



An-Najah National University
Faculty of Graduate Studies

**IMPACT OF SOIL AMENDMENT ON SOIL
PROPERTIES AND PLANT GROWTH OF
PEPPER (*CAPSICUM ANNUUM*)**

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**This Thesis is Submitted in Partial Fulfilment of the Requirements for the Degree
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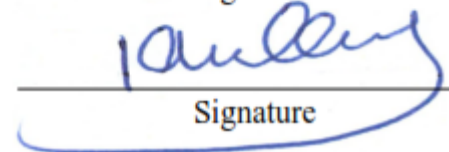
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Declaration

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

ASSESSMENT OF SOIL AMENDMENT ON SOIL PROPERTIES AND PLANT GROWTH OF PEPPER (*CAPSICUM ANNUUM*)

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

Water scarcity is one of the most significant global factors influencing food productivity. Palestine has one of the world's most limited renewable water resources. Agriculture consumes 51.5 percent of total water consumption. Therefore, other water resources and strategies are needed to cope with this situation. Soil amendments play an important role in enhancing crop growth and production. The objective of the study is to reduce the amount of water requirement of pepper plant through applying inorganic and organic soil amendments. In this study, different soil amendments including hydrogel, stevia straw, and compost were used under different irrigation levels (100%, 70%, and 50%) to irrigate "Nahas" pepper plants. Pepper seedlings were grown into 10 Litre- sized pots with one seedling per pot. Pots were filled with sand and peat moss, 3:1 ratio.

The amendments were applied to the soil in each pot at a rate of 250 g of straw stevia, 250 g of compost, and 2.5 g of a hydrogel. The results showed that adding hydrogel (2.5 gm/plant) increased significantly plant height by 48.4cm, number of fruits by 5.2, fresh plant weight by 58.1 g, dry plant weight by 17.2 g, fresh fruit weight by 62.4g, dry fruit weight by 45.8g, and fresh root weight by 21 g. However, adding hydrogel under 50% irrigation levels resulted in higher plant length by 51.7 cm, leaf chlorophyll content by 63.7, average number of fruit / plant by 3, fresh shoot weight by 60.8 g, fresh fruit weight by 44.7 g and fresh root weight by 21.2 g.

The addition of compost and stevia straw to soil increased soil moisture but they had a negative effect on plant growth and productivity. In conclusion, the results of this study indicated the positive effect of applying hydrogel in conserving soil moisture content through its water-absorbing properties. Hydrogel helps to alleviate water stress, maintain soil moisture, and optimize water use efficiency, especially in regions facing water scarcity or drought conditions, and reduced the amount of water used for irrigation by

50% of irrigation. According to the results obtained under the condition of this experiment could be recommended that adding hydrogel could be used under drought condition effective tool for soil water management.

Keywords: Soil amendment; Hydrogel; Compost; Stevia straw; Irrigation levels.

Chapter One

Introduction

Continuous economic growth and increasing demand for food, fodder, and fuel lead to overexploitation of water resources around the world (Gheewala 2018; Li, 2020). Most countries in the Middle East suffer from a constant shortage of water (Human Development Report, 2006; Shan, 2020). In Palestine, the situation is getting worse due to the decrease in usable water due to pollution, population growth, and increasing water demand (Shan, et al., 2020). Water resources in Palestine are not only affected by natural factors but are also subject to policy restrictions. Israel took control of the water resources of Palestine. Over 90% of the freshwater resources are used by Israel, while less than 10% is the Palestinian share (Palestinian Water Authority, 2011; Kouttab, 2013). Restrictions on Palestinian water allocations by the Israeli occupation authorities are the main cause of water shortages in the West Bank (Kouttab, 2013).

On the other hand, water has become less available due to population growth and economic development, alongside with climate change as drought events (IDMP, 2022). Climate change affects temperature and water change, which leads to temporal and spatial changes in water resources, which leads to drought (Zhang, 2011; Wang Y. L., 2019). Thus, temperature and rainfall have interactive effects on water resources (Shukla, 2015; Wang Y. L., 2019). In recent years, Palestine climate witnessed high temperatures, low rainfall, and unequal distribution of rain (UNDP, 2009). Drought stress leads to a change in the physiological and biochemical characteristics of the plant, and it is the key limiting factor for any crop growth, development, and production (Okunlola, 2017; Ahmed, 2020; Besharati, 2022). Generally, drought results in crop water deficit which mainly arises from insufficient or uneven precipitation and accordingly shortage of soil moisture (Jaleel, et al., 2008). Indeed, drought threatens people's lives with serious consequences like famine and food insecurity.

The performance of agriculture is significantly impacted by the effects of climate change and its variability on water supplies. The supply of water for agricultural purposes is being greatly impacted by changes in precipitation patterns, a rise in the frequency and intensity

of extreme weather events, and changes in temperature regimes. The growth and yield of crops can be affected by changes in rainfall patterns, such as extended droughts or an increase in rainfall variability. Elevated evaporation rates enhance water loss from soil and vegetation as a result of rising temperatures. For agricultural systems, these climate-related changes in water resources provide serious difficulties, including decreased crop yield, greater susceptibility to pests and diseases, and decreased water use efficiency. The effects of climate change and its variability on water resources have major implications for the performance of agriculture as it has implications for hampering economic growth and development. Previous reports showed that climate change may increase the vulnerability of more than 60% of the rural population living in the countryside who depend on natural resources and agriculture as a source of income (Nhemachena, et al.,2020). (Taheripour, et al., 2020) Studied the effect of Water scarcity for six Middle Eastern countries has a significant impact on the economy, water scarcity by up to 20% may lead to a decrease in GDP by up to 12%.

1.1 Soil amendments

Soil amendments have a role in improving soil fertility by improving the chemical, physical and biological properties of the soil. (Alghamdi, A.G, et al., 2022) In addition, it works to enhance the beneficial microbial activity of the soil, increase water holding capacity and retain nutrients, and adjust the pH in the soil. Fertile soil helps plant roots to grow effectively to absorb nutrients and be used by the plant. (Aytenew, M., and Bore, G. 2020)

Soil amendments play an important role in enhancing crop growth and agricultural productivity. Some of the main reasons that highlight the importance of soil amendments are;

Nutrient Source

Soil amendments such as organic matter and mineral fertilizers add nutrients to the soil. Nitrogen, phosphorus, potassium and micronutrients have important roles in overall plant growth and development. Soil amendment replenish nutrient levels in the soil, ensuring that crops have sufficient supplies for optimal plant growth and increased productivity(

Diacono and Montemurro, 2011). Composting is one of the most environmentally friendly ways to recycle organic waste. (Al-Sari, et al., 2018). The use of organic fertilizer for crops and animals can improve the availability of nitrogen and phosphorous in the soil. It has an important role in organic farms from a biological point of view because it provides field crops with nitrogen and phosphorous for their important role in the growth and optimal productivity (Carr, P. M,et al., 2020). Polymers amendments has become more important, especially in areas with water scarcity (Abedi-Koupai, et al., 2008).

Improve Soil fertility

Soil organic and inorganic amendments have proven to mitigate drought effects on the plant and increase its yield by improving soil's moisture storage capacity (Abu-Rabada, 2021). The soil amendments are chemical or natural materials, which can be mixed into the soil to improve its physical and chemical properties. The capability of saving water and nutrients in deep sandy soils can be improved by using soil amendment (Al-Omran, and Al-Harbi, 2020). Adding crop straw to the soil is an ancient process used to improve and conserve soil and improve its water-holding capacity (Xu, 2019 ; Głąb, 2020). Straw is an important resource that can be recycled in nature, characterized by its low cost, biodegradability and high cellulose content (Wan, 2013; Cheng, 2015). Adding straw to soil increases soil organic carbon and mitigates global warming and climate change (Wang H. S., 2019; Głąb, 2020).

Water Retention and Drainage

Some soil additives, like hydrogel, vermiculite, and organic matter, enhance the soil's capacity to retain water and to drain it. By promoting the flow of water through the soil layer and holding of moisture for plant needs during dry periods, these additions help decrease water retention. Since it influences several physiological processes, including photosynthesis, nitrogen uptake, and general plant metabolism, adequate water availability is crucial for crop growth. (Miller and Naeth, 2019).

Water determines plant growth and development; its availability means a successful harvest. According to(FAO, 2011) . irrigation managment process for crop contribute to increasing number of seedling planted and increasing productivity. The soil water content

is important in the plant's growing season for optimal crop production in all sorts of agricultural fields within rainfed or irrigated agriculture (Ajayi and Horn, 2016). Since soil properties are subject to enhancement by agricultural practices such as tillage, mulch, sowing rate and the addition of organic fertilizers, the water holding capacity in the soil is enhanced leading to a higher yield.

Inhibition of diseases and Pests

Some soil modifications, such as biocontrol agents, organic amendments, and particular mineral amendments, can assist in inhibiting diseases of plants and pests. They encourage beneficiary microbial populations that outnumber infectious pathogens, strengthen plant defenses, or make conditions undesirable for the growth of pests and diseases. This can encourage sustainable crop protection and lessen the need for chemical pesticides. (Akanmu, et al.,2021)

Water availability is a critical factor influencing crop growth and productivity. In arid and semi-arid regions, water scarcity poses a significant challenge for agricultural practices.

1.1.1 Hydrogel

Hydrogel, a superabsorbent polymer with water retention properties, has shown promise as a soil amendment to improve plant available water. Super absorbent hydrogels are a new class of polymeric materials with strong hydrophilicity groups and can absorb 100-1000 times the water of its original weight (Cheng, 2015; Vakili, 2013). Hydrogel could retain water and increase the soil permeability (Gulrez,et al., 2011). The performance of hydrogel is determined by hydrogel formation conditions and chemical composition. Hydrophilic synthetic polymers (hydrogels) typically consist of polyacrylamide (PAM) and polyvinyl alcohol. Fully chemically synthetic polymers are interlocked to prevent their dissolving in the solution (Abedi-Koupai, et al.,2008).

1.2 Vegetables production in Palestine

Palestinian agricultural production heavily depends on the production of vegetables. Palestine offers ideal conditions for producing a variety of vegetables due to its varied climate and fertile soils. In addition to being essential for food security and nutrition, vegetables are also significant for farmers' livelihoods and the local economy.

In 2021/2022, the Ministry of Agriculture and the Palestinian Central Bureau of Statistics estimated the total area of agricultural land in Palestine at 1.21 million dunams. The area of vegetables in Palestine reached 202.3 thousand dunams (PCBS, 2020/2021). In Palestine, different types of crops, fruits, and vegetables are grown (Yahya, 2021). Vegetables are considered essential elements of the nutritional diet prevalent among Palestinian households. According to the Ministry of Agriculture Vegetable production represent 65% of the total crop production. This is mainly due to the high productivity of vegetables per dunum compared to other crops. (Ghattas, et al ,2015) Irrigated agriculture in Palestine is a growing economic sector, the total available water quantities are estimated to be 291 Millions of cubic meters per year (The World Bank, 2004). However, agriculture is consuming 150 MCM, equivalent to 51.5%. Moreover, the irrigated protected area is only limited to 19.7% and 21% of the agricultural vegetable area in the West Bank and Gaza, respectively. The irrigated open cultivation area is only limited to 66.3% and 76.3% of the agricultural vegetable area in the West Bank and Gaza, respectively (PCBS, 2022).

The agricultural sector in Palestine faces many obstacles that affect the sector in terms of productivity, sustainability and development. These challenges arise from economic, environmental, social and political factors that have the greatest impact on farmers' livelihoods. Following (Shaheen and Salim, 2012) .Some of the main constraints facing the agricultural sector in Palestine are:

Land fragmentation and accessibility

The fragmentation of agricultural land and the difficulty of accessing it is one of the most main challenges facing agriculture in Palestine. This is due to the political and historical factors that restrict the movement of farmers to access their lands and practice their agricultural work.

Water Scarcity

Water scarcity is the major challenge facing the agricultural sector in Palestine. Palestine faces a major shortage and limited access to water resources, which is due to political factors. The Israeli control over the water resources in the region and their unfair distribution, in addition to the restrictions imposed on their use and the difficulty in obtaining permits for the development and construction of new water infrastructure. Palestinian farmers struggle to obtain water to irrigate their crops, which directly affects productivity and sustainability .

Control of the Israeli military crossings and checkpoints

Political factors are among the most important factors facing the agricultural sector. Restricting movement and the apartheid wall that prevents and impedes the movement of farmers to access their lands and agricultural markets. In addition to the restrictions imposed on the movement of exporting agricultural products to international markets, which in turn impedes economic growth in Palestine. In addition to working to compete with Palestinian products by flooding the Palestinian markets with settlement products

1.3 Production of pepper in Palestine

According to the Ministry of Agriculture, the area planted with pepper was 1,512 dunums in West Bank in 2013 and the annual production is estimated at 9,487 tons/ dunums. The cultivated area of pepper in Palestine is 4864 dunums, 1340 dunums are cultivated in plastic houses, cultivated widely in the areas of Tulkarm, Tubas, and Jericho. (Haddad, 2014)

Pepper is a vegetable with great economic importance worldwide and very popular in the market due to its organoleptic properties and its high content of biologically active

compounds(Cortés-Estrada, et al. 2020). Pepper is one of the Solanaceae family. Is a perennial plant, The pepper plant is propagated by seeds. It is either cultivated directly in the ground or seedlings are planted inside the greenhouse. It is used as fresh food or dried and ground spices (González-García, et al.,2021).

The successful cultivation of pepper relies on optimal soil conditions that support vigorous plant growth, nutrient availability, and water holding capacity. Pepper is considered one of the most susceptible crops to water stress in horticulture. To optimize pepper production, and profitability, and to ensure the most efficient use of limited 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 water scarcity conditions. Deficiency of irrigation and drought stress have a negative impact on the growth and productivity of the pepper crop. These stress are constantly increasing due to climate change.(Mardani, et al. 2017).

1.4 Objectives of the study

The main objective of the study is to reduce the amount of water requirement of pepper plant through applying inorganic and organic soil amendments. The specific objectives of the study are:

- A. To investigate the effect of soil amendments (Hydrogel, stevia straw and compost) on growth parameters and production of pepper plant.
- B. To study the effects of soil amendments (hydrogel, stevia straw, **compost**) on soil's chemical and physical properties.

Chapter Two

Literature review

3.1 Effect of water stress on plant growth and yield of pepper

One of the most important environmental factors that have a major role in affecting the growth and development of the pepper plant is the water stress. Therefore, understanding the physiological and biochemical responses of pepper plants to water stress is important for the sustainable management of the crop. Water stress affects plant growth and development, including seed production, seedling growth, vegetative growth, blooming, and fruit yield. Many scientists have examined the pepper plant's response to water stress at various growth stages, concentrating on the physiological and biochemical changes that result from water stress's impact on the plant's development. (Garcia, et al., 2016) Pepper is one of the most widely cultivated vegetables grown around the world. The effect of water stress on the pepper plant was studied at three developmental stages.

Water stress delayed fruit ripening in stages one (5 leaves) and stage two (third flower production), but decreased yield in stage three (first fruit setting). The findings show that water stress alters the accumulation of biochemical active compounds such as vitamin C, sugars, organic acids, flavonoids in the fruit differently at different stages of plant development. (Borràs D. P., et al. 2021).

Water stress has a significant impact on flowering and fruit development in pepper plants. A study by (Ahmadi et al. 2017) revealed that water stress caused a delay in flowering time and reduced the number of flowers formed. Additionally, water stress during the fruiting stage resulted in decreased fruit size, lower fruit weight, and reduced overall yield. Insufficient water availability during critical growth stages hampers reproductive development and limits fruit production in pepper plants.

Water stress during the reproductive stage of pepper plants can lead to substantial reductions in fruit set, size, and overall yield. Research by (Martínez-Rodríguez., et al. 2019) and (González-González., et al. 2021) revealed that water stress negatively

influenced flower bud formation, pollination, and fertilization processes, resulting in a lower number of marketable fruits.

In other study, the effect of irrigation levels on plant growth of pepper at ETc (33%, 67%, 100%, and 133%) was studied. The results showed that at 67% ETc there was no effect on the yield of fruit and quality of the crop compared with 100% ETc. Despite the reductions in plant water status, growth, and leaf gas exchange. Over-irrigation at 133 % ETc resulted in increased leaf water potential, and plant growth and had no increase in fruit yield compared to irrigation at 100 % ETc or 67 % ETc. (Kabir, 2021).

Water stress significantly affects the morphology and growth parameters of pepper plants. Studies by (Sharma et al. 2017) and (Xu et al. 2019) demonstrated that water stress reduced plant height, leaf area, stem diameter, and overall biomass accumulation in pepper plants. Additionally, water stress negatively influenced root development and resulted in shallower root systems.

A study conducted by (Garcia., et al. 2016) observed that under water stress conditions, pepper plants exhibited reduced shoot height, decreased leaf area, and inhibited overall vegetative growth compared to well-watered plants. Water stress triggers physiological responses in plants, such as stomatal closure and reduced cell expansion, leading to these morphological changes.

In order to adapt to water stress, pepper plants contribute a number of physiological processes. To limit water loss by transpiration, one of the main reactions is the variation of stomata behavior. In order to conserve water, pepper plants under water stress displayed reduced stomatal resistance and increase water availability in leaf , according to studies by (Cui et al. 2018) and (Park et al. 2020).

2.2 Effect of soil amendments on soil quality

By enhancing crop growth and production, enhancing soil fertility, and preserving long-term soil health, soil amendments are essential in modern agriculture. Due to their potential to enhance crop qualities and soil quality, synthetic soil amendments, including chemical fertilizers and soil amendment, have drawn a lot of attention. By enhancing the

water-retention properties of growth media, hydrogels have been proposed for agricultural usage with the goal of enhancing water availability for plants: (Montesano's., et al.2015) studied the effect of using hydrogel on improving the growth of the cucumber crop. In the experiment, 2 grams of hydrogel / liter of soil were used. Growth parameters monitored after 35 days of planting. the results showed using hydrogel of cucumber crop growth improve plant height, plant weight, leaves, stems, and fruits and leaf surface area.

(Lee et al. 2019) studied the effect of using hydrogel as a soil amendment to improve soil moisture retention and growth promotion in various crops. The hydrogel found to improve the soil's ability to retain water, reducing water loss, and providing moisture from the roots of the plant. This had a positive effect on the growth and development of the pepper plant.

In another study conducted by (Chen., et al.2018) the effect of hydrogel on the growth and production of pepper plants was investigated. The addition of hydrogel to the soil significantly increased the plant height, stem diameter, and leaf surface area of pepper plants compared to the control treatment. In addition to improving soil moisture, water conservation, water supply to plants, enhancing overall growth, increasing productivity, and obtaining high quality pepper fruits.

(Hafiz-Afham , et al. 2023) studied the effect of hydrogel on the productivity of the pepper crop. He mixed the hydrogel in the soil in different proportions (20%, 40%, 60%, 80%, 100%)The results showed that the use of hydrogels at a rate of 40% and 60% indicated optimal plant growth in addition to the ability of the hydrogel to provide water to the plant without affecting plant growth.

(Buck ., et al 2010) found that the hydrogel could modify the physical properties of soils like soil particle ,bulk density, porosityand and water holdding capacity. It indicates that the hydrogel has an effect on the time needed for the soil to dry. When hydrogel is used in dry soil, the hydrogel can moisten the soil at levels according to the type of soil used. (Arbona., et al 2005) reported an increase of 30% in soil moisture after using hydrogel. (Fernández., et al. 2018) the use of hydrogel to evaluate the effect of water use and productivity of the pepper crop, used 5 ratio of hydrogel. The variables under study were

water consumption, irrigation frequency, water use efficiency, plant height and fruit characteristics. Results showed that hydrogel, at doses ranging from 2 - 2.5 grams / plant Water efficiency was correlated with hydrogel use producing up to 10.1 kg.m-3.

(Abu Ghyadah and Alokely, 2018) studied the effect of using a super absorbent polymer obtained from diapers. The results showed that the use of hydrogel at 2% and 3% improved plant growth and reduced the amount of water used for irrigation.

(Hamdy,. et al.2020) studied the effect of adding hydrogel with different irrigation levels on the growth and production of murcott plant. The results indicated that all hydrogel treatments improved the vegetative growth and productivity of murcott tree. The addition of 750 gm/tree with an irrigation level of 75% of ETc obtained optimal values for vegetative growth and productivity.

(Solichatun,. et al. 2021) studied the effect of the growth regulator paclobutrazol on the growth of pepper seedlings in water-deficient soil. The results showed that there was a significant effect on the levels of chlorophyll, carotene and proline on pepper plants grown under water deficit.

Silica nanoparticles (SiNPs) have a role in promoting growth and increasing cucumber yield under water deficit and salinity pressures. (Al-Saeedi,. Et al, 2019) cultivated cucumber plant using four levels of SiNPs (100, 200, 300, 400 mg/ kg) and 3 different irrigation systems calculated based on crop evaporation (ETc) (100, 85, 70% ETc). The results from field experiment under greenhouse conditions showed that SiNPs helped cucumber plants to grow normally without any obvious symptoms of irrigation water deficiency (85% of cucumber ETc) during the entire growing season. However, the fruit yield per plant was the highest.

(Hosseini,. et al, 2021) Studied the effect of using sanoplant as a moisture-preserving material in the soil throught experment was measured plant growth parameters, in addition to measuring the nitrogen content in the leaves, the results indicate that the use of sanoplant with different irrigation levels improve the water holding capacity in soil,

use of sanoplant at concentration 7 grams / kilogram of soil saved 50% of the amount of water used in irrigation.

(Yang ,. et al. 2020) studied the effect of super absorbent polymer on crop growth and soil treatment in dry and semi-arid regions. In their study super-absorbent polymer (SAP) was used as a soil modifier with different concentrations, soil temperature, photosynthesis rate, crop growth, and production indicators for maize were monitored. The results showed that the higher the concentration of SAP in the soil, the higher the rate of photosynthesis, additionally, an increase in plant length, leaf surface area and crop productivity was observed.

Materials such as compost, manure, leaf residue, and agricultural residues are examples of organic matter additions. The structure, water-holding ability, and nutrient content of the soil are all improved by adding organic matter. Additionally, organic matter encourages the cycling of nutrients, maintains beneficial soil microorganisms, and improves the general health of the soil.

(Ali ,. et al.2018) studied the effect of using soil modifiers to improve water use efficiency and corn productivity under different irrigation conditions, the use of 5 treatments (farm manure, wheat crop residue, gypsum, gymizole, humic acid) and two levels of irrigation (350 mm and 175 mm). The results showed that the use of wheat crop residues with irrigation of 350 mm enhances the availability of water, and increases the grain yield by (62%) in addition to increasing the efficiency of water use by (35%), and the efficiency of rain use by (50%).

Chapter Three

Materials and methods

3.1 Study site and Experimental design

The experiment was conducted in a greenhouse on the farm of the Faculty of Agriculture of An-Najah National University, Tulkarm, Palestine (32.31° N, 35.02° W, and altitude of 75 m) during the year 2021/2022 growing season.

The experiment was designed as a factorial treatment (4x3) design in a completely randomized design (CRD) with 4 replicates per each treatment . Four treatments were conducted by applying soil amendments, including control without soil amendment, compost (Al Junaidi nursery, Nablus), stevia straw (Palstevia, Palestine), and hydrogel (Supermall, India). Three levels of irrigation 50, 70, and 100%, based on the ET_c readings were applied. The rate at 100 % ET_c was considered as an optimal rate. Appendix (A) shows the design of the experiment and the type of amendment, and the irrigation level.

A homogeneous healthy pepper cultivar seedlings were used in the experiment Appendix (B.2). The seedlings were grown in natural light conditions from October 14th, 2021, to January 22nd, 2022. Plastic containers of 10 L were used to grow the plants, One seedling per pot . The growing media was composed of sand and peat moss, 3:1 ratio.

The amendments were applied to the soil in each pots at a rate of 250 g of straw stevia, 250 g of **compost**, and 2.5 g of a hydrogel. The fertilization and irrigation treatment process started after 10 days of planting. To determine the amount of irrigation, the readings of the ET_c were obtained at daily from basis the meteorological station located at the college of agriculture and veterinary medicine at An-Najah national university.

hydrogel composed of crystal mud soil water beads was used. The size of hydrogel particles is approximately 2.5 to 3 mm in diameter, and after absorbing water the size increases from 13 to 16 mm in diameter. The product is considered safe and reliable and can be reused for up to 2 years. Hydrogels absorb and store water hundreds times of their weight (400-1500) grams of water per dry gram of hydrogel.

The chemical fertilizers were added weekly in the first growth stage using compound fertilizer (6-6-6) at rate of 0.9 cc/seedlings/day, in the stages of plant development 5-3-8 NPK at rate of 2.8 cc/seedlings/day was applied, and for fruit, growth 5-3-8 NPK at rate of 3.7 cc/seedlings/day was applied. In the harvest phase 5-3-8NPK at rate of 4.7 cc/seedlings/day.

3.2 Soil measurement

3.2.1 EC and pH analyses

The key soil properties of pH and electrical conductivity (EC) are crucial for soil fertility, nutrient availability, and general plant health. Understanding soil pH and EC is essential for managing soil nutrients, increasing crop productivity, and managing soil.

A measurement of the concentration of hydrogen ions (H^+) in the soil solution, pH describes the acidity or alkalinity of the soil. The pH scale has a range of 0 to 14, with 7 being regarded as neutral. A number of 7 or less denotes an acidic soil, whereas a value of 7 or more denotes an alkaline or basic soil. The pH range between 6 and 7 is generally considered to be ideal for most crops, as this range promotes optimal microbial activity and higher nutrient availability.

EC evaluates the soil solution's capacity to carry an electric current and serves as a measure of the overall amount of dissolved salts present in the soil. DeciSiemens per meter (dS/m) or milliSiemens per centimeter (mS/cm) are the usual quantities used to express electrical conductivity (EC). Increased salt concentration in the soil is indicated by higher EC readings. Factors including soil parent material, irrigation techniques, fertilization, and leaching all have an impact on soil EC.

The pH and Ec were measured in the soil before planting and regularly throughout the experiment time. Briefly, 50 g of the soil sample was taken at a depth of 15 cm and were placed in 50 ml of distilled water and left for 24 hours. The water was then extracted, and the pH value was measured using a pH meter (Jenway, Pontypool). The EC for the soil samples was measured using an electrical conductivity meter (Hanna, Canada). Appendix (B.1).

3.2.2 Soil moisture content

The amount of water in the soil is referred to as soil moisture, and it is essential for plant growth and ecosystem health. It is essential to determine soil fertility, nutrient availability, microbial activity, and general soil health. Sustainable agriculture, the management of water resources, and the preservation of ecosystems all depend on an understanding of and control over soil moisture. Soil moisture content was measured in two stages, the first stage was after 30 days of planting and the second was after 60 days of planting. The samples were taken at a depth of 15 cm and then weighed and placed in the oven at a temperature of 105 for 24 hours. Then the samples were weighed again after drying and the moisture content of the soil was calculated according to the equation. (Gilbert, et al. 2014)

$$\% \text{ Moisture content (MC)} = \frac{\text{Weight of moist soil (M)} - \text{Weight of dry soil (D)}}{\text{Weight of dry soil (D)}} \dots\dots\dots (1)$$

3.3 Plant measurement

Growth parameters are measurements or indicators that are used to evaluate a plant's growth and progress. These variables offer significant data on the general productivity of plants.

Plant length is the vertical distance from the base of the plant to the topmost point, such as the tallest stem or leaf. The length of the plant was measured after 10 days of planting sequentially over the length of the experiment using a meter.

Leaf area refers to the total surface area of the leaves of a plant. It is an important parameter as it influences photosynthesis, gas exchange, and transpiration rates. The fourth leaf from each plant was selected and measure the leaf surface area by leaf surface area meter (ADC BioScientific Ltd., UK).

Flowering and fruit production are important growth parameters for many crops. Monitoring the number of flowers, fruits, and their development stages helps estimate crop yield potential and assess reproductive success. The number of flowers and the number of fruits were taken weekly.

The harvesting of the fruits took place on January 22nd, 2022. The number and weight of the fruits were recorded. The color intensity of the fruits was measured by chroma meter CR-400 (Konica Minolta, China). The weight of the whole plant was measured after separating the plant from its roots. The roots were washed well with water, dried, and weighed. The roots, plants, and fruits were dried in an oven for 24 hours at a temperature of 105 °C.

Dry leaf samples were sent to the An-Najah National University laboratory to determine the amount of N, P, and K in the leaf. The amount of nitrogen in the digested sample was determined using the Kjeldahl distillation and titration method (Bremner and Hauck, 1982). The P content was determined using the blue method through the Spectrophotometer and determined the potassium content through the Flame photometer (Isaac and Kerber, 1971)

Chlorophyll content refers to the concentration of chlorophyll pigments in plant tissues, particularly in the leaves. Chlorophyll is responsible for capturing light energy during photosynthesis, the process by which plants convert sunlight into chemical energy to fuel their growth and development. Chlorophyll measurements were taken using a chlorophyll meter (SPAD-502Plus Chlorophyll Scale, Konica Minolta Sensing, Inc, Japan). Six readings were taken for each plant during the crop growth. Chlorophyll was measured in the upper leaves of the plant.

3.4 Statistical analysis

Experiment used a factorial treatment design for both components soil amendment and irrigation levels with the combined treatment being entirely randomized in a completely randomized design. data analysis was done using Minitab software version.18 (2017), and 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 length

4.1.1 Effect of soil amendment on plant length

Data in Table (1) effect of soil amendment on the plant length. ($P = 0.00$) there are significant differences between soil amendment (control, hydrogel, stevia straw, compost) on plant length. The highest plant reached when adding hydrogel (48.45cm) and the smallest plant achieved when using stevia straws (32.58cm) and compost (20.16cm). Several studies have investigated the impact of hydrogel as a soil amendment on plant length. The application of hydrogel has shown promising results in promoting plant growth and increasing plant length in various (Lee et al. 2019).

4.1.2 Effect of different irrigation levels on plant length.

Table (1) showed that there are significant differences of different irrigation levels on the plant length of pepperplants ($p= 0.04$), it was found that there is a direct relationship between plant length and the amount of irrigation. The plant length of different irrigation levels (50%, 70% and 100) is 31.2cm, 36.6cm and 40.9cm, respectively. According to (Sharma, et al. 2017) and (Xu, et al. 2019), water stress reduced plant length. When pepper plants do not receive adequate water, they experience water stress, leading to stunted growth. The lack of water availability is limited the plant's ability to carry out essential physiological processes, resulting in reduced cell expansion and elongation, ultimately leading to shorter plant length.

4.1.3 Effect of soil amendment under different irrigation levels on plant length

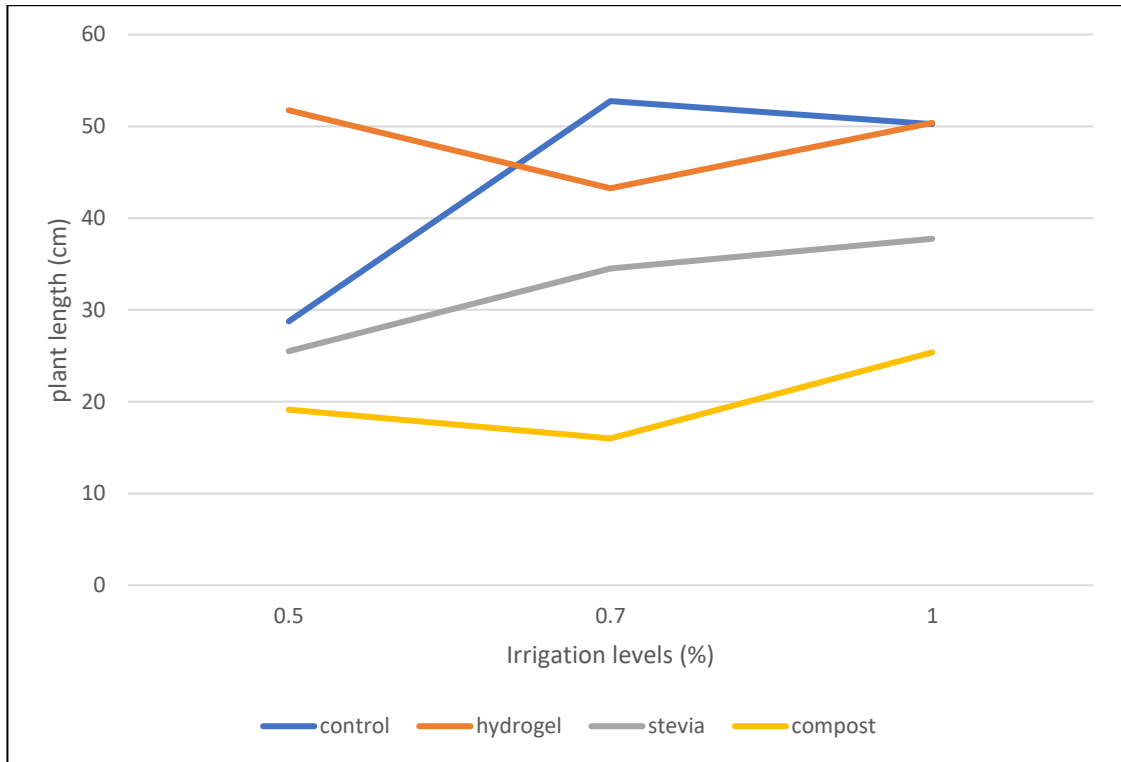
From table (1) ($p= 0.09$) then there's no significant differences among soil amendment and irrigation level on plant length. The plant control length was (52.75 cm) but when using hydrogel and 50% irrigation levels plant length equals (51.75 cm). The result agrees with (Joseph A et al, 2020) hydrogel application improve plant growth of chili and reduce water consumption by 50% as compared to control. Hydrogel, when incorporated into the soil, forms a water-absorbing gel matrix that can retain moisture and release it slowly to

plant roots. This increased water-holding capacity provided by hydrogel has been found to enhance plant growth and, subsequently, plant length. Adequate soil moisture availability ensures optimal cell expansion and elongation, leading to taller plants. (Austin, M. E., and Bondari, K. 1992).

The hydrogel was able to supply enough water as a result for standard plant growth. The application of hydrogel produced plants with the same length as the control plant and saving 50% of the irrigation cost. This is in line with previous studies (Montesano et al., 2015). According to (Abu Ghayadah, et al. 2018), the application of hydrogel had a positive impact on the growth of pepper plants which resulted to the highest plant length. When hydrogel is added into the soil, it develops a matrix of water-absorbing gel that may store moisture and release it gradually to plant roots. It has been discovered that the hydrogel's higher water-holding capacity promotes plant growth and, as a result, increases plant length. Optimal cell expansion and elongation are ensured by the presence of sufficient soil moisture. leading to taller plants and improving shoot and leaf growth compared with those of control . (Austin, M. E., and Bondari, K. 1992)

Figure 1

The effect of different soil amendment (control,hydrogel, stevia straw and compost) under different irrigation levels(50%, 70%, 100%) on plant length of pepper plants



4.2 Leaf chlorophyll content

4.2.1 Effect of soil amendment on chlorophyll content

The data in table (1) showed that the use of soil amendment had a significant effect on the chlorophyll content. ($P = 0.01$) there are significant differences between soil amendment (control, hydrogel, stevia straw, compost). Using the hydrogel improved the chlorophyll content (54.4) SPAD compared to the control (53.8) SPAD. When using stevia straw, the chlorophyll content was (44.9) SPAD, and when using compost (36.6) SPAD, we noted that the use of stevia straw and compost did not increase the chlorophyll content in the leaves compared with the control.

Adding the hydrogel to the soil contributed to maintaining water holding capacity in the soil, which in turn contributed to improving the process of photosynthesis and chlorophyll production. These results agree with Patel and Sharma's (2017) showed that preserving the ideal soil moisture levels led to greater chlorophyll content.

4.2.2 Effect of different irrigation levels on chlorophyll content of leaf pepper

We can see from the results in the table (1) that the more irrigation available to the plant, the more chlorophyll content in the leaves. When pepper plants are subjected to insufficient irrigation, they experience water stress, which can affect chlorophyll content. Inadequate water availability can lead to a reduction in the production of chlorophyll, the pigment responsible for capturing sunlight and facilitating photosynthesis. As a result, pepper leaves may exhibit lower chlorophyll content, leading to a potential decrease in photosynthetic activity and overall plant health (Cruz, 2021)

4.2.3 Effect of soil amendment under different irrigation levels on chlorophyll content of leaf pepper

Data in table (1) showed there are no significant effect of soil amendment under different irrigation level on chlorophyll content of pepper leaves, ($P = 0.24$) means that there are no significant difference among soil amendment and irrigation levels. When adding hydrogel as a soil amendment in soil under 50% irrigation levels achieved high chlorophyll content in leaves (63.75) SPAD compared to control plant (57.75) SPAD. Adding hydrogel to soil saved water for longer time, resulting in higher chlorophyll content, however, the content was decreased under the water deficit condition. KrishnaSurendar(et al 2013). The amount of chlorophyll in pepper leaves can also be impacted by effective water management techniques. Patel and Sharma's (2017) showed that preserving the ideal soil moisture levels led to greater chlorophyll content.

Figure 2

The effect of different soil amendment (control, hydrogel, stevia straw and compost) under different irrigation levels (50%, 70%, 100%) on chlorophyll content in leaves pepper

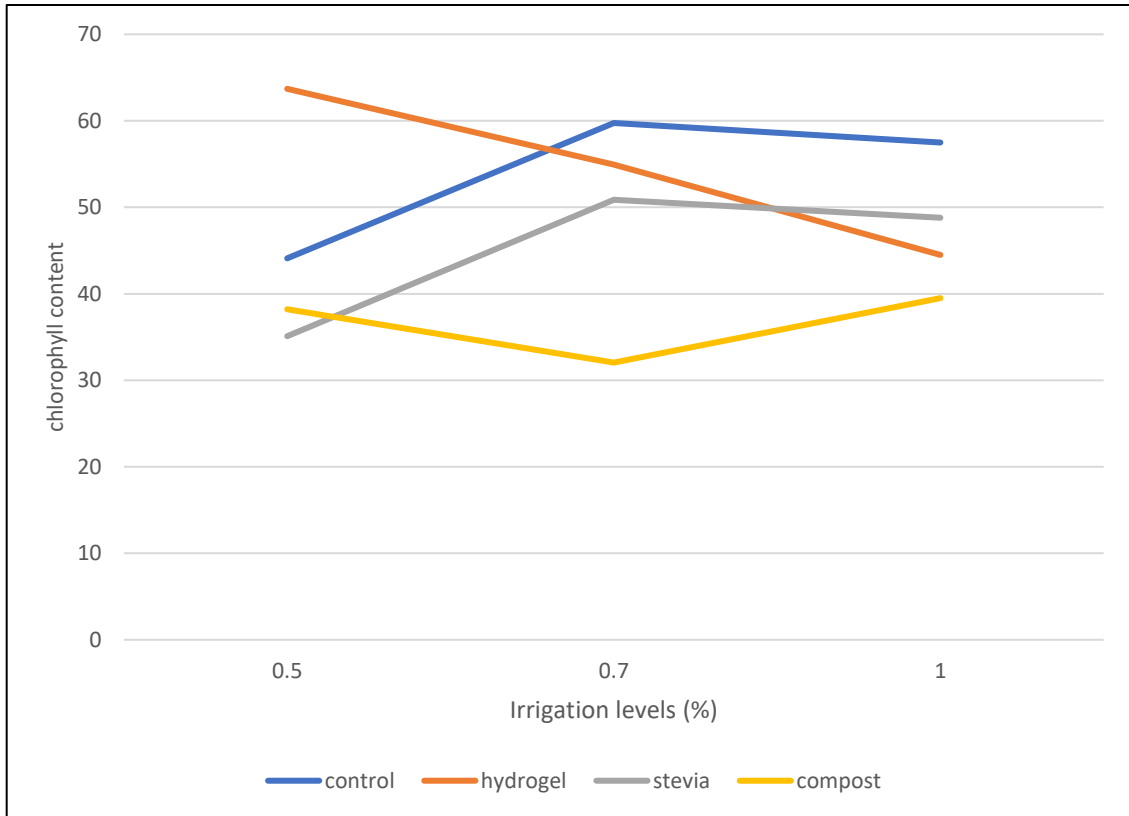


Table 1

Effect of different soil amendments under different irrigation levels on the plant length (cm) and chlorophyll content

	Plant length (cm)	Chlorophyll (SPAD)
Soil amendment		
ontrol	43.91 a	53.86 a
Hydrogel	48.45 a	54.40 a
Stevia	32.58 b	44.96 ab
Compost	20.16 c	36.6 b
P-value	0.00	0.01
Water level		
50%	31.28 b	45.30
70%	36.62 ab	49.40
100 %	40.93 a	47.67
P-value	0.04	0.74
Soil amendment* water		
Control* 50%	28.75	44.1
Control * 70%	52.75	59.75
Control * 100%	50.25	57.75
Hydrogel * 50%	51.75	63.75
Hydrogel * 70%	43.25	54.95
Hydrogel * 100%	50.37	44.52
Stevia * 50%	25.5	35.15
Stevia* 70%	34.5	50.87
Stevia * 100%	37.75	48.87
Compost * 50%	19.12	38.22
Compost * 70%	16	32.05
Compost * 100%	25.37	39.22
P-value	0.09	0.24

4.3 Number of flowers

4.3.1 Effect of soil amendment on number of flowers

Data in table (2) showed that using soil amendment affected the number of flowers of the pepper plant after 50 days of planting. The highest number of flowers was recorded with hydrogel, the number flowers was (19.25) compared with the control plant, which was (17.6). As for stevia, the number of flowers was (12.2) and the lowest number of flower when compost was used (4.83). Compared to the control group of pepper plants grown in non-amended soil. The addition of hydrogel to the soil improved the availability of water for the plant during the flowering process and improved the flowering process of the plant

4.3.2 Effect of different irrigation levels on number of flower

The result in table (2) showed that pepper plants subjected to insufficient irrigation, negatively impact flower development. A study by Ahmadi et al. (2017) revealed that water stress caused a delay in flowering time and reduced the number of flowers formed. Inadequate water availability can disrupt the physiological processes involved in flower initiation and development (Jaimez, et al, 2000) Water stress can result in the reduction of flower bud formation and, consequently, a decrease in the overall number of flowers produced by the pepper plants.

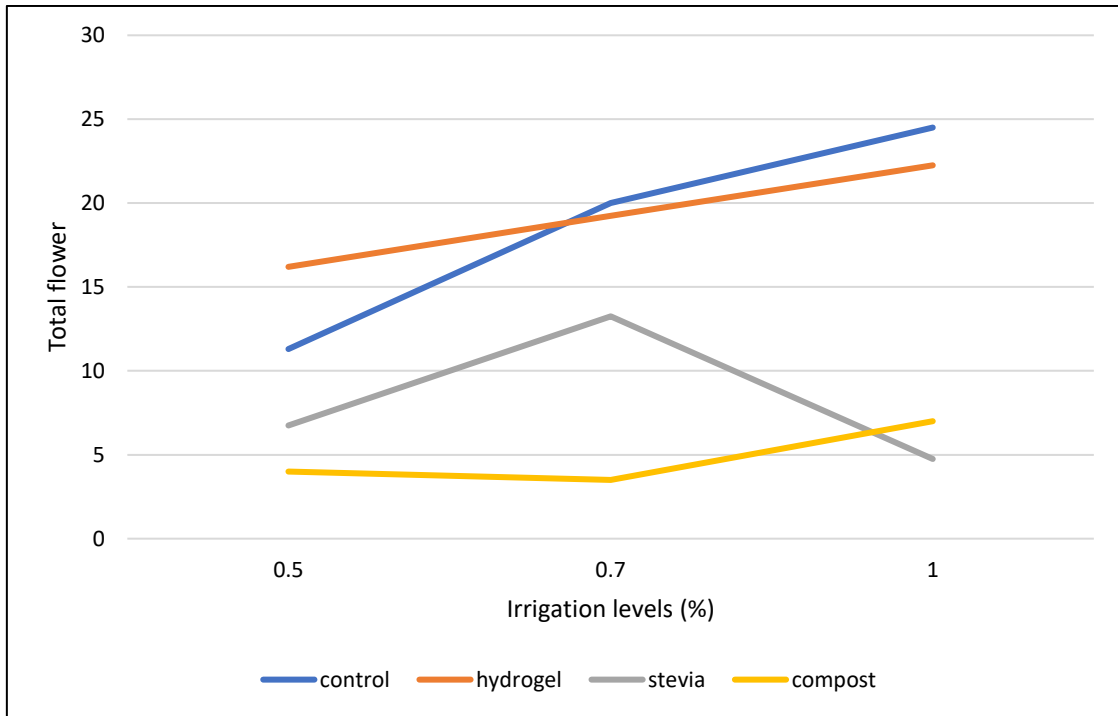
4.3.3 Effect of soil amendment under different irrigation levels on the number of flower

The result in Figure (3) showed there was no significant effect of using soil amendment with different irrigation levels, as the control obtained the highest number of flowers at 24.5, followed by the use of hydrogel with irrigation levels of 100% and 70%. (22.3, 19.3), respectively.

During the experiment, we noticed that when using hydrogel, early flowering production was observed compared to other treatments. This could be due to more water reserved in the soil, this result agreed with previous work of, Borràs (2021), who found that water stress of pepper plants delayed flower production.

Figure 3

The effect of adding different soil amendment (control, hydrogel, stevia straw and compost) under different irrigation levels(50%, 70%, 100%) on number of pepper flower



4.4 Number of fruits

4.4.1 Effect of soil amendment on number of fruits

The data in table (2) showed the number of fruit after 70 days , the data exhibited significant differences ($P= 0.00$) in the number of produced fruits when hydrogel was supplied to the substrate . Pepper plants grown in hydrogel-amended soil exhibited a higher number of fruits (5.2) compared to the control group(3.3) fruits per plant.. This result agreed with the study of Pattanaaik et al (2015) who claimed that the yield of Assam lemon is increased by the application of hydrogel, compared to control trees.

The property of the hydrogel in its ability to increase water holding capacity in soil improving obtaining the highest number of flowers and fruits (Chen., et al.2018)The water stress of irrigation for the pepper crop during the growth and development period plays a major role in reducing the number of flowers and decreasing the number of fruits this result agree with (Ahmadi et al. 2017) and (Martínez-Rodríguez., et al.2019).

4.4.2 Effect of soil amendment under different irrigation levels on the number of fruits

The use of soil amendment with different irrigation levels had a significant effect on the number of pepper fruits ($p = 0.04$). Result in table (2) showed that the stevia straw achieved the highest number of fruits at an irrigation level of 100%, the number of fruits was (7.5), followed by hydrogel with an irrigation level of 100% and 70%, the number of fruits was (6.7 and 6) . the hydrogel treatment positively influenced fruit production across different irrigation levels, significant interaction between the two factors was observed. Hydrogel ability to retain water can be particularly advantageous in conditions of water scarcity or limited irrigation this result agree with (Hafiz-Afham , et al. 2023) and (Lee et al. 2019) where it can help buffer the plants against water deficits and maintain productivity.

(Chen., et al.2018) The addition of hydrogel to the soil significantly improving soil moisture, increasing productivity, and obtaining high quality pepper fruits.

Figure 4

The effect of different soil amendment (control, hydrogel, stevia straw and compost) on number of pepper fruit under different irrigation levels (50%, 70%, 100%)

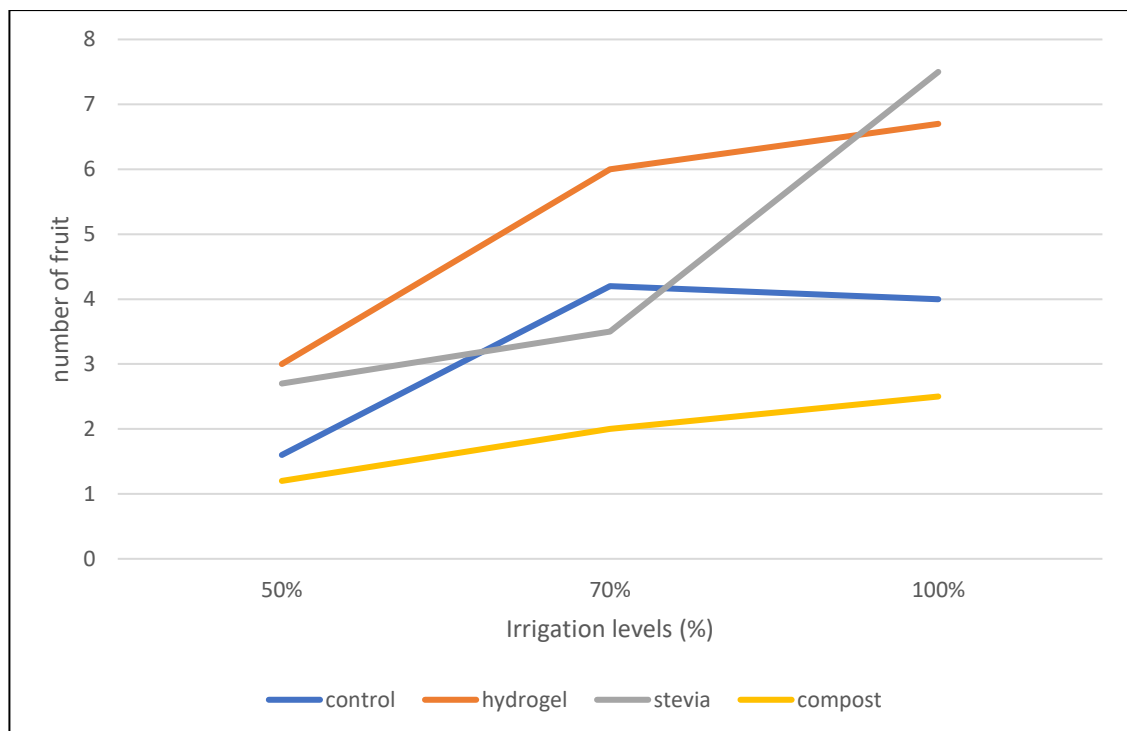


Table 2

Effect of different soil amendment under different irrigation levels on the total flower and number of fruits

	No. flower/plant	No.fruit/ plant
Soil amendment		
Control	17.6 ab	3.3a
Hydrogel	19.25 a	5.2a
Stevia	12.25 b	4.5a
Compost	4.83 c	1.9c
P-value	0.00	0.00
Water level		
50%	8.87 b	2.1 c
70%	14 a	3.9 b
100%	17.62 a	5.1 a
P-value	0.00	0.00
Soil amendment* water		
ontrol *50%	8.5	1.6 ef
Control *70%	20.0	4.2 bc
Control *100%	24.5	4 bcd
Hydrogel* 50%	16.3	3 cdef
Hydrogel *70%	19.3	6 ab
Hydrogel *100%	22.3	6.7 a
Stevia *50%	6.8	2.7 cdef
Stevia*70%	13.3	3.5 cde
Stevia* 100%	16.8	7.5 a
Compost* 50%	4.0	1.2 f
Compost * 70%	3.5	2 def
Compost * 100%	7.0	2.5 cdef
P-value	0.53	0.04

4.5 Fresh shoot weight

4.5.1 Effect of soil amendment on fresh shoot weight (g)

The effect of soil amendment treatments on fresh shoot weight is shown in table (3). The results revealed a significant effect of using soil amendment under different irrigation levels on the fresh shoot weight of plant ($P=0.00$), where the hydrogel achieved the highest weight of the plant (58.1gm), compared with the weight of the control plant (47gm), followed by the weight of the plant used with stevia straw (46.8gm), while the compost had a negative effect on the plant length with (28.8gm).

According to Abobatta. (2019), "Increase shoot weight related that hydrogel prevents water and nutrition materials from leaching and therefore increases navel orange vegetative growth. The application of hydrogel increased all vegetative growth parameters".

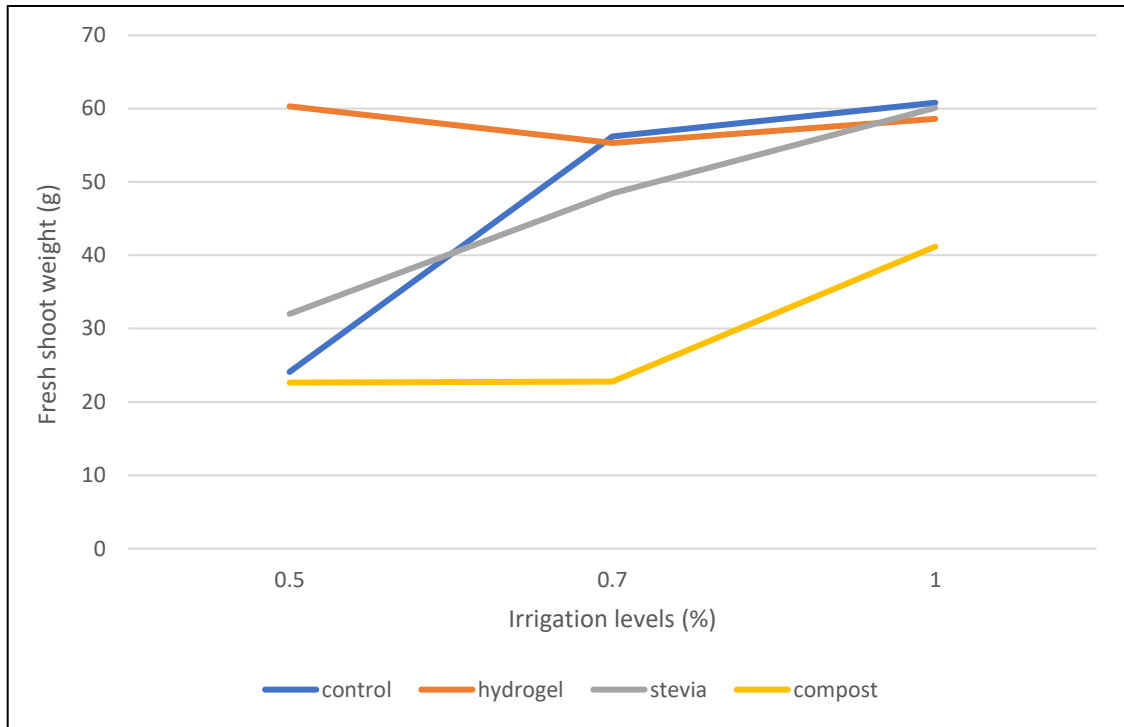
In a field experiment, Chen et al. (2018) discovered that hydrogel application significantly increased pepper plant length, stem diameter, and leaf area when compared to control treatments. The hydrogel addition increased soil moisture, assuring a steady supply of water for the plants and encouraging growth all around.

4.5.2 Effect of soil amendment under different irrigation levels on fresh shoot weight

The effect of interaction between soil amendment treatments and irrigation levels on fresh shoot weight is shown in table (3). No significant differences were observed among soil amendment and irrigation levels ($P=0.38$), both hydrogel with a 50% irrigation level and stevia straw with full irrigation level produced the same shoot plant weight of (60gm) as the control treatment. This suggests that incorporating hydrogel with a 50% irrigation level can result in comparable plant weight to a fully irrigated control plant. These results are consistent with a study conducted by Abu Ghayadah et al (2018), who found that adding hydrogel to soil can enhance plant growth and minimize water usage.

Figure 5

The effect of different soil amendment (control, hydrogel, stevia straw and compost) under different irrigation levels(50%, 70%, 100%) on shoot fresh weight of pepper



4.6 Shoot dry weight

4.6.1 Effect of soil amendment on dry shoot weight

Data in table (3) showed that adding soil amendments to the media had no significant effect on shoot dry weight($P = 0.27$) the weights were (16.1gm, 17.2gm, 15.4gm) , and (12.5 gm) for control, hydrogel, stevia straw, and compost , respectively. The results showed that using hydrogel increases water availability and decreases water stress (Buck ., et al 2010), which has a good impact on pepper plants' dry shoot weight. The potential of hydrogel as a useful soil supplement in agricultural techniques to promote plant growth and biomass production is indicated by this research.

4.6.2 Effect of soil amendment under different irrigation levels on dry shoot weight of plant

No significant interaction was obtained between the effect of the two factors on shoot dry weight ($P= 0.81$) (Table 3), control with full irrigation level achieved the highest shoot dry weight (19.5gm), followed by the hydrogel with the irrigation level of 70% the dry weight of the plant was (18.7gm), followed by using stevia straw with full irrigation level (18.25gm).

Figure 6

The effect of different soil amendment (control, hydrogel, stevia straw and compost) under different irrigation levels (50%, 70%, 100%) on shoot dry weight of peper

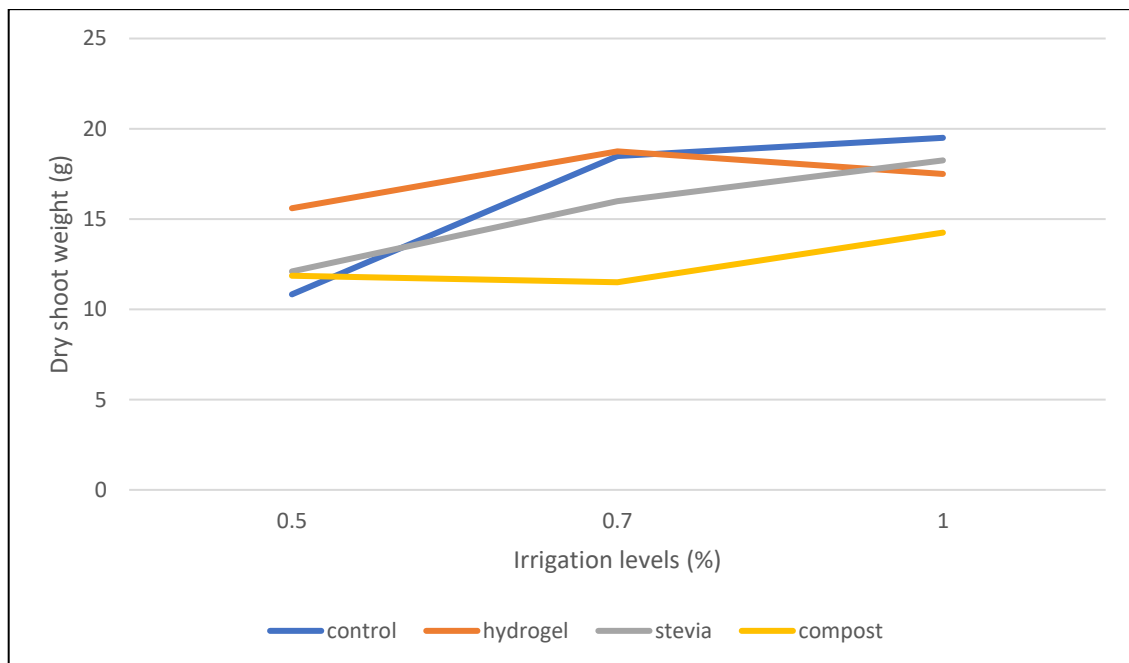


Table 3

Effect of different soil amendment under different irrigation levels on the shoot fresh weight, shoot dry weight

	Shoot fresh weight (g)	Shoot dry weight (g)
Soil amendment		
Control	47.04 a	16.12
Hydrogel	58.1 a	17.29
Stevia	46.85 a	15.48
compost	28.87 b	12.53
P-value	0.00	0.27
Water level		
50%	34.77 b	12.51
70%	45.69 ab	16.18
100%	55.19 a	17.37
P-value	0.01	0.07
Soil amendment* water		
Control * 50%	24.10	10.37
Control * 70%	56.22	18.5
Control * 100%	60.8	19.5
Hydrogel * 50%	60.31	15.62
Hydrogel * 70%	55.31	18.75
Hydrogel * 100%	58.68	17.5
Stevia * 50%	32.01	12.19
Stevia * 70%	48.43	16
Stevia * 100%	60.11	18.25
Compost * 50%	22.65	11.86
Compost * 70%	22.78	11.5
Compost * 100%	41.18	14.25
P-value	0.38	0.81

4.7 Fruit fresh weight

4.7.1 Effect of soil amendment on fruit fresh weight

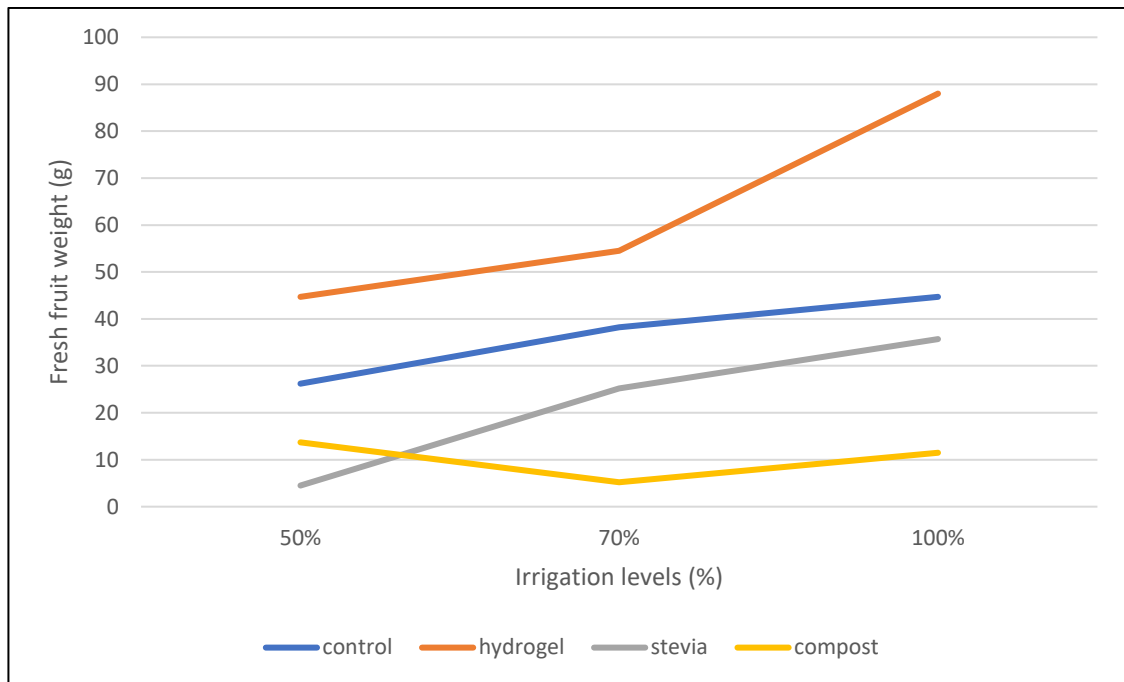
The results revealed that the use of soil amendments had a significant effect on the weight of the fruits, ($p = 0.00$), (Table 4) the highest weight of fruits achieved with hydrogel (62.4gm), followed by the control plant (36.7gm), the weight of the plant treated with stevia straw (21.8 gm), and the lowest weight of the fruits achieved when using compost (10.1 gm). These findings are consistent with the findings of (Alshallash, et al 2022), who found that the highest average of fruit weight recorded high values when hydrogel was added. The improved water availability and decreased water stress can be ascribed to the higher fruit fresh weight seen in the hydrogel-treated plants. For efficient nutrient absorption, photosynthesis, and cellular activities, which together lead to fruit growth and biomass accumulation, enough soil moisture is necessary. The application of hydrogel creates a suitable environment for pepper plants to grow in, resulting in improved fruit development and greater fresh weight. Figure (7) explains the result.

4.7.2 Effect of soil amendment under different irrigation levels on fruit fresh wt

Table(4) shows that adding hydrogel under different irrigation levels gave the highest fresh fruit weight. The fruit fresh weight was (88, 54.5 and 44.7 gm) when the hydrogel was used with 100, 70 and 50% irrigation levels, respectively. which gave the same weight as the plant control with irrigation level 100%, (44.7gm). The higher significant weight was obtained under both 100 and 70% irrigation level, however, both hydrogel with 50% and the control gave similar significant weight. There was a significant relationship between the water deficit and cell size in plant tissues; These findings are in line with, (Hamdy, 2020) who reported the application of hydrogel to 'Murcott' mandarin trees can improve production, fruit quality, and fruit weight with the best values when hydrogel was used at 750 g/tree under 75% of Etc. The pictures in the appendix (B.13) illustrate this.

Figure 7

The effect of different soil amendment(control, hydrogel, stevia straw and compost) under different irrigation levels(50%, 70%, 100%) on fresh fruit weight of pepper



4.8 Fruit dry weight

4.8.1 Effect of soil amendment on fruit dry weight

The use of soil amendment had a significant effect on the dry weight of the fruits ($P = 0.00$), the use of hydrogel gave the highest weight of the dry fruits (45.8 gm) compared to the control (26.9gm), for stevia straw and compost, it had a negative effect on the weight fruit dry, both gave (15.7 , 6.5 gm) respectively. The picture is in the appendix (B.17) illustrate this.

4.8.2 Effect of soil amendment under different irrigation levels on fruit dry weight

According to the results in table (4) ($P= 0.65$)theres no significant difference among soil amendment and irrigation levels on fruit dry weight , the use of hydrogel with a 100% irrigation level resulted in the highest weight of dry fruits (63.2gm). application hydrogel whith 100% irrigation levels improve fruit growth and dry weight.

When using hydrogel under 70% and 50% irrigation levels produced 42.2 , 32 gm fruit dry weight respectively. this indicate that water stress reduce fruit growth and dry fruit

weight (González., et al.2021).adding hydrogel improving water holding capacity in soil comparison with control group and other treatment ,dry fruit weight under the control was 34.5 gm. However both stevia straw and compost had a negative impact on the dry fruit weight.

Figure 8

The effect of different soil amendment(control, hydrogel, stevia straw and compost) under different irrigation levels(50%, 70%, 100%) on dry fruit weight of pepper.

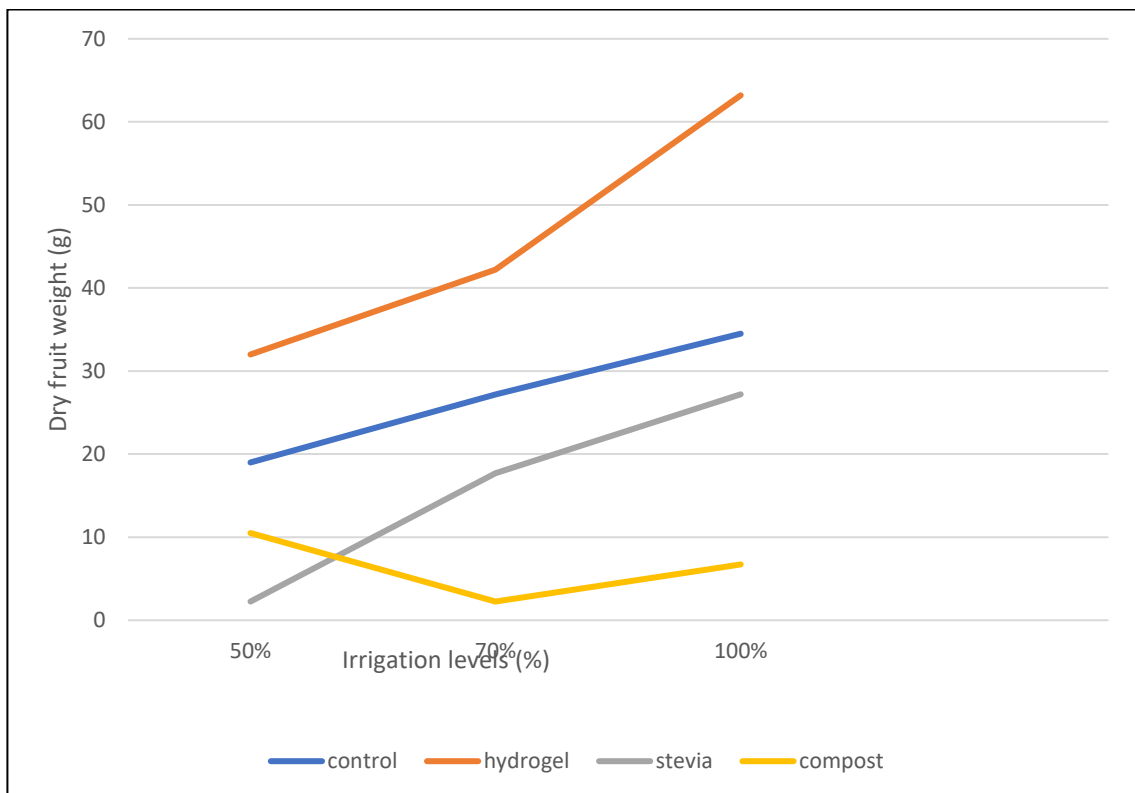


Table 4

Effect of different soil amendment under different irrigation levels on the fruit fresh weight, fruit dry weight

	Fruit fresh weight (g)	Fruit dry weight(g)
Soil amendment		
Control	36.7	26.9 b
Hydrogel	62.4	45.8 a
Stevia	21.8	15.7 bc
Compost	10.1	6.5 c
P-value	0.00	0.00
Water level		
50%	22.3	15.9 b
70%	30.8	22.3 ab
100%	45.2	32.9 a
P-value	0.04	0.05
Soil amendment* water		
Control * 50%	26.2	19
Control * 70%	38.2	27.2
Control * 100%	44.7	34.5
Hydrogel * 50%	44.7	32
Hydrogel * 70%	54.5	42.2
Hydrogel * 100%	88	63.2
Stevia * 50%	4.5	2.25
Stevia * 70%	25.2	17.7
Stevia * 100%	35.7	27.2
Compost * 50%	13.7	10.5
Compost * 70%	5.2	2.25
Compost * 100%	11.5	6.7
P -value	0.61	0.65

4.9 Root fresh weight

4.9.1 Effect of soil amendment on root fresh weight

The effect of using soil amendment on the fresh weight of root showed no significant effect under the experiment conditions ($P = 0.14$), adding hydrogel to soil resulted in similar weight of the roots (21 gm) of the control treatment. However, with the addition of stevia straw the root weight was (16.9gm) The minimum weight of the roots was (14.5gm) when compost was added to the media. The pictures in the appendix (B.14) and (P) illustrate this.

It is consistent with previous studies adding hydrogel it provides moisture and nutrients to the plant which promotes the growth and development of roots and increase weight root. The increased root fresh weight observed in the hydrogel-treated plants can be attributed to improved water availability and reduced water stress. Adequate soil moisture is essential for root elongation and branching, nutrient uptake, and overall plant development. Hydrogel application provides a stable moisture reservoir in the root zone, ensuring a continuous supply of water to the roots, promoting their growth, and resulting in higher root biomass.

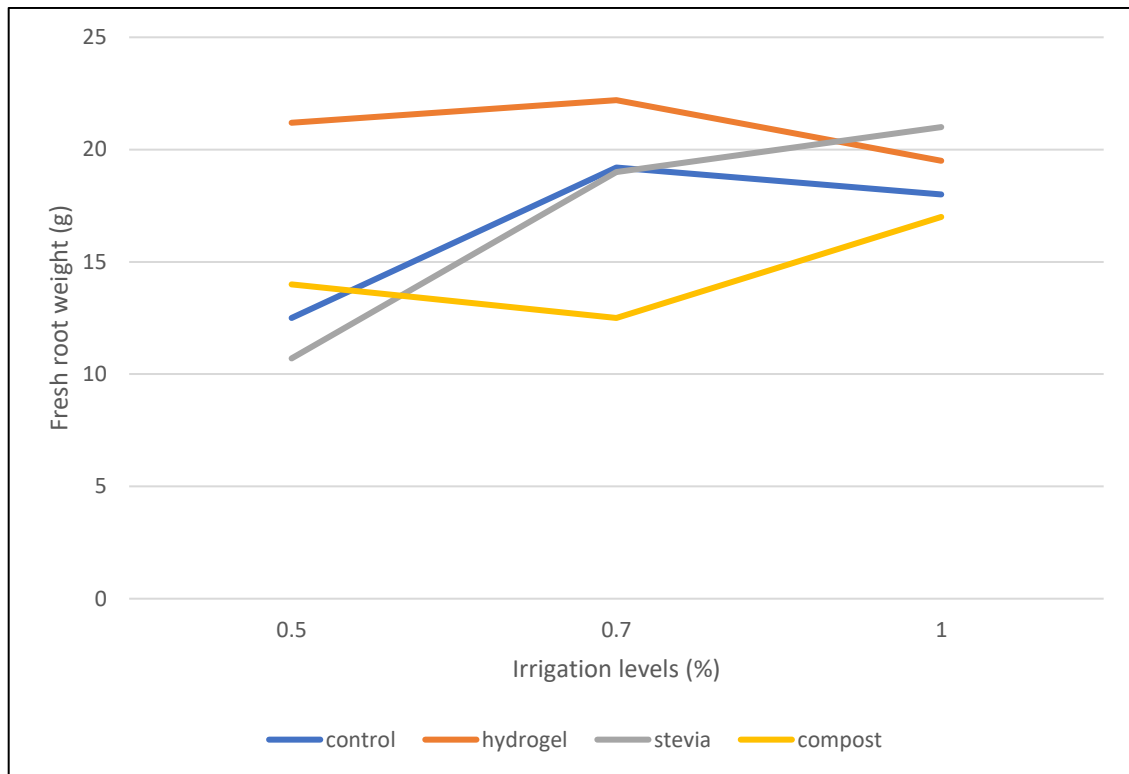
4.9.2 Effect of soil amendment under different irrigation levels on fresh root weight

Table (5) shows that the weight of the roots increased when the hydrogel was used with various irrigation levels, exceeding that of the control. The highest weights were obtained when the hydrogel was used with a 70% irrigation level (22.2gm) and a 50% irrigation level (21.2gm). Using stevia straw along with 100% watering resulted in a root weight of 21 gm. Using hydrogel effectively utilizes water and fertilizers, retaining water and supplying dry soil, lowering irrigation costs and lengthening irrigation schedules. 2018 (Abobatta). The pictures in the appendix (B.16) illustrate this.

Hydrogel can greatly improve the root-soil interface environment, store water and maintain soil moisture, and produce a favorable ecological environment for root growth. 2019 (Abdallah)

Figure 9

The effect of different soil amendment (control, hydrogel, stevia straw and compost) under different irrigation levels(50%, 70%, 100%) on fresh root weight of pepper



4.10 Dry root weight of pepper

4.10.1 Effect of soil amendment on root dry weight

Table (5) show ($P = 0.8$) there was no significant deference of soil amendment application on dry root weight.

4.10.2 Effect of soil amendment under different irrigation levels on root dry weight

There was no significant interaction between the two factor on the root dry weight, the highest reading was for the control with an irrigation level of 100%, which gave a weight of (12.5 gm).

Figure 10

The effect of different soil amendment(control, hydrogel, stevia straw and compost) under different irrigation levels(50%, 70%, 100%) on dry root weight of pepper

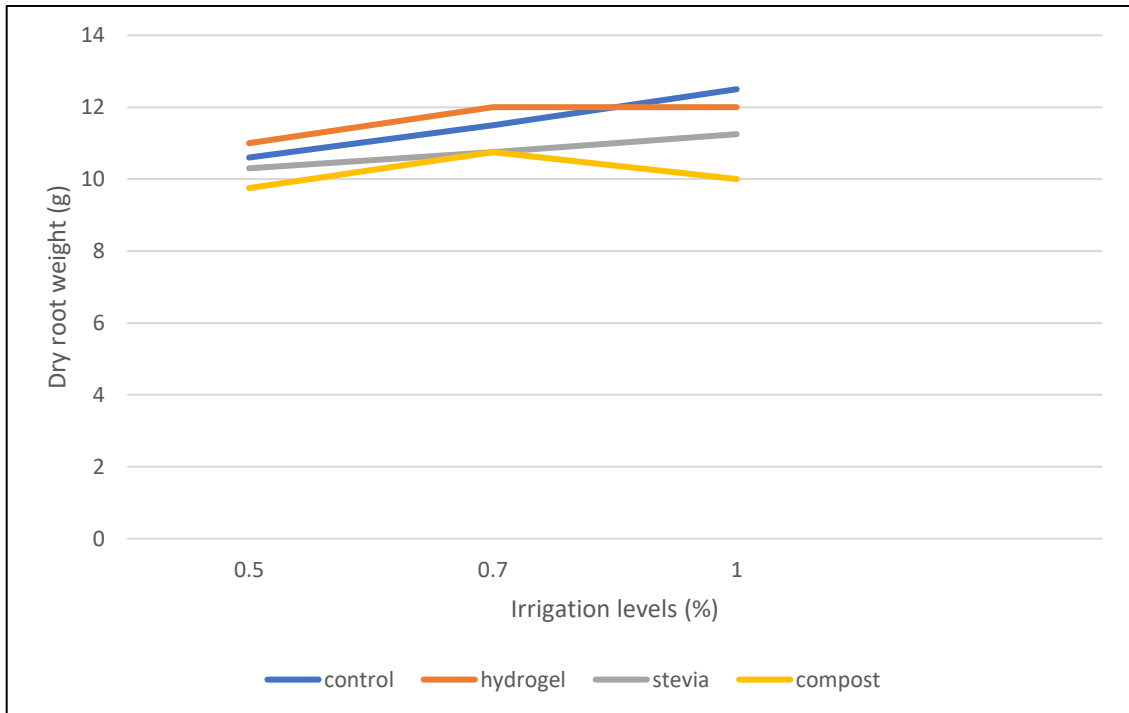


Table 5

Effect of different soil amendment under different irrigation levels on the root fresh weight and root dry weight

	Root fresh weight (g)	Root dry weight(g)
Soil amendment		
Control	16.58	10.66
Hydrogel	21	10.66
Stevia	16.91	9.91
Compost	14.5	10.16
P-value	0.14	0.88
Water level		
50%	14.62	9.12
70%	18.25	11.25
100%	18.87	10.68
P-value	0.17	0.10
Soil amendment* water		
Control 50%	12.5	8
Control 70%	19.25	11.50
Control 100%	18	12.5
Hydrogel 50%	21.25	11
Hydrogel 70%	22.25	12
Hydrogel 100%	19.5	9
Stevia 50%	10.75	7.75
Stevia70%	19	10.75
Stevia 100%	21	11.25
Compost 50%	14	9.75
Compost 70%	12.5	10.75
Compost 100%	17	10
P-value	0.56	0.34

4.11 leaf area and fruit color

4.11.1 Effect of soil amendment on leaf area and fruit color

There was no significant difference of soil amendment in the leaf surface area and color of fruit, all treatments gave significantly the same leaf surface area ($P= 0.77$). (Table 6)

4.11.2 Effect of soil amendment under different irrigation levels on leaf area and fruit color of plant

The results indicate that there was no significant effect of using soil amendment with different irrigation levels on the surface area of pepper leaf and color fruit ($P= 0.21$) (Table 6). This result agrees adding soil amendment in soil improve water holding capacity. Water stress significantly affects the morphology and growth parameters of pepper plants. Studies by (Sharma et al. 2017) and (Xu et al. 2019) demonstrated that water stress reduced plant height, leaf area (Appendix B.20).

Table 6

Effect of different soil amendment under different irrigation levels on the color fruit and leaf area

	Color fruit (I)	Color fruit (a)	Color fruit (b)	Leaf area (mm²)
Soil amendment				
Control	26.81	-7.42	8.52	13818.2
Hydrogel	32	-9.05	10.44	13151.4
Stevia	30.87	-9.08	10.59	13748.7
Compost	31.96	-9.58	14.15	14574.7
P-value	0.77	0.61	0.13	0.75
Water level				
50%	22.75 b	-6.48 a	8.08 b	14898.8
70%	37.05 a	-10.68 b	13.91 a	12849.6
100%	31.43 ab	-9.19 ab	10.79 ab	13721.4
P-value	0.02	0.02	0.02	0.26
Soil amendment* water				
Control 50%	18.98	-5.36	6.15	13942.7
Control 70%	29.58	-8.38	9.55	11295.3
Control 100%	31.88	-8.53	9.87	16216.7
Hydrogel 50%	33.65	-9.24	10.59	14814.7
Hydrogel 70%	34.94	-10.2	11.82	11366
Hydrogel 100%	27.43	-7.71	8.91	13273.7
Stevia 50%	17.4	-4.91	5.48	14615.7
Stevia70%	37.81	-10.9	12.9	13157.7
Stevia 100%	37.4	-11.44	13.39	13472.7
Compost 50%	20.99	-6.42	10.09	16222
Compost 70%	45.87	-13.22	21.37	15579.3
Compost 100%	29.03	-9.1	10.99	11922.7
P-value	0.41	0.51	0.31	0.21

4.12 PH and Ec.

4.12 .1 Effect of different soil amendment under different irrigation levels on the PH and Ec.

Table (7) presents data of the effects of different soil amendments and water levels on pH and electrical conductivity (EC), as well as their interactions, on a pepper plant growth. Media pH was significantly influenced by the addition of soil amendments ($P= 0.00$) Table(7) . ,However, the Ec of the substrate was not significantly affected ($P= 0.17$) The control and compost treatments have pH values of 7.5, whereas the hydrogel treatment has a pH value of 6.5. The compost treatment has the greatest EC value, which is between 1.2 to 1.5.

Both pH and EC of the media were differ significantly under different water regiem effect ($P= 0.00$), soil at 100% water level had a pH of 6.5 ,at 50% and 70% water levels the pH was (7.5, 7.2), respectively.

4.12.3 Effect of soil amendment and irrigation levels on PH and Ec.

Results show how the interaction between soil amendments and water levels impacted pH, and EC. The hydrogel treatment had the lowest pH (4.9) and the compost treatment had the highest pH (8.2) at the 100% water level.

The above data indicated that adding soil amendments, particularly compost , might raise soil pH and moisture levels, which may promote pepper plants' growth. Additionally, water levels interact with soil amendments to influence soil properties, indicating that the combination of soil amendments and appropriate water levels can optimize plant growth

4.13 Soil moisture of soil

4.13.1 Effect of soil amendment on soil moisture content

The result showed a significant difference of soil amendment on soil moisture in soil ($P=0.00$) Table (7).The mean soil moisture ranges from 16.9% for the control treatment to 31.7% for the compost treatment. the highest moisture content in the soil was with stevia straw and compost. The hydrogel gave a moisture content approximately the same

as the moisture content of the control. Results indicated significant effect of irrigation level on soil moisture content ($P= 0.00$) Table (7). The mean soil moisture ranges from 16.9% for the control treatment to 31.7% for the compost treatment. Soil moisture rises along with the water level, from 20.1% at 50% water level to 27.7% at 100% water level.

stevia straw and compost they having a high water holding capacity, high moisture levels have a negative impact on plant growth and development. Water-logged soil caused the roots to suffocate from a lack of oxygen, which caused some root cells to die. This prevented the roots from absorbing nutrients and inhibited plant growth, resulting in a weak and dwarfed plant.

4.13.3 Effect of soil amendment and irrigation levels on soil moisture content

The result in table (7) shows ($P= 0.88$) there's no significant differences in soil moisture among the soil amendment and irrigation levels. Compost treatment had the maximum soil moisture (25.7%) while the control treatment had the lowest soil moisture (13.2%) at the 50% water level. The compost treatment had the maximum soil moisture (33.1%) and the control treatment had the lowest (16.2%) at the 70% water level, respectively.

The results that compost treatment consistently contains higher moisture levels may indicate that it could be a useful strategy to enhance soil moisture retention. (Appendix B.21)

Table 7

Effect of different soil amendment under different irrigation levels on the soil moisture, PH and Ec.

	Soil moisture	PH	Ec
Soil amendment			
Control	16.9% b	7.5 a	1.2
Hydrogel	19.3 %b	6.5 c	1.2
Stevia	28.9 %a	7 b	1.2
Compost	31.7 %a	7.3 ab	1.5
P-value	0.00	0.00	0.17
Water level			
50%	20.1% b	7.5 a	1.4
70%	24.9% a	7.2 a	1.1
100 %	27.7 %a	6.5 b	1.3
P-value	0.00	0.00	0.08
Soil amendment* water			
Control * 50%	13.2 %	7.5 b	1
Control * 70%	16.2 %	7 bc	1.4
Control * 100%	21.5 %	8.2 a	1.2
Hydrogel * 50%	15.8 %	7.5 b	1.6
Hydrogel * 70%	21.6%	7.1 bc	0.7
Hydrogel * 100%	20.6 %	4.9 e	1.1
Stevia * 50%	25.7 %	7.5 b	1.3
Stevia * 70%	28.8 %	7 bc	1.1
Stevia * 100%	32.2 %	6.3 d	1.2
Compost * 50%	25.7 %	7.6 ab	1.7
Compost * 70%	33.1 %	7.6 ab	1.2
Compost * 100%	36.4 %	6.8 cd	1.5
P-value	0.88	0.00	0.10

4.14 Conclusions

In this experiment different soil amendments were used to improve water holding capacity and growth of pepper plants under lower water stress. The results showed that using hydrogel under 50% irrigation levels resulted in similar growth and production of pepper plants compared to the control group, in addition the results obtained were better in some parameters than the control, this indicated that adding hydrogel as a soil amendment was able to save 50% of the water requirement. The application of hydrogel has been shown to promote root development by providing a steady supply of water and nutrients to the roots, hydrogel supports optimal plant growth and productivity. Additionally, hydrogel aids in nutrient retention, reducing nutrient leaching and minimizing environmental impacts associated with excessive fertilizer application. Stevia straw and compost have a high water-holding capacity in the soil, excess moisture levels in the soil create conditions lead to waterlogging, which soil becomes saturated and unable to drainage effectively. This case effect negatively on the growth of plants and development. The use of hydrogel in agriculture offers numerous benefits, including enhanced water management, improved plant growth, and sustainable farming practices. Through its water-absorbing properties, hydrogel helps to alleviate water stress, maintain soil moisture, and optimize water use efficiency, especially in regions facing water scarcity or drought conditions.

4.15 Recommendations

According to the results obtained under the condition of this experiment, the following points could be recommended:

1. Hydrogel, as a soil amendment could be used under drought condition, as an effective tool for soil water management. The properties of the hydrogel enable it to absorb water and retain moisture in the soil and release it gradually to the plant, reducing water stress and improving water use efficiency.
2. Farmers can benefit from incorporating hydrogels into their irrigation practices, especially in drought-prone areas with limited water supply.

3. In addition, combining hydrogels with organic can enhance soil fertility, nutrient availability, and plant growth. Organic amendments improve soil structure, increase microbial activity and nutrient retention, complementing the hydrogel properties of amendment can enhance sustainable farming practices.
4. More field trials are required to assess the impact of adding hydrogel to soil with various crops.
5. Long-term impact of hydrogel on soil properties, plant growth, and environmental sustainability are also needed.
6. Raising farmer understanding of the benefits and significance of utilizing hydrogel correctly in agriculture through different training programs, workshops, and instructional materials to disseminate information about hydrogel methods and urge farmers to use them as a tool for water management.
7. More research to improve the use of hydrogels in agriculture is needed. Research may be used to identify various hydrogel kinds and examine how they affect the properties of the soil, how crops respond, and how cost-effective they are.

List of Abbreviations

Abbreviation	Meaning
ET _C	Crop Evapotranspiration
MCM	Million Cubic Meters
GDP	Gross Domestic Product
SAP	SUPER ABSORBENT POLYMER
EC	Electrical conductivity
NPK	Nitrogen, phosphors and Potassium
G	Gram
g/l	Gram/Litter
Cm	centimeter
CRD	completely randomized design
SiNPs	Silica nanoparticl
PAM	Polyacrylamide
ET _C	Crop Evapotranspiration

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Appendices

Appendix A

Plot design in the field for soil amendment and level irrigation

M: compost; S: stevia; H: hydrogel; C: control. 50, 70, and 100% are the level of irrigation based on the ETc records

M1	M2	M3	M4
S1	S2	S3	S4
H1	H2	H3	H4
C1	C2	C3	C4

50%

M1	M2	M3	M4
S1	S2	S3	S4
H1	H2	H3	H4
C1	C2	C3	C4

70%

M1	M2	M3	M4
S1	S2	S3	S4
H1	H2	H3	H4
C1	C2	C3	C4

100%

Appendix B

Figures

Figure B.1

Left: pH meter. Right: electrical conductivity meter



Figure B.2

The seedlings used in the experiment



Figure B.3

Effect of soil amendment on plant length pepper under full irrigation levels

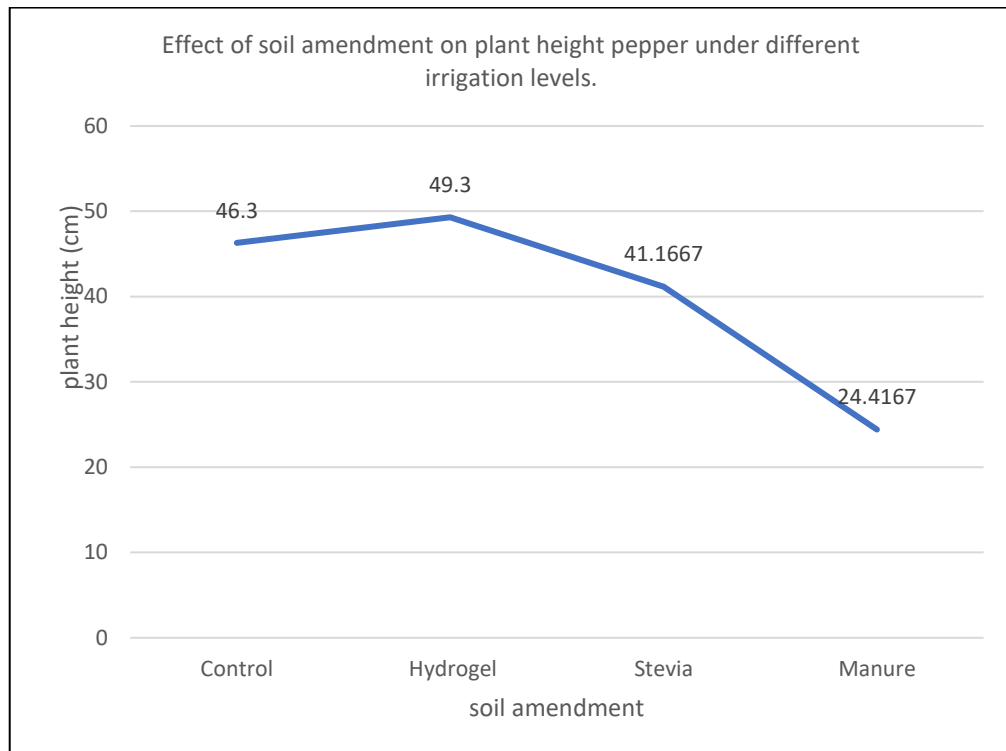


Figure B.4

Effect of soil amendment on plant height pepper under full irrigation levels



Figure B.5

Effect of soil amendment on plant height pepper under different irrigation levels



Figure B.6

Effect of soil amendment on chlorophyll content of leaf pepper under full irrigation levels

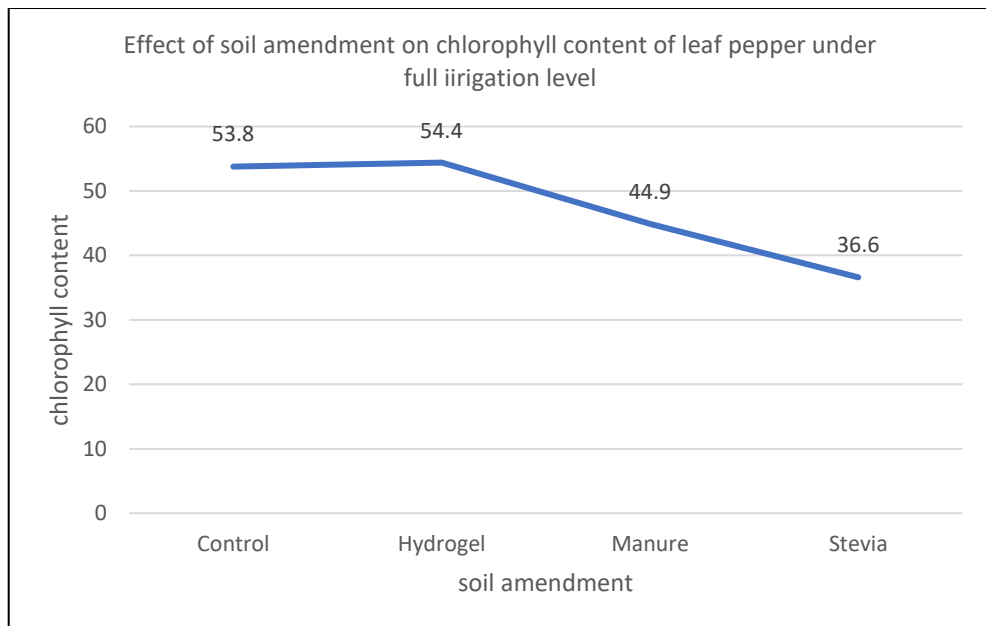


Figure B.7

Effect of soil amendment on number of flowers pepper under full irrigation levels

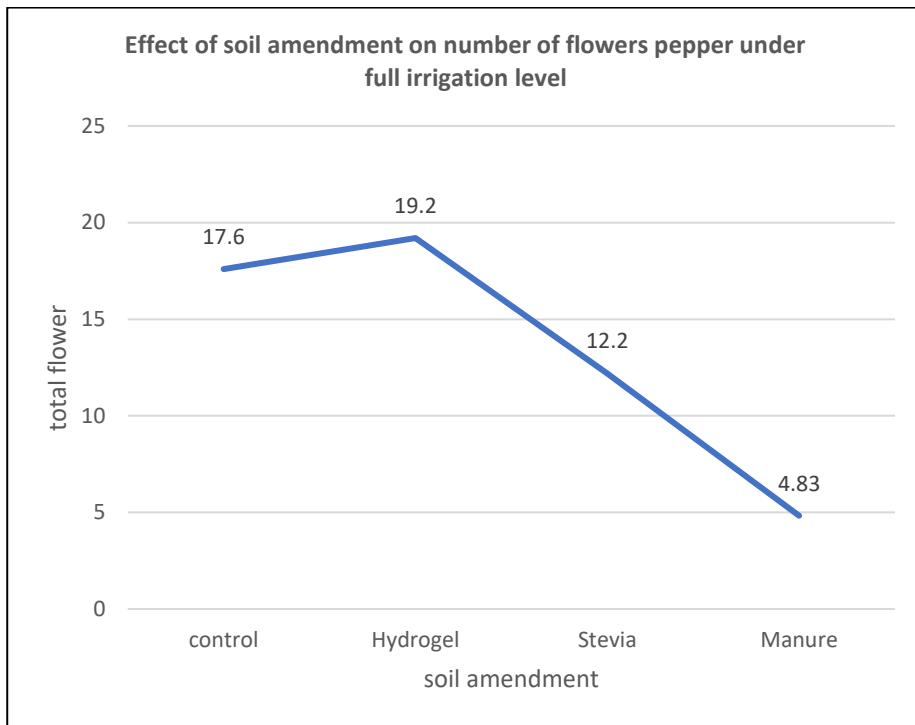


Figure B.8

Effect of soil amendment on number of fruit pepper under full irrigation levels

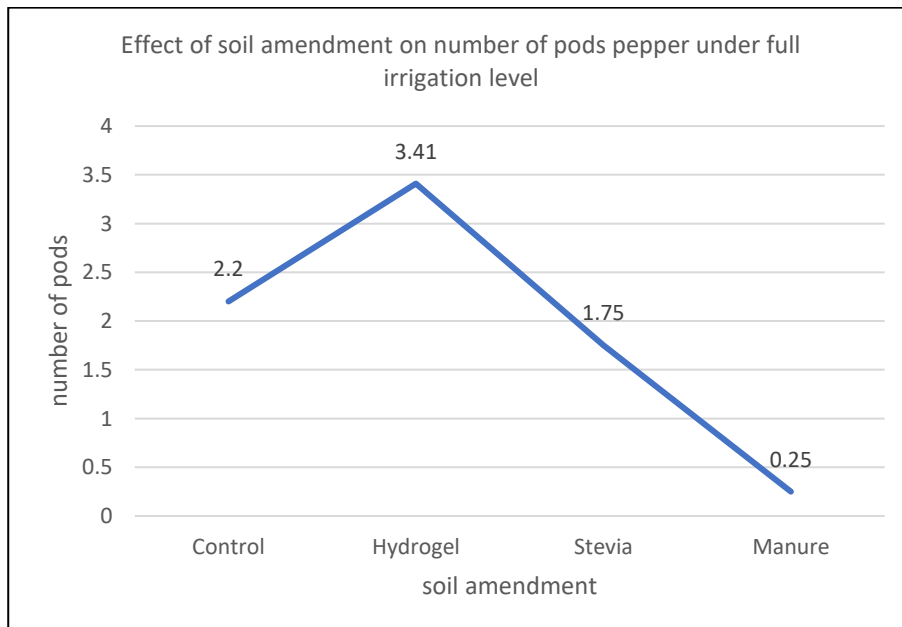


Figure B.9

Effect of soil amendment of fresh shoot weight under full irrigation levels

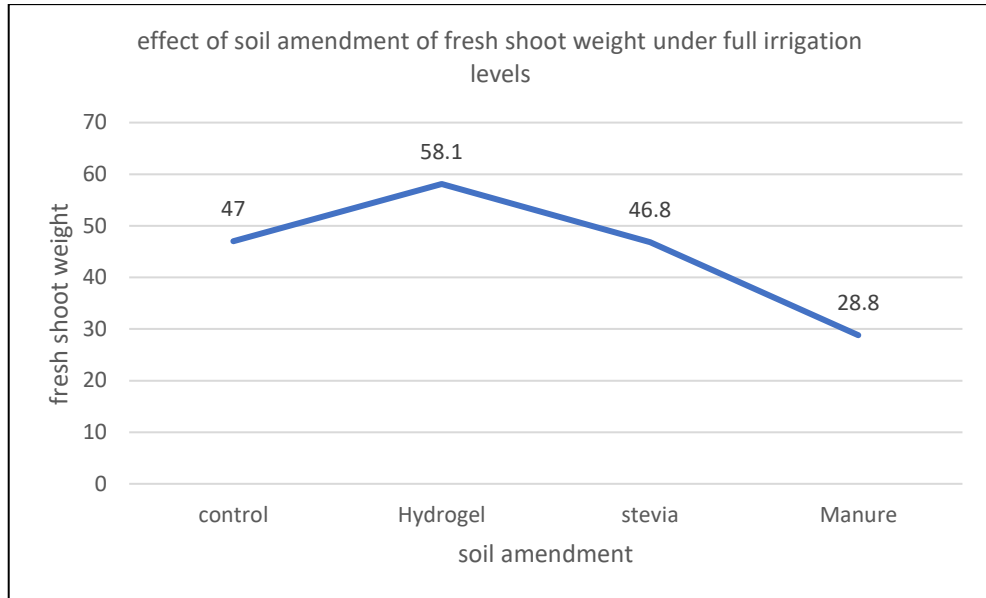


Figure B.10

Effect of soil amendment on dry weight pepper under full irrigation levels

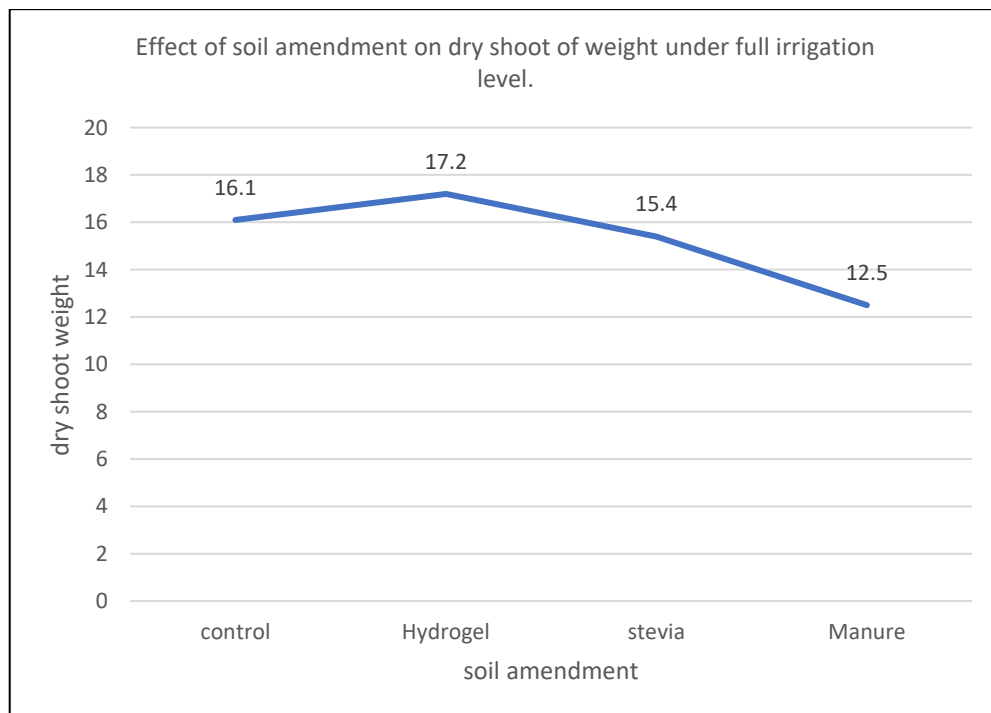


Figure B.11

Effect of soil amendment of fresh fruit weight under full irrigation levels

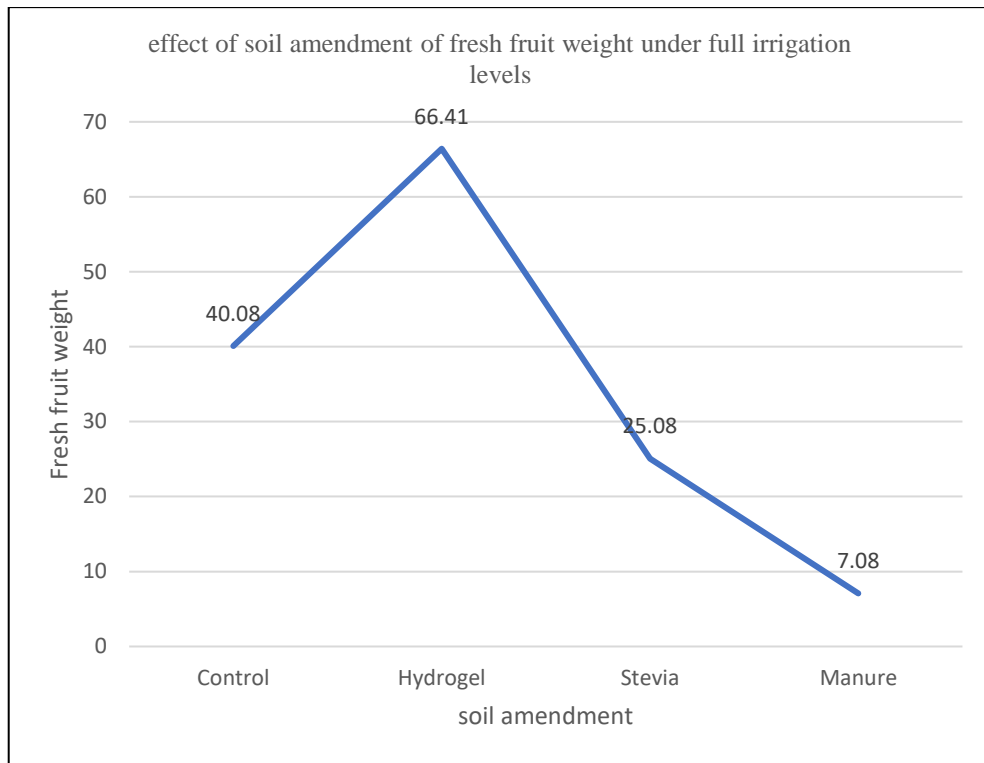


Figure B.12

Effect of soil amendment on fresh fruit weight pepper under full irrigation levels

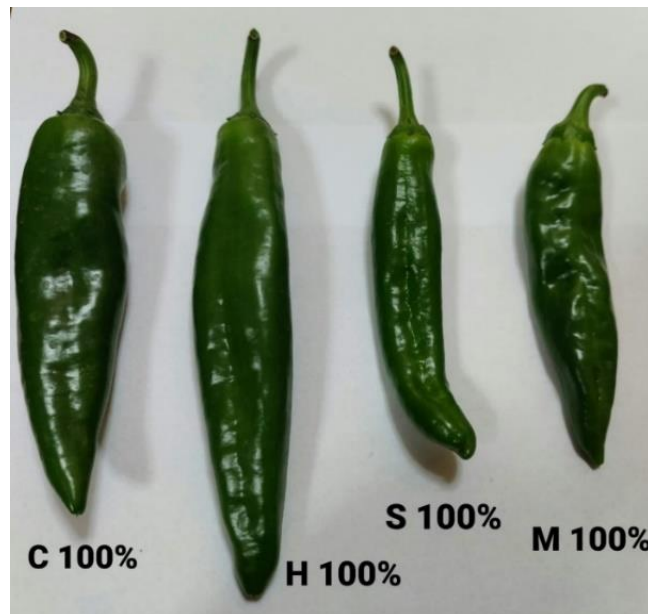


Figure B.13

Effect of soil amendment on fresh fruit weight under different irrigation levels

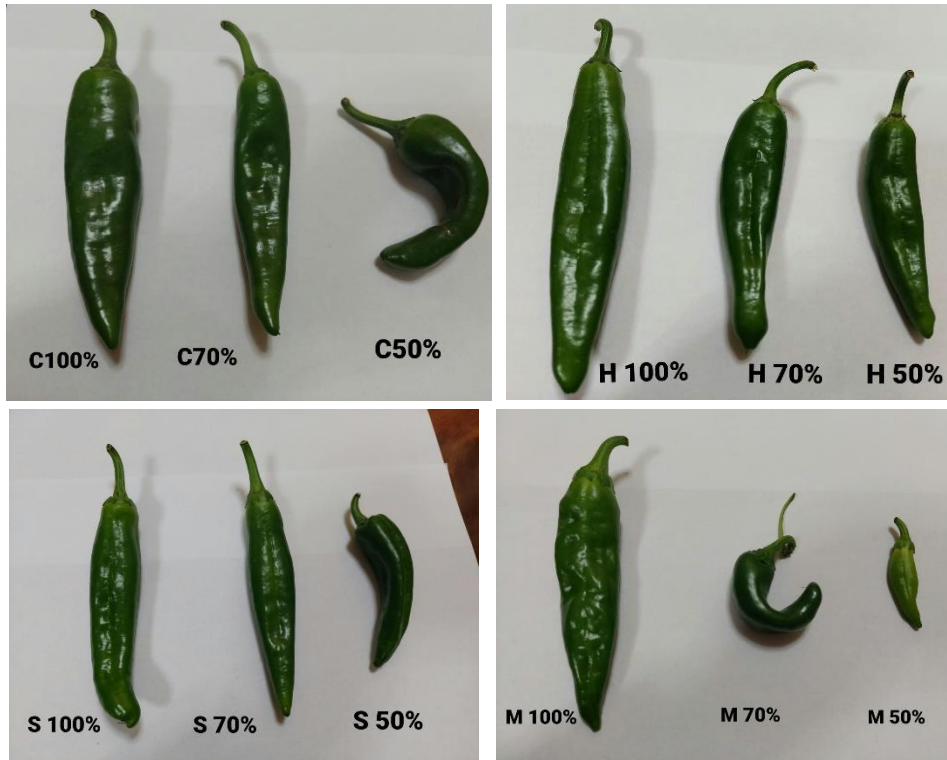


Figure B.14

Effect of soil amendment of fresh root weight under full irrigation levels

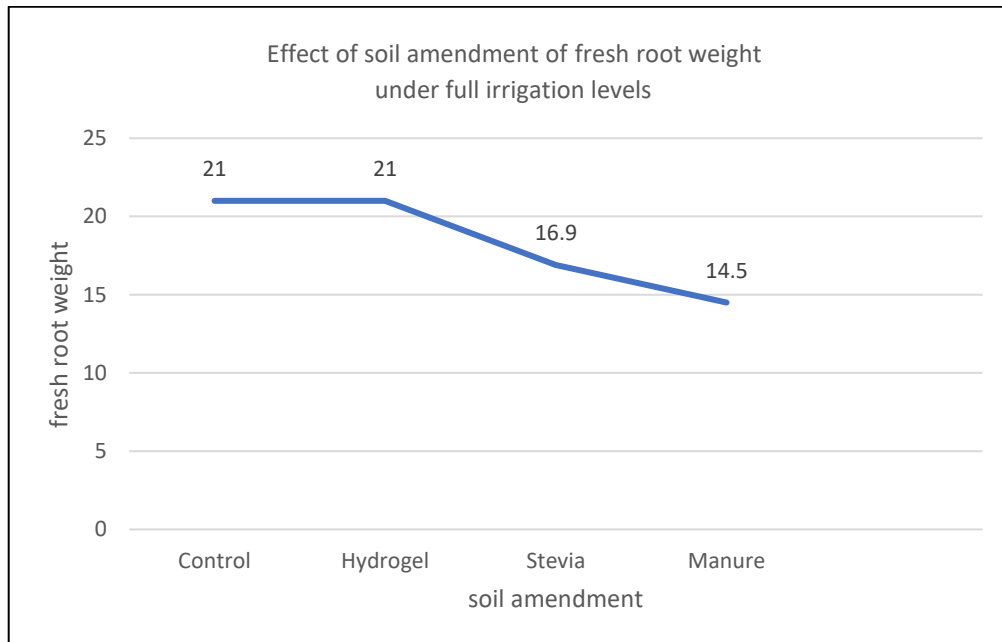


Figure B.15

Effect of soil amendment of fresh root weight under full irrigation levels



Figure B.16

Effect of soil amendment of fresh root weight under different irrigation levels

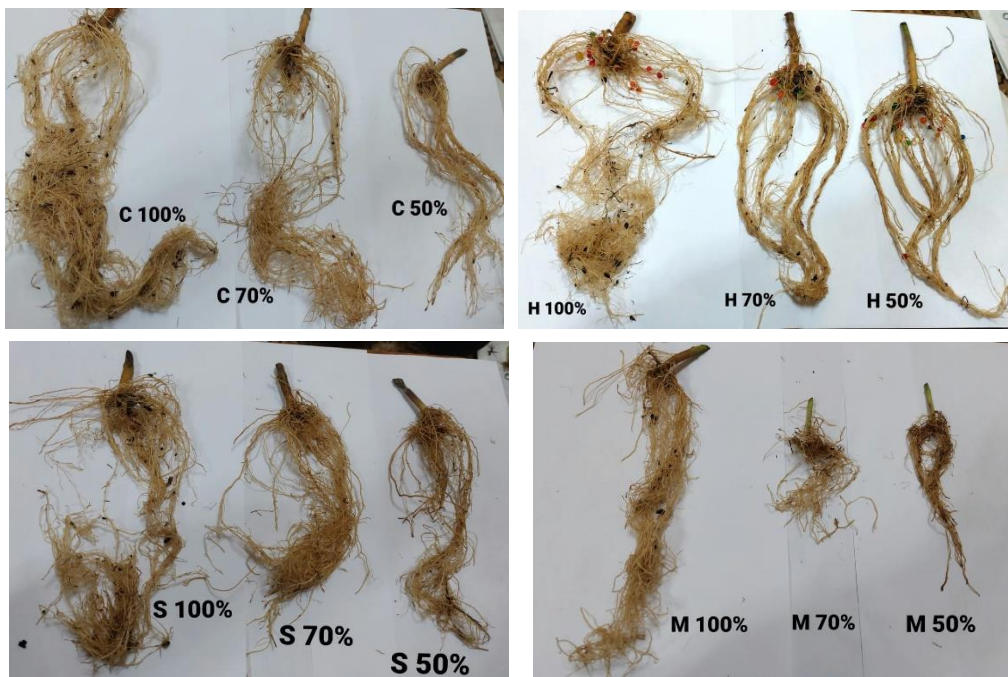


Figure B.17

Effect of soil amendment of dry fruit weight under full irrigation levels

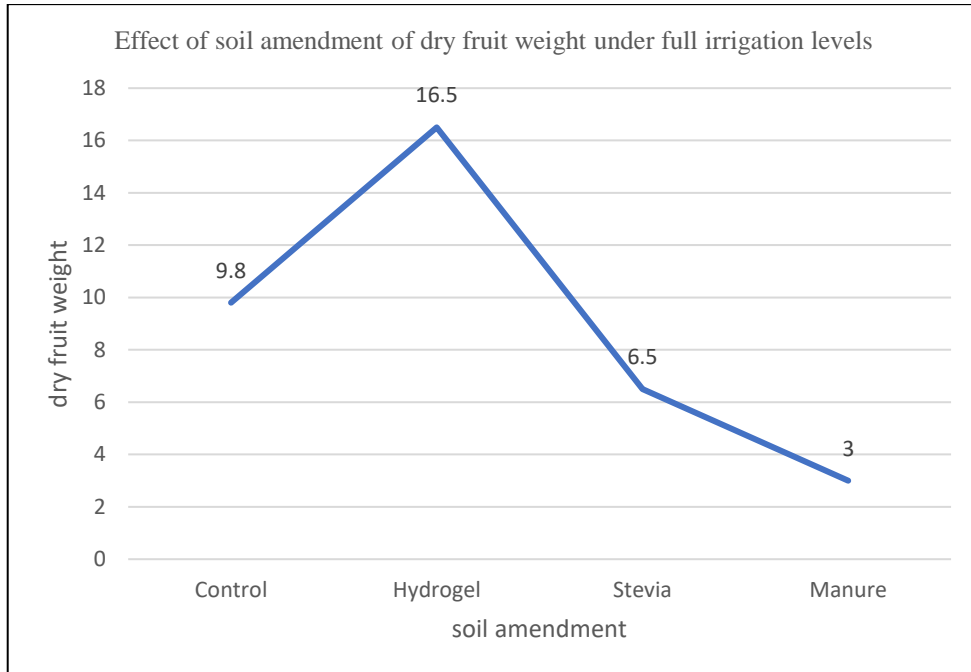


Figure B.18

Effect of soil amendment of dry root weight under full irrigation levels

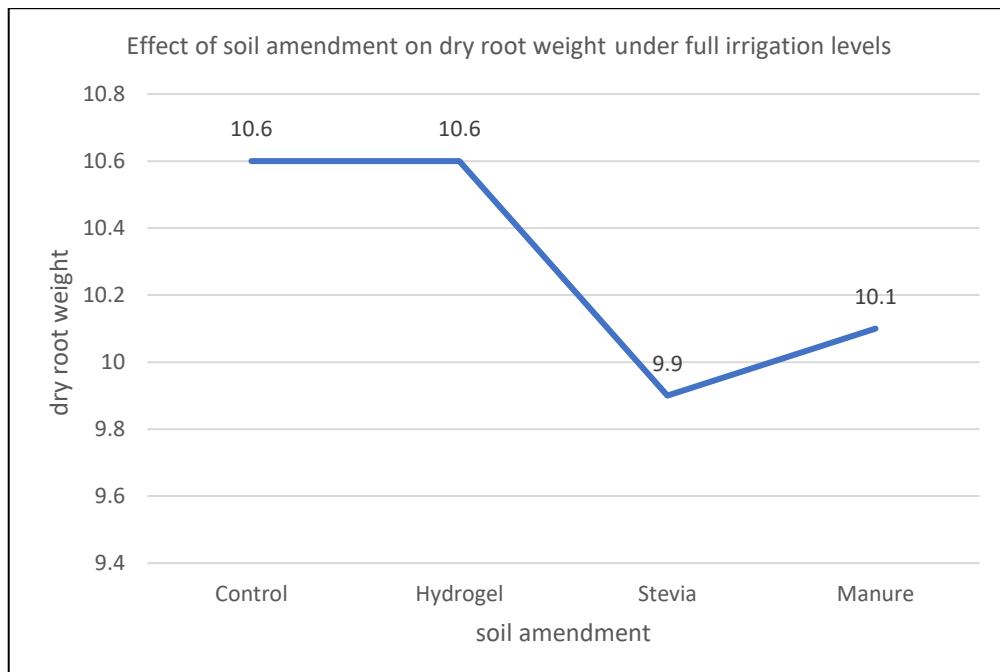


Figure B.19

Effect of soil amendment of on leave area under full irrigation levels

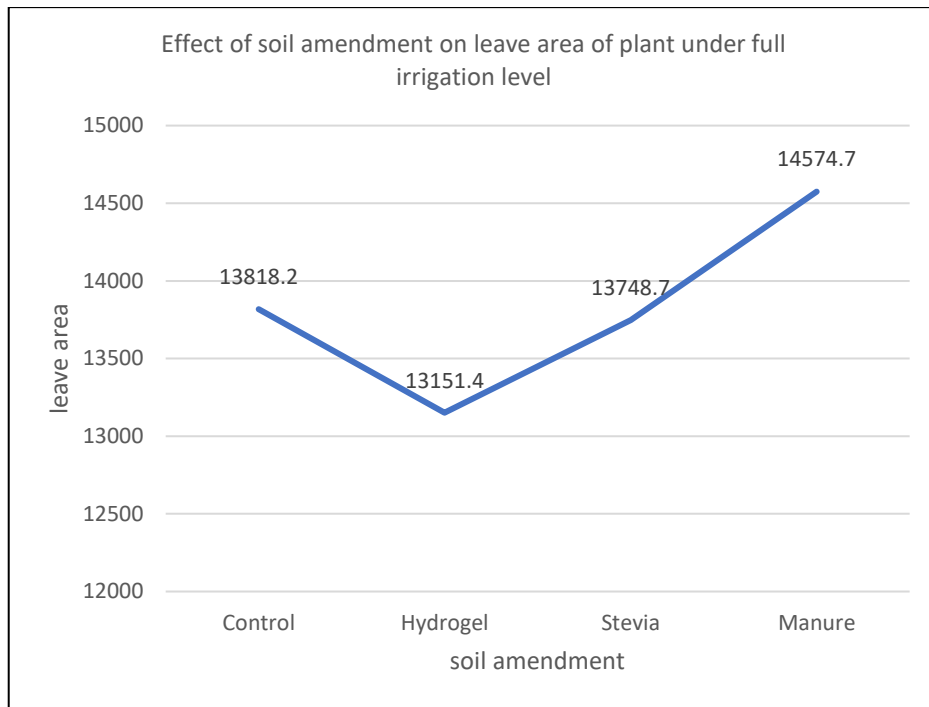


Figure B.20

The effect of different soil amendment(control, hydrogel, stevia straw and compost) under different irrigation levels(50%, 70%, 100%) on leave area of pepper

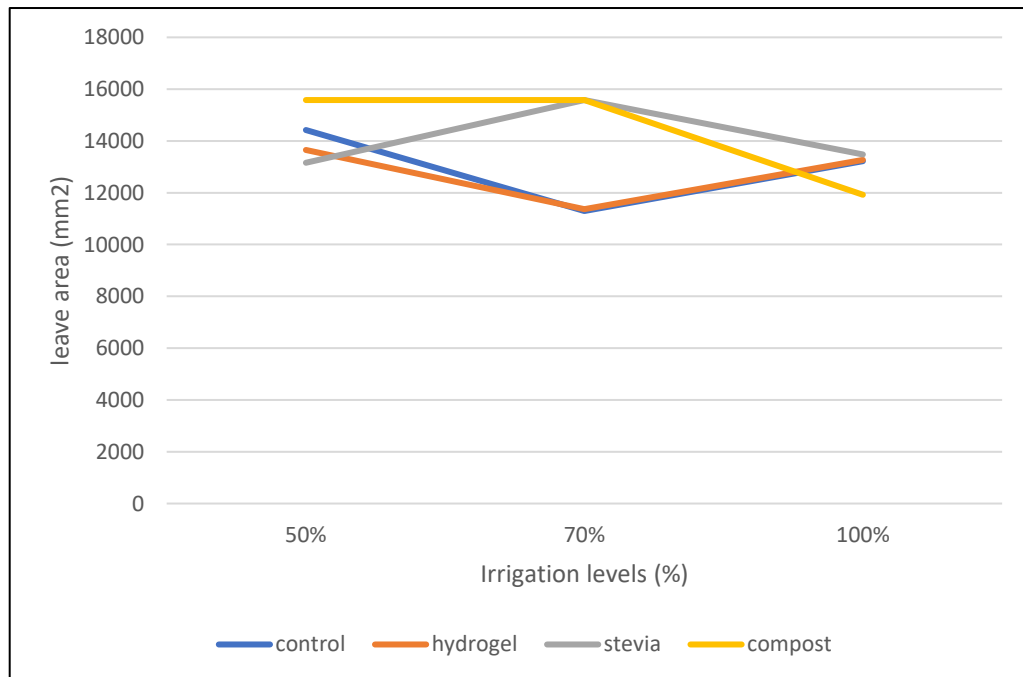
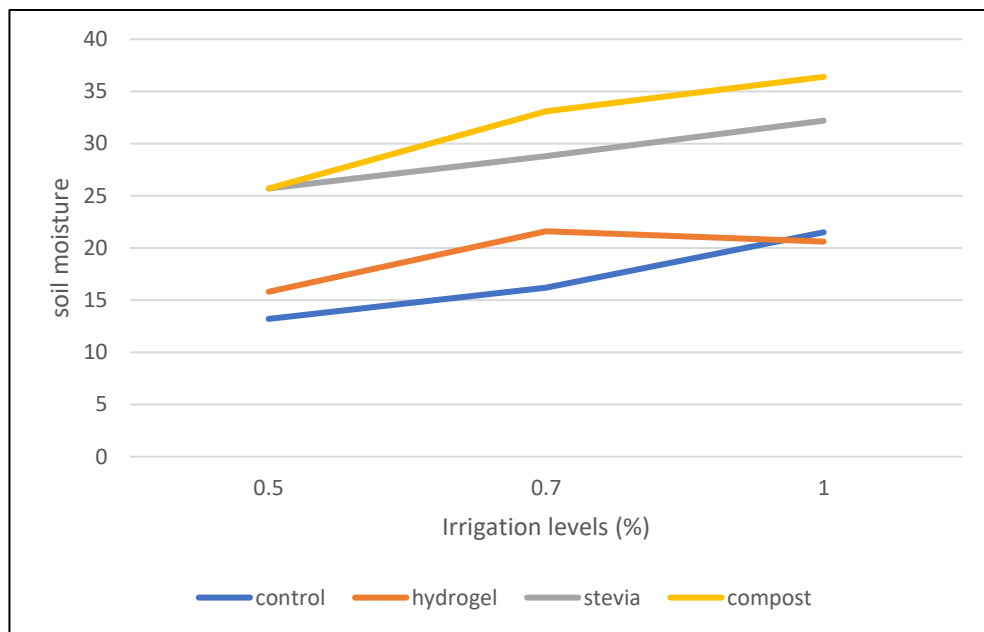


Figure B.21

The effect of different soil amendment(control, hydrogel, stevia straw and compost) under different irrigation levels(50%, 70%, 100%) on soil moisture





جامعة النّجاح الوطنيّة
كلية الدّراسات العليا

تأثير محسنات التربة على التربة ونمو نبات الفلفل

إعداد

لارا محمد شاكر بدير

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أ. د. حسن ابو قاعد

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

2023

تأثير محسنات التربة على خواص التربة ونمو نبات الفلفل

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الملخص

ندرة المياه هي أحد أهم العوامل العالمية التي تؤثر على إنتاجية الغذاء يعود ذلك الى العوامل السياسية والطبيعية، تمتلك فلسطين أحد أكثر موارد المياه المتجددة في العالم محدودة. تستهلك الزراعة 51.5% من إجمالي استهلاك المياه. لذلك، تدفع ندرة المياه للبحث عن موارد مياه بديلة والمزيد من المحاصيل المتحملة للجفاف، تلعب تعديلات التربة دورا هاما في تعزيز نمو وإنتاج المحاصيل. الهدف من الدراسة هو تقليل كمية المياه التي يحتاجها نبات الفلفل من خلال تطبيق تعديلات التربة العضوية وغير العضوية. في هذه الدراسة، تم استخدام محسنات مختلفة للتربة مثل حبيبات الهيدروجيل، قش نبات الاستيفيا و الكومبست مع مستويات ري مختلفة (100%، 70%، 50%) لري نباتات الفلفل "النحاس". نمت شتلات الفلفل داخل قواوير زراعية سعتها 10 لتر لكل شتلة. تم تحضير التربة الزراعية المكونة من رمل و بيتموس، بنسبة 3:1. تم تطبيق التعديلات على التربة في كل قوار بمعدل 250 جم من قش الاستيفيا، و 250 جم من الكومبست، و 2.5 جم من حبيبات الهيدروجيل. تمت دراسة تأثير هذه التعديلات على خواص التربة ونمو نبات الفلفل والإنتاجية. حصلنا على اعلى النتائج عند استخدام حبيبات الهيدروجيل حين ان ارتفاع النبات (48.4) سم، عدد القرون (5.2)، وزن النبات الطازج (58.1) جرام، وزن الفاكهة الطازجة (62.4) جرام، وزن الثمرة الجافة (45.8) جرام، ووزن الجذر الطازج (21) جرام. وفي الختام أوضحت نتائج هذه الدراسة التأثير الإيجابي لتطبيق الهيدروجيل في الحفاظ على محتوى رطوبة التربة. تظهر النتيجة عند إضافة هيدروجيل تحت مستويات الري 50% حقق اعلى طول نبات (51.7) سم، محتوى الكلوروفيل في أوراق الفلفل (63.7)، عدد فلفل الفاكهة/نبات (3)، وزن الفلفل الطازج (60.8) جرام، وزن الفاكهة الطازجة (44.7) جم ووزن الجذر الطازج

(21.2)، إضافة قش الاستيفيا والكومبست ادت إلى زيادة رطوبة التربة ولكن لها تأثير سلبي على نمو النبات وإنتاجيته. وفي الختام أشارت نتائج هذه الدراسة إلى الأثر الإيجابي لتطبيق الهيدروجيل في الحفاظ على محتوى رطوبة التربة من خلال خصائص امتصاص الماء، حيث يساعد الهيدروجيل على التخفيف من الإجهاد المائي والحفاظ على رطوبة التربة، وتحسين كفاءة استخدام المياه، خاصة في المناطق التي تواجه ندرة المياه أو ظروف الجفاف وتقليل كمية المياه المستخدمة للري بنسبة 50% من الري. وفقا للنتائج التي تم الحصول عليها بموجب هذه التجربة يمكن التوصية بأن إضافة الهيدروجيل يمكن أن يستخدم في ظل ظروف الجفاف كأداة فعالة لإدارة مياه التربة.

الكلمات المفتاحية: محسنات التربة الهيدروجيل؛ قش الاستيفيا؛ كومبوست؛ مستويات الري.