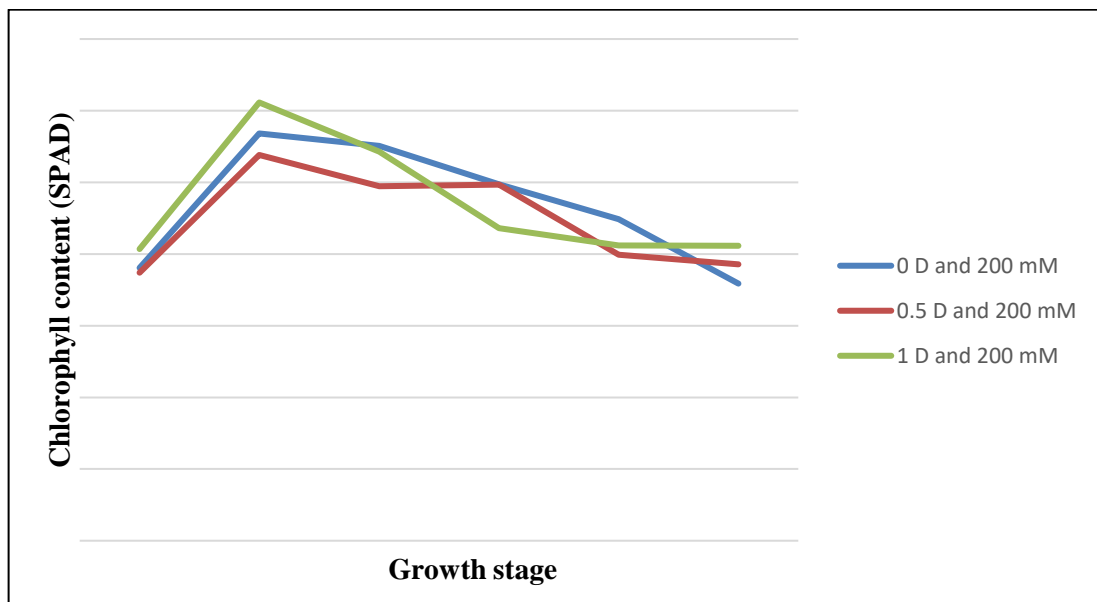


Figure A.17

Chlorophyll concentrations of pepper plant irrigated with 100 mM saline water under three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g

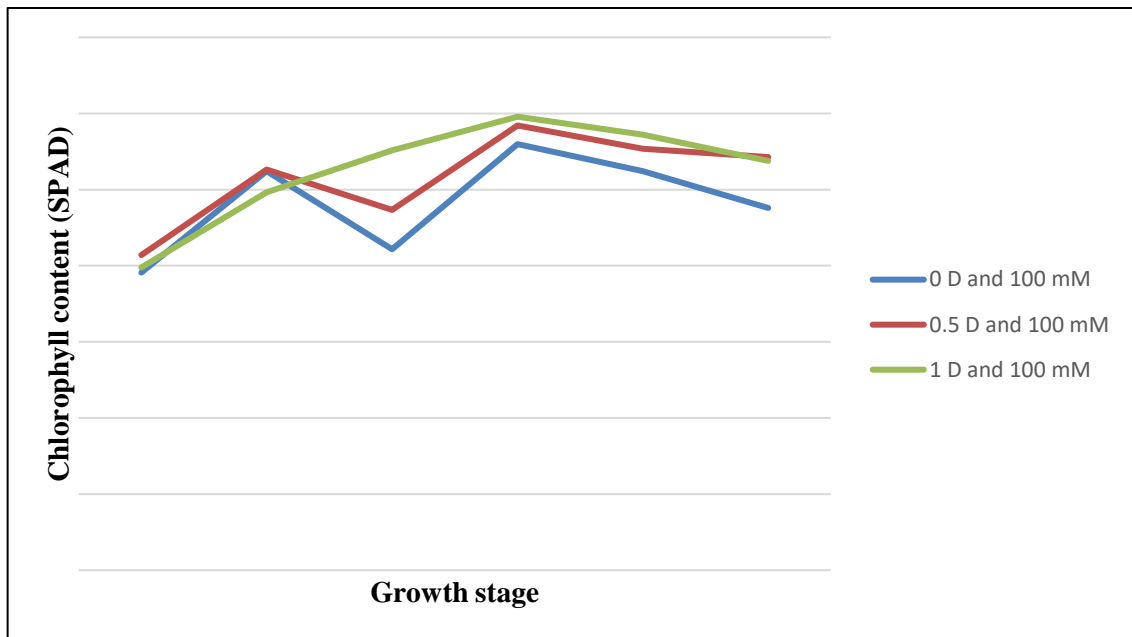


Figure A.18

(No. F) Number of flowers on pepper plant irrigated with three saline water (0, 100, and 200 mM)

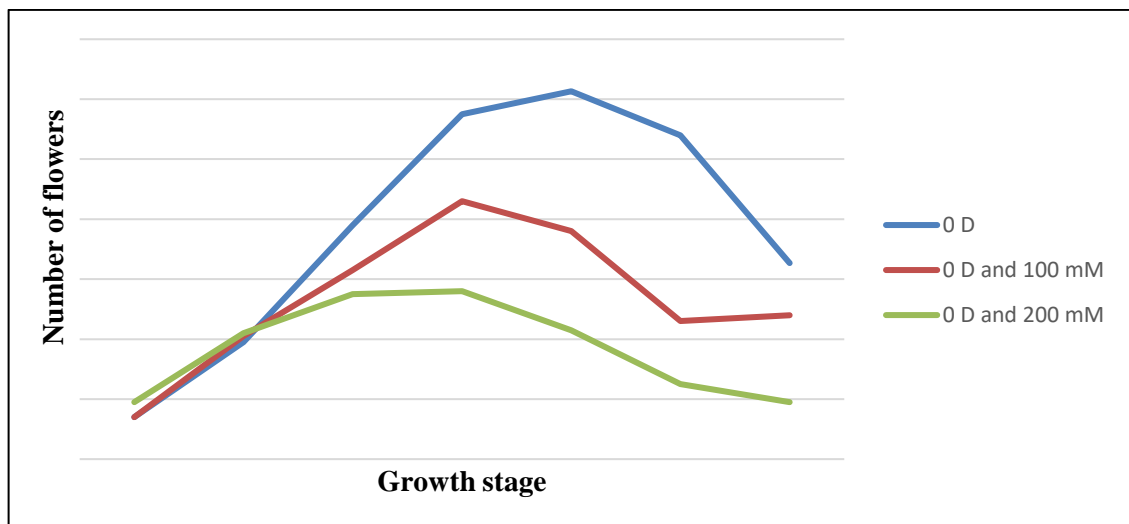


Figure A.19

(No. F) Number of flowers on pepper plant irrigated with tap water under three DISPER Osmotic GS levels.

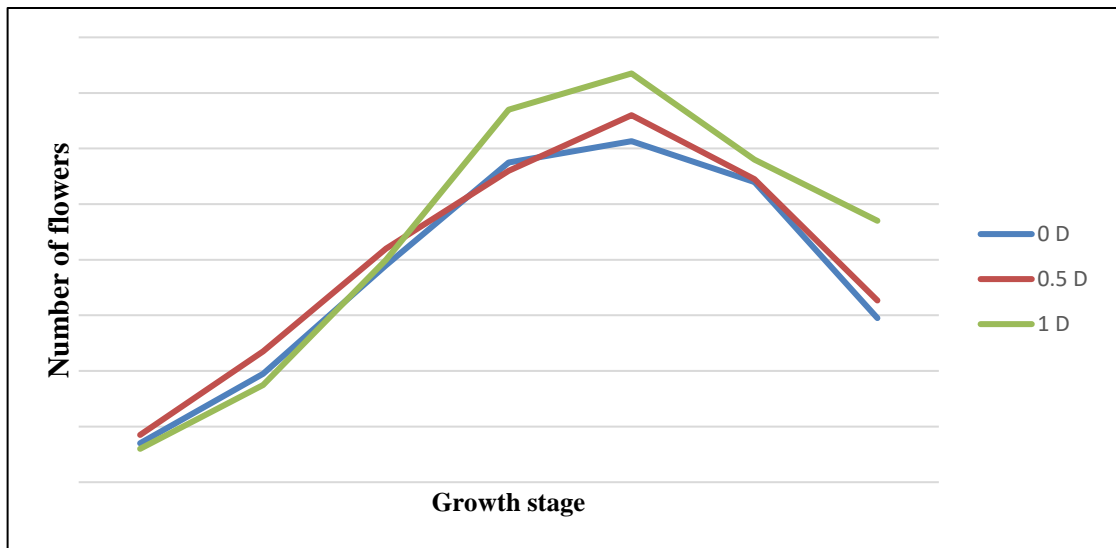


Figure A.20

(No. Fr) Number of fruits irrigated with three saline water (0, 100, and 200 mM)

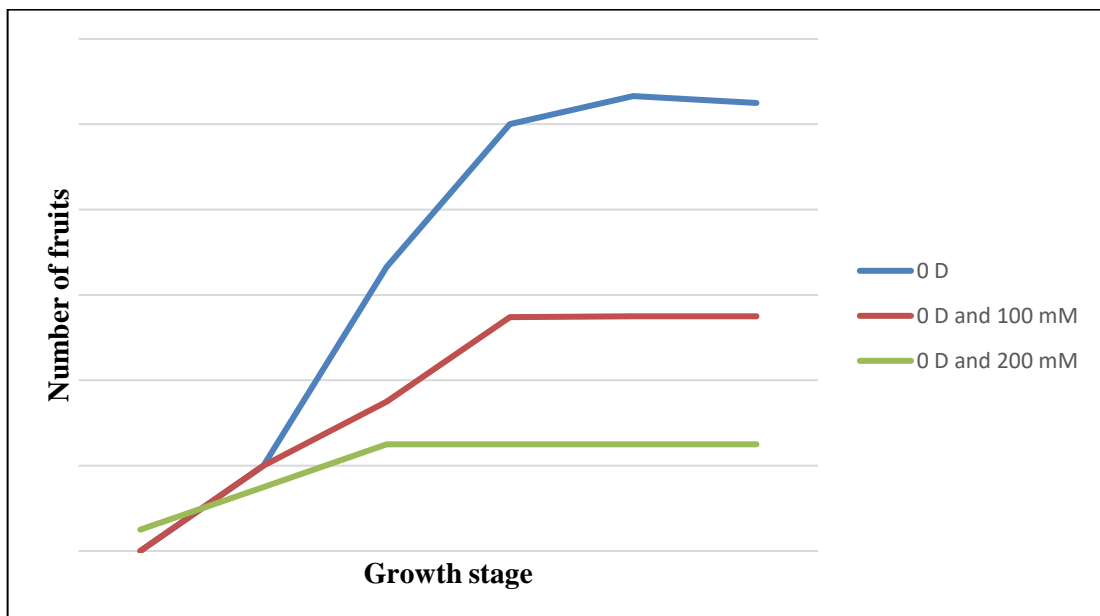
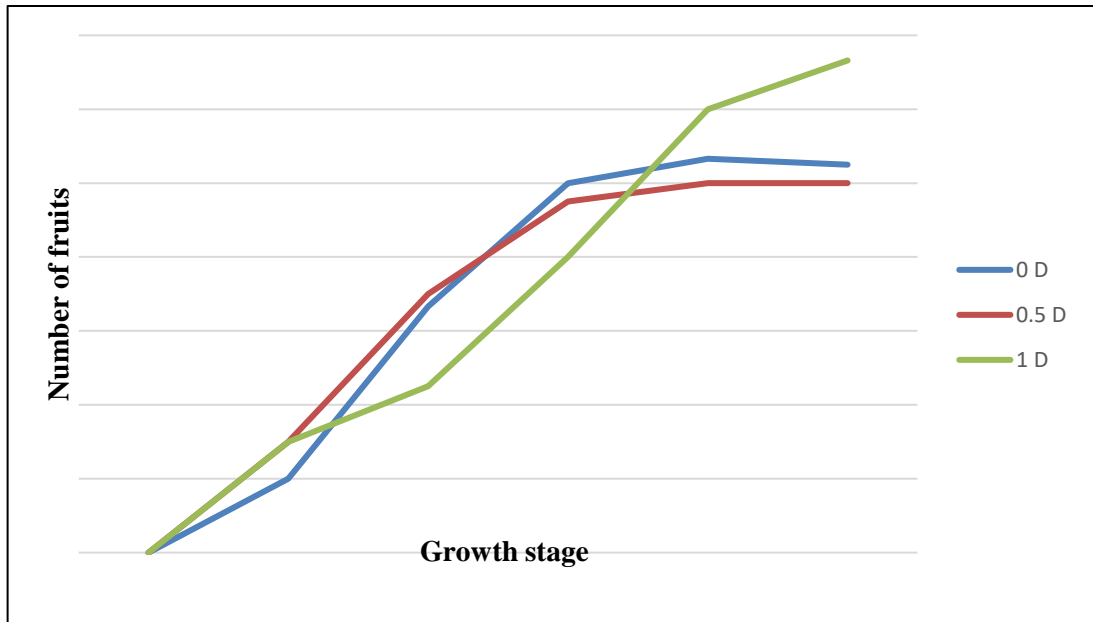


Figure A.21

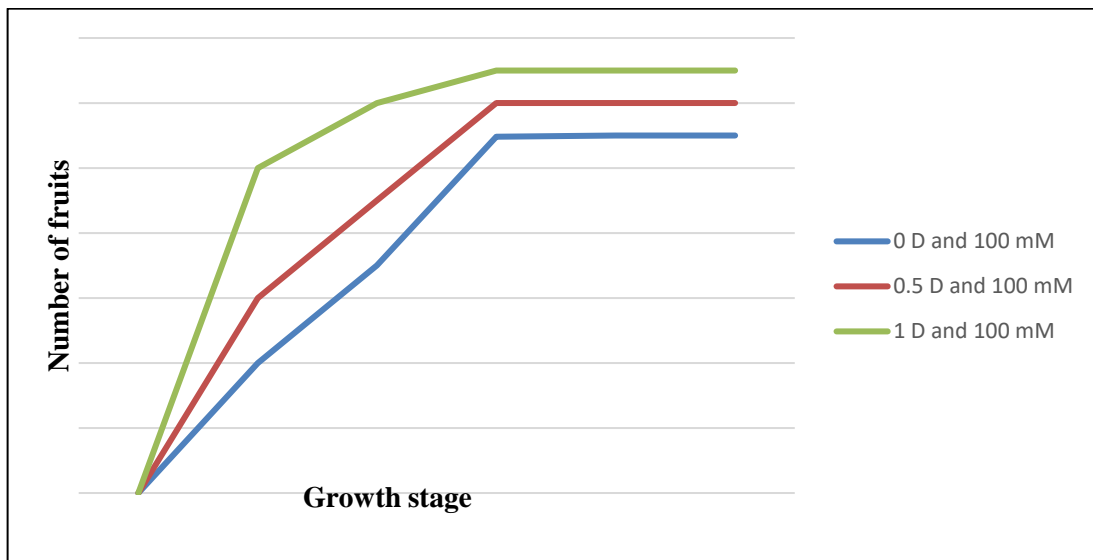
(No. Fr) Number of fruits irrigated with tap water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.22

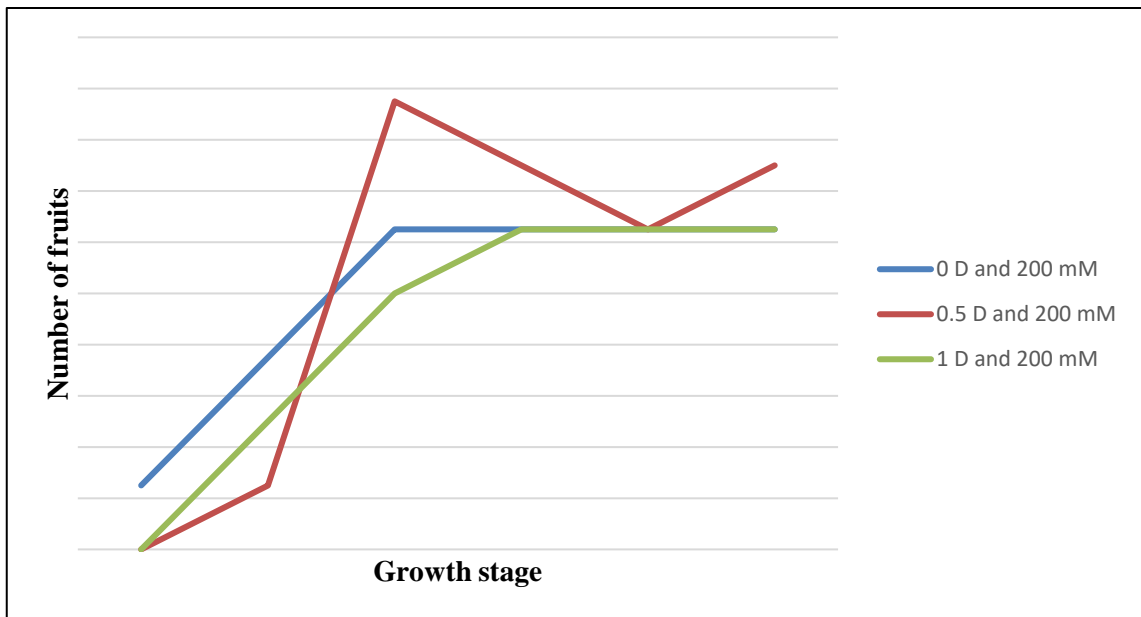
(No. Fr) Number of fruits irrigated with 100 mM saline water under three DISPER Osmotic GS levels. Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.23

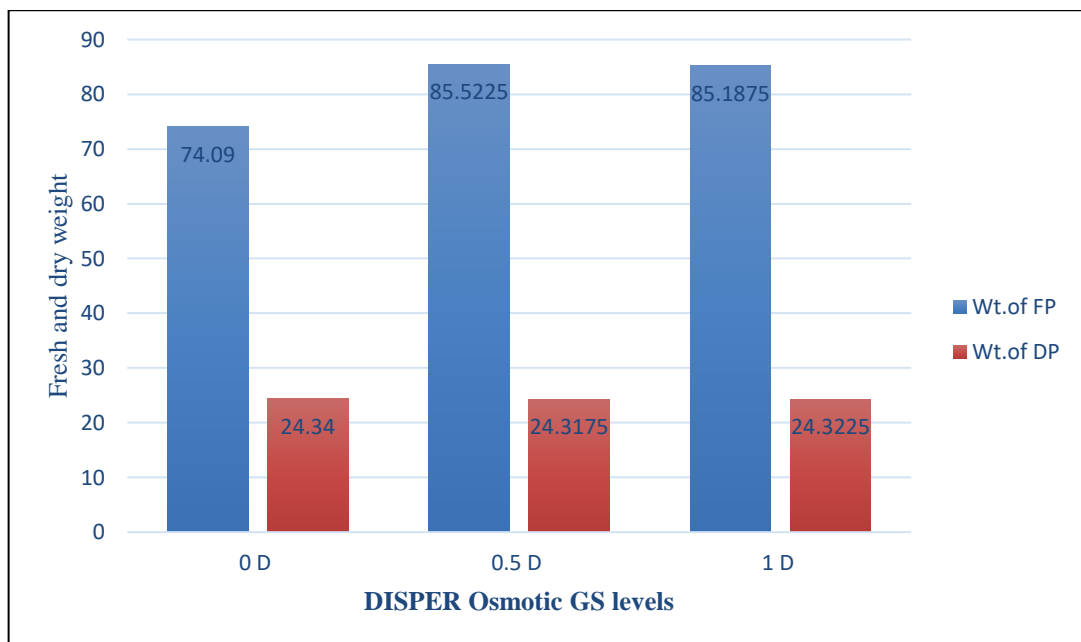
(No. Fr) Number of fruits irrigated with 200 mM saline water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.24

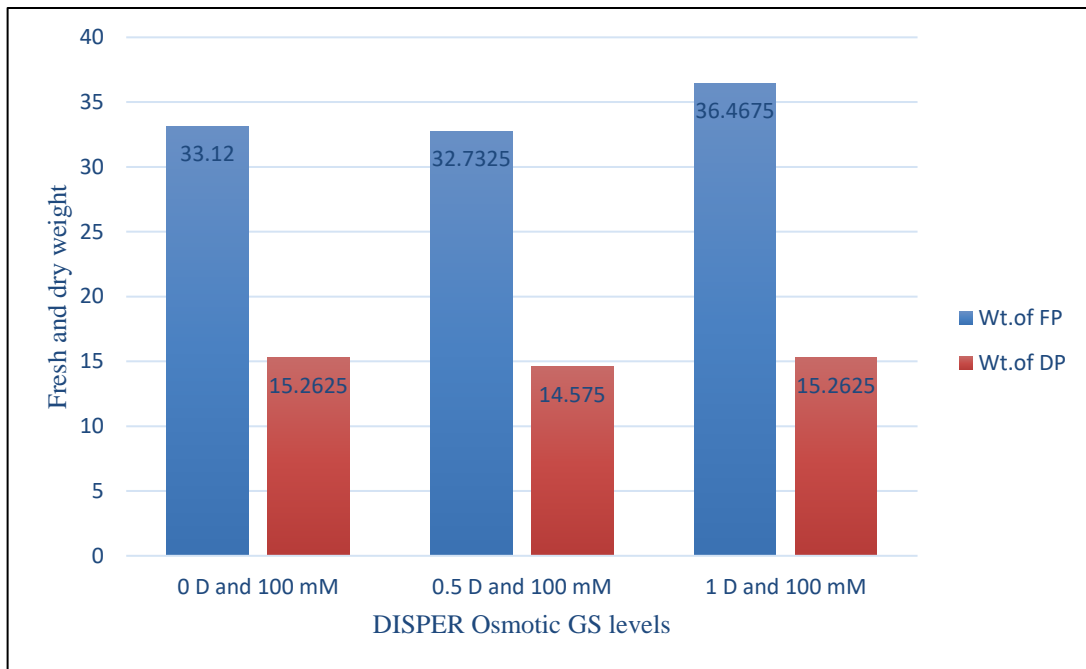
Fresh and dry weight for plants irrigated with tap water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.25

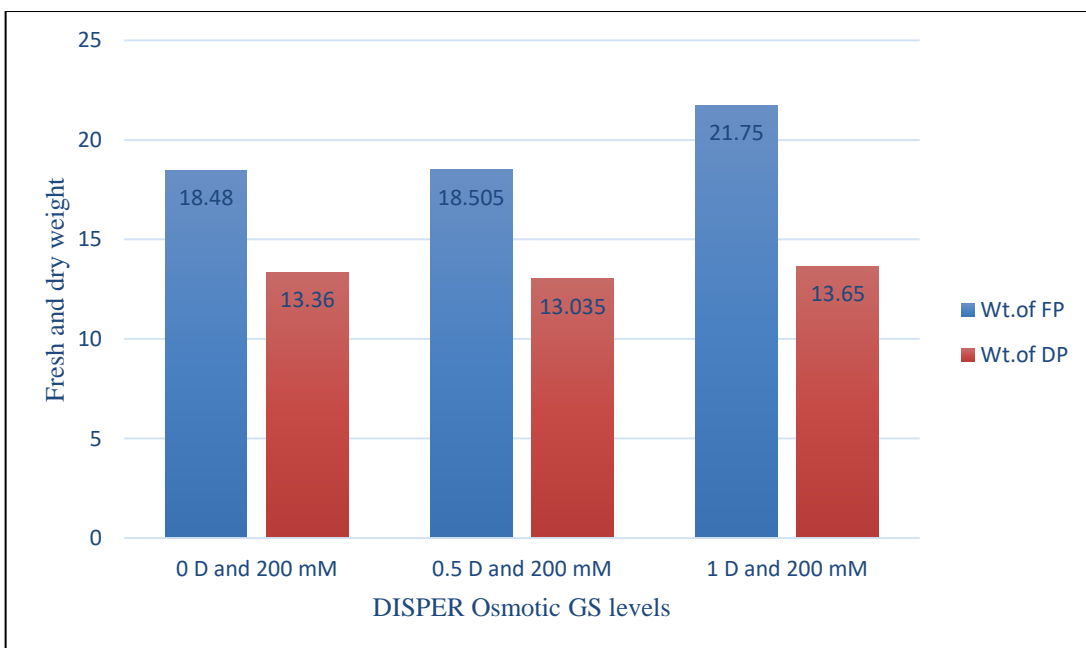
Fresh and dry weight for plants irrigated with 100 mM saline water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.26

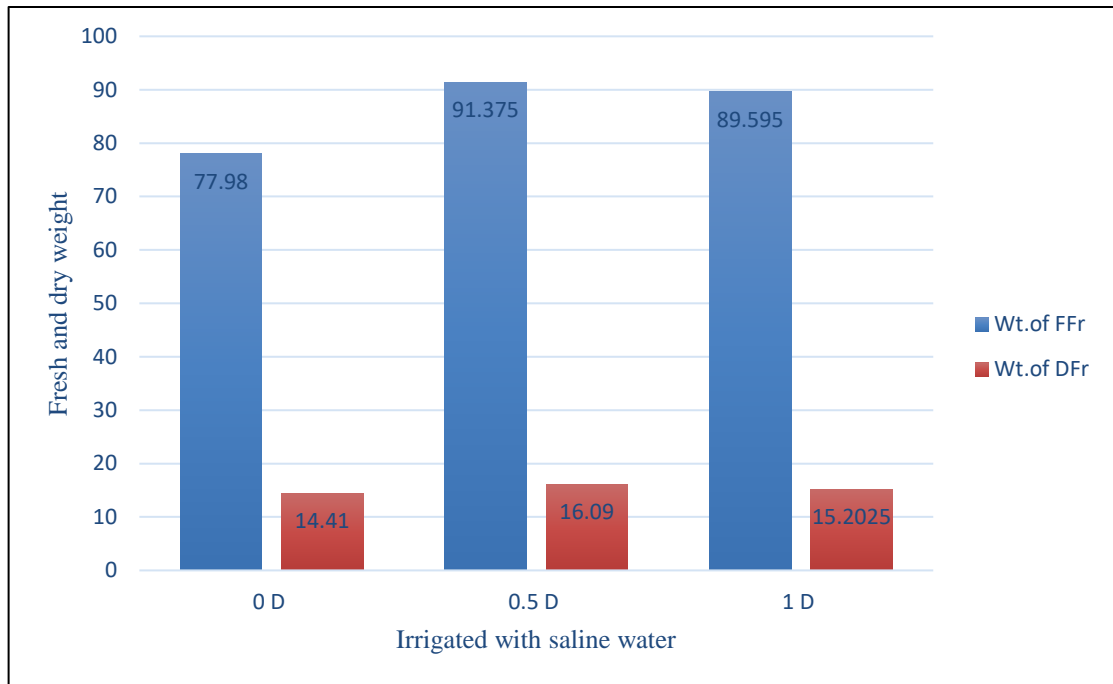
Fresh and dry weight for plants irrigated with 200 mM saline water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.27

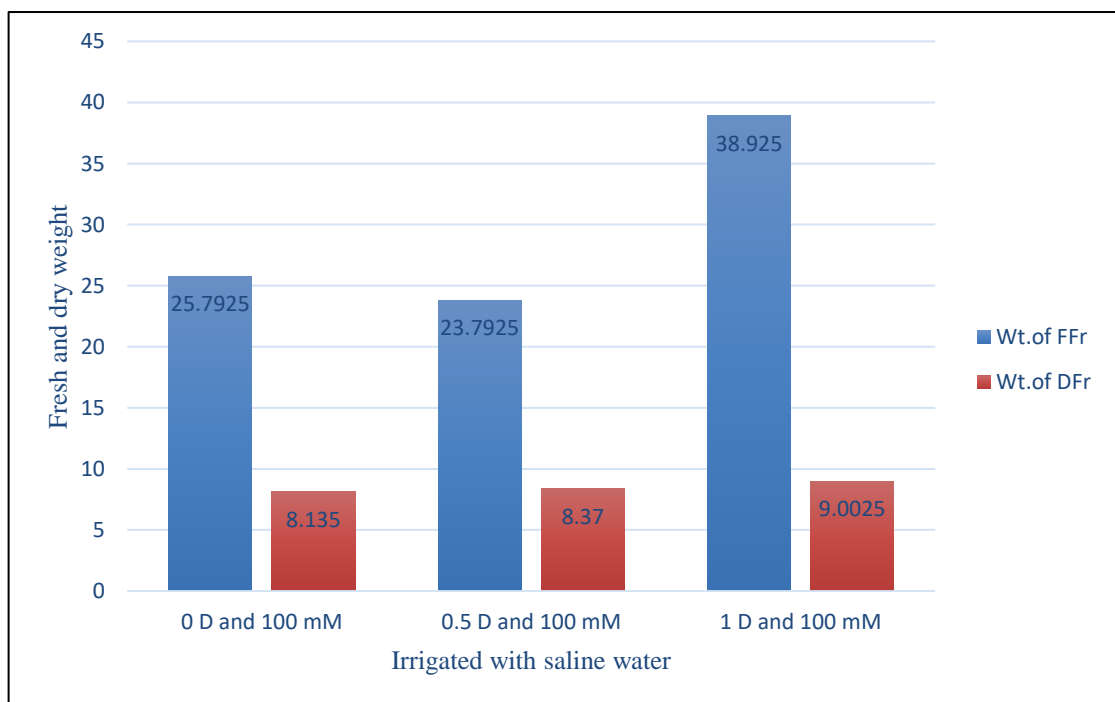
Fresh and dry weight for fruits irrigated with tap water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.28

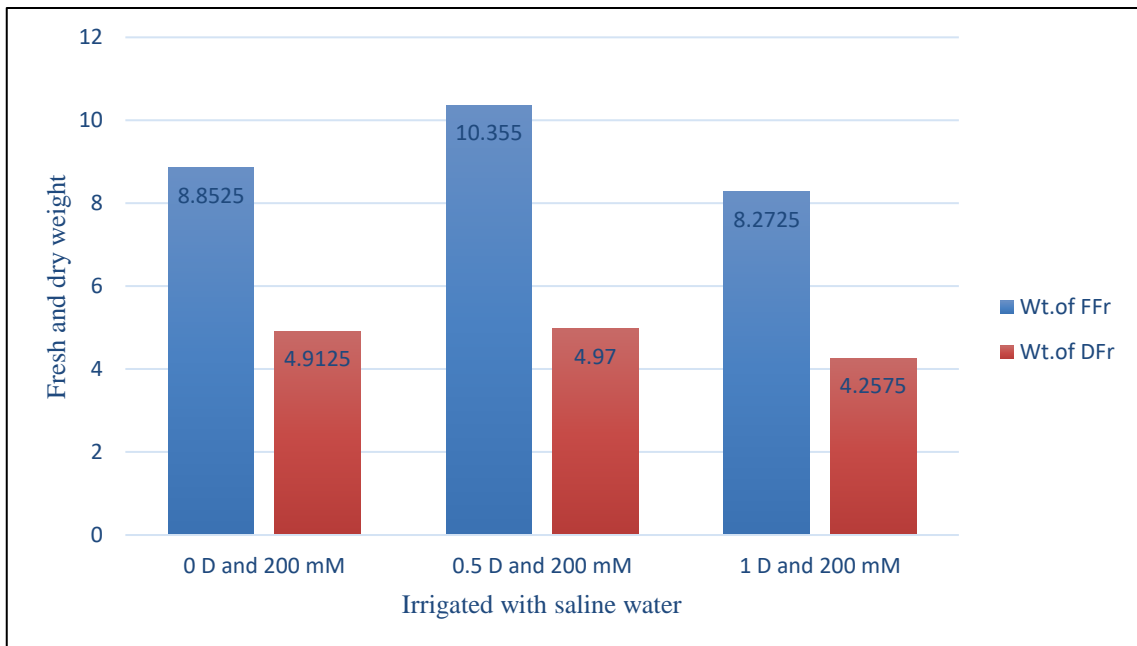
Fresh and dry weight for fruits irrigated with 100 mM saline water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.29

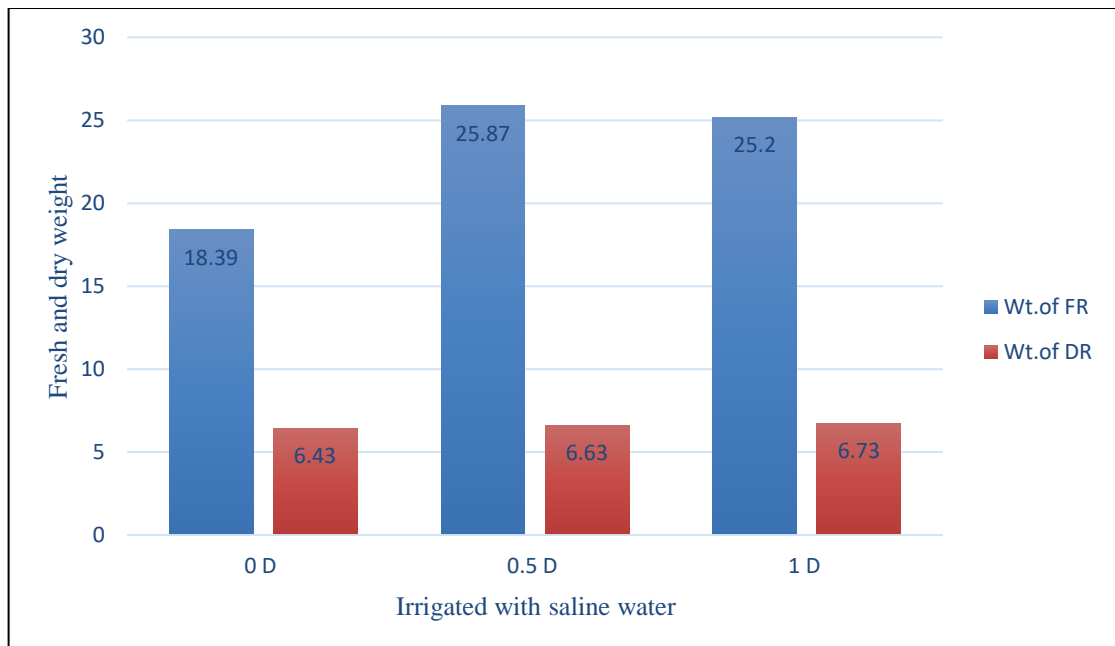
Fresh and dry weight for fruits irrigated with 200 mM saline water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.30

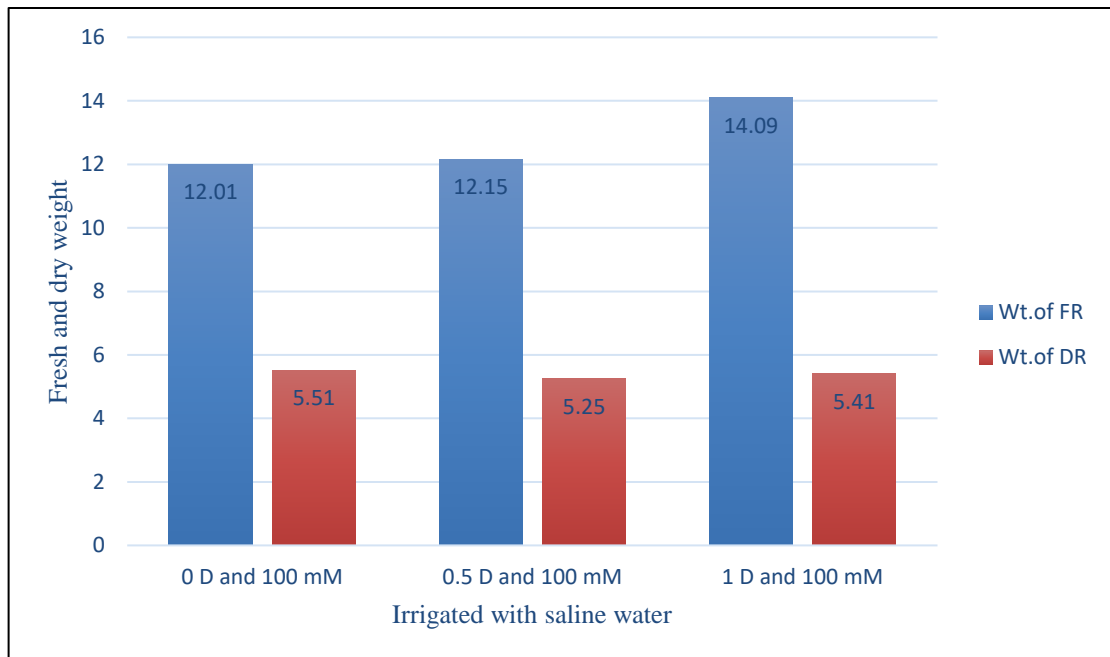
Fresh and dry weight for root irrigated with tap water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.31

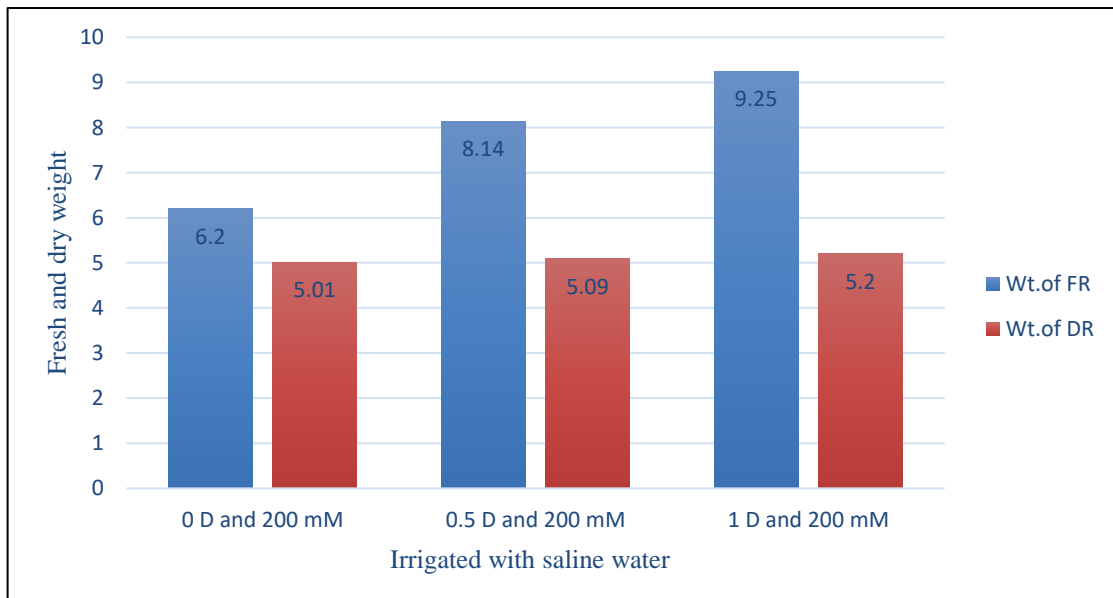
Fresh and dry weight for root irrigated with 100 mM saline water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.32

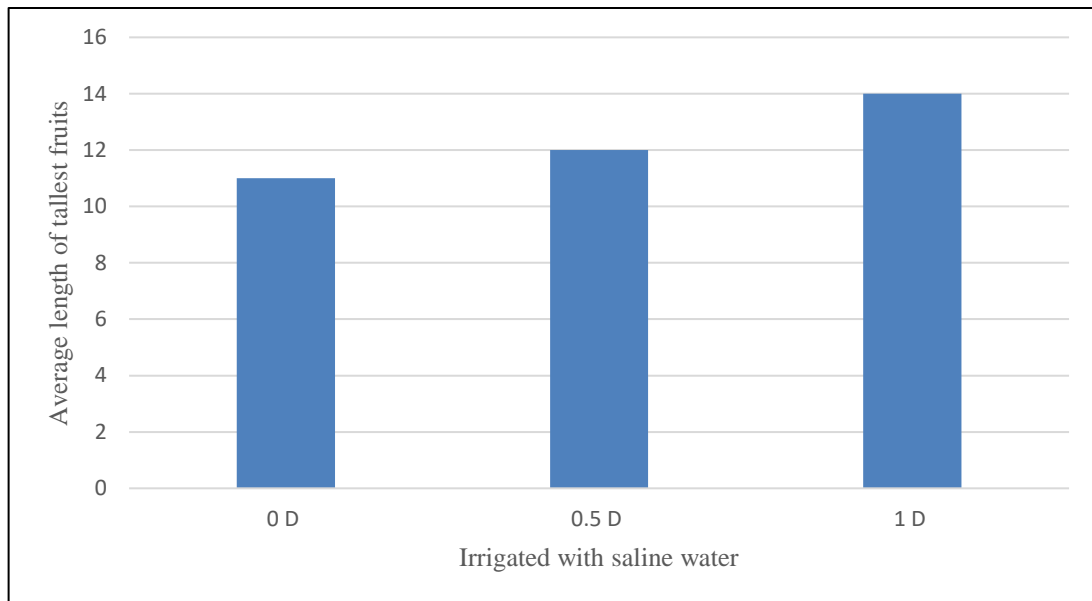
Fresh and dry weight for plants irrigated with 200 mM saline water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.33

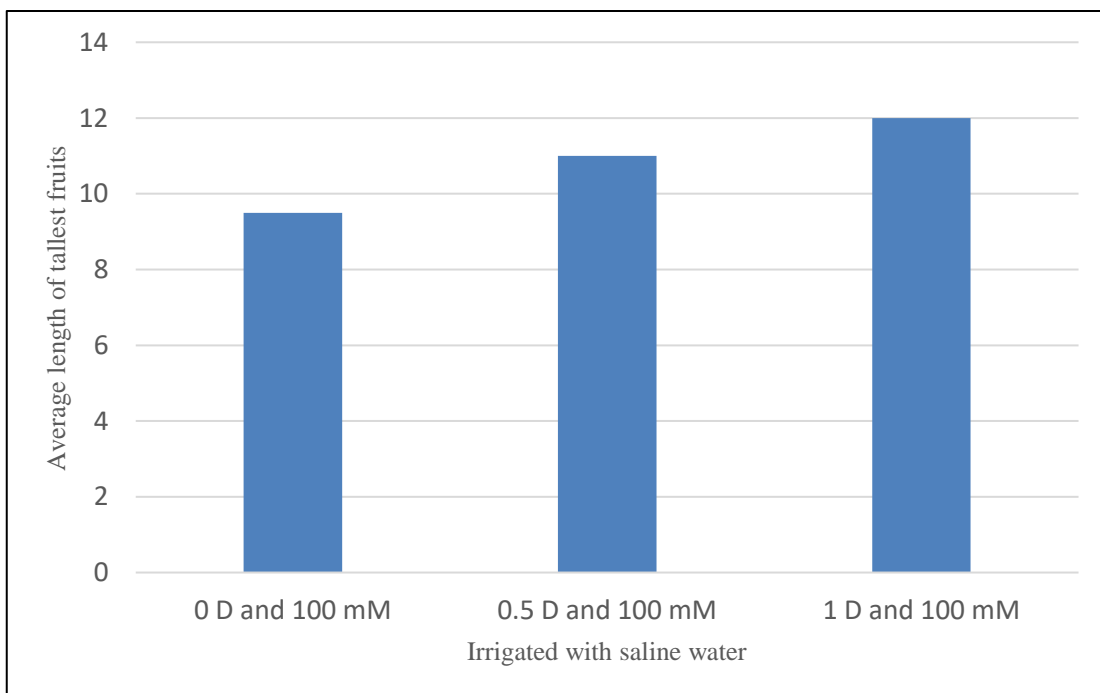
Average length of tallest fruits irrigated with tap water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.

Figure A.34

Average length of tallest fruits irrigated with 100 mM saline water under three DISPER Osmotic GS levels



Note: Three amounts of DISPER Osmotic GS were used, 0, 0.5, and 1 g.



جامعة النّجاح الوطنيّة
كليّة الدّراسات العليا

تأثير منظمات النمو على نمو وإنتاج الفلفل تحت ظروف الملوحة

إعداد
لما عمر أحمد عمر

إشراف
د. هبة الفارس
أ. د. حسن ابو قاعود

قدمت هذه الرسالة استكمالاً لمتطلبات الحصول على درجة الماجستير في الإنتاج النباتي، من كلية الدراسات العليا، جامعة النجاح الوطنية، نابلس - فلسطين.

2023

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الملخص

تعتبر عوامل الإجهاد الأحيائية هي الأكثر تقييداً لنمو النبات وإنتاجه. يعد الجفاف الناتج عن نقص المياه من بين العوامل الأكثر تأثيراً. تمتلك فلسطين معظم موارد المياه المتجددة المحدودة. ويعتمد القطاع الزراعي على 51.5% من إجمالي استهلاك المياه. وبالتالي يتأثر بشدة. هناك عامل رئيسي آخر يحد من الإنتاجية وهو ارتفاع الملوحة بشكل رئيسي في المناطق القاحلة وشبه القاحلة مثل فلسطين، ويرتبط التأثير الضار للملوحة بالإجهاد المائي بالإضافة إلى عدم التوازن الغذائي. لذلك، أجريت هذه الدراسة لتقييم استخدام الديسبر كمنظم تناضحي لنمو الفلفل تحت الظروف المالحة.

تم استخدام ثلاثة مستويات من منظمات التناضح (DISPER Osmotic GS) ب (0، 0.5، و 1 جم/نبات) مع ثلاثة تراكيز ملح (0، 100، 200 ملم) من كلوريد الصوديوم. أجريت التجارب في مدينة طولكرم شمال فلسطين. تمت زراعة شتلات الفلفل (*Capsicum annuum*) صنف (الشرباتي) في البيت المحمي تحت ظروف الإضاءة الطبيعية خلال الفترة من 14 أكتوبر 2021 حتى 22 يناير 2022. تمت زراعة نبات واحد في كل أصيص (قطر وارتفاع 30×30 سم). مملوءة بخليط من التربة بنسبة 2:1 رمل إلى بيتموس أظهرت النتائج تأثيراً إيجابياً لإضافة DISPER Osmotic GS على نمو النبات وإنتاج نباتات الفلفل تحت إجهاد الملوحة DISPER. مستويات الملوحة الاسموزية للمياه المالحة المروية (100، 200 ملم) من المياه المالحة حصلت الباحثة على أفضل نتيجة في محتوى الكلوروفيل لأوراق الفلفل بمقدار (53.775، 41.175 ملجم/م³) ومعلقات الزهرة بمقدار 12.500 زهرة و 6.500 زهرة على التوالي، مقارنة بالمعاملة المتحكم بها، بالإضافة إلى ذلك أظهرت النتائج ارتفاع الوزن الطازج للجذور (14.090، 9.250 جم) ومتوسط طول الثمار (12، 6 سم) لجميع القياسات على التوالي. أدى استخدام DISPER Osmotic

GS عند 0.5 و 1 جم إلى زيادة متوسط مساحة الأوراق (179 سم²، 169.632). ونتيجة لذلك، يمكن استخدام تطبيق DISPER للتخفيف من آثار الملوحة الضارة على نمو النبات وتطور نباتات الفلفل تحت الظروف المالحة.

الكلمات المفتاحية: منظم النمو؛ الدسبر؛ مستويات ملوحة الري؛ المياه المالحة.