College of Graduate Studies and Academic Research

The Effect of Soil Moisture Conservation Techniques on Growth and Survival Rate of Some Species of Fruit Trees Seedlings

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DEDICATION

I would like to dedicate this thesis to

My Mother and Father for their support, and inspiring me.

My dear Wife

My wonderful Sons (Omar, Sama and Hala)

My sisters and Brothers.

For a full support and sincere encouragement to complete this work

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Acronyms and Abbreviations

M	Mulch
H.M.	Half Moon
S.HG	Superabsorbent Hydrogel
Coc	Cocoon
Cont	Control
PCBS	Palestinian Central Bureau of Statistics
GDP	Growth Degree Percentage
MoA	Ministry of Agriculture
ARIJ	Applied Research Institute- Jerusalem
WB	West Bank
CR	Chilling Requirement
T	Temperature
CRD	Completely Randomized Design
OM	Organic Matter
CEC	Cation Exchange Capacity
EC	Electrical Conductivity
ppm	Part per million
HR	Heat Requirement
GIS	Geographic Information System
mm	Millimeter
SMC	Soil Moisture Content
WHT	Water Harvesting Techniques
LRC	Land Research Center

Abstract

This study was carried out at Za'tara town in the eastern slopes of Bethlehem during the year 2018/2019. The study area is classified as semi-arid. The aim of this study is to evaluate and compare the effects of using different soil moisture conservation techniques on almond and plum seedlings under semi-arid conditions.

This study was laid out in a completely randomized design (CRD). Four soil moisture conservation techniques (cocoon, superabsorbent hydrogel, black plastic mulch and half-moon) and the control were examined to measure their impact on the survival rate, plant height, stem diameter, leaf area, branches length of almond (*Prunus amygdalus, var.* Um Al-Fahm) and plum (*Prunus salicina*, *var*. Santa Roza) seedlings in addition to the soil moisture content during the first year after planting.

At the outset in May and until end of Jun/2019 in the study area for almond and plum experiments there were insignificant variation among cocoon, plastic mulch and superabsorbent hydrogel. Also, they were significantly higher than half-moon and control. However, cocoon keep the highest soil moisture values during the experiment period until August/2019, where it became significantly the highest value over the other treatments.

For almond, the results of this study revealed significant positive effect for all the treatments compared to the control. The cocoon technique was superior over the other treatments in term of survival rate (66.8%) followed by the mulch (40%). For plant height, the highest increase was resulted by the cocoon (22.75 cm) compared with the control followed by the mulch treatment (14.5 cm). Also, cocoon revealed the maximum value of branches length (94.33 cm), followed by mulch (68.30 cm). Plant diameter was highest

for mulch treatment followed by cocoon treatment (0.28 cm and 0.25 cm, respectively). However, the leaf area revealed insignificant variation among the treatments, whereas the cocoon presented the highest leaf area (4.83cm^2) followed by hydrogel, mulch and half-moon (4.61, 3.86, 3.31 cm^2, respectively).

Almost, similar trends were observed in plum for survival rate, plant height, plant diameter, and branch length for the examined treatments, except the leaf area, where the cocoon significantly presented the highest leaf area (9.41 cm^2) compared to the other treatments.

In conclusion, for almond and plum, cocoon is highly recommended in such environmental conditions due to the fact that this technique revealed the highest results in term of soil moisture content (SMC), growth parameters and survival rate.

Also, black plastic mulch revealed good results and it could be recommended in such environmental conditions due to the lower time consuming, lower implementing efforts and lower cost.

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Keywords: Cocoon, black plastic mulch, superabsorbent Hydrogel, Half-moon, almond and plum survival rate, almond and plum growth parameters.

Chapter One

1. Introduction.

Recently, large parts of the world testify a notable decline in the natural resources and food security as a result of the global warming, drought and greenhouse gas emissions and their disastrous consequences (Kumawat et al., 2020). Drought severity and increased heat stresses are the most obvious impact of climate change in semi-arid area and it is the major risk factor in orchards for plant growth and production (Paudel et al., 2019).

The highest seedling death usually occurred during the first year after planting due to many environmental factors like high temperatures, drought, water stress, in addition to the root diseases that could appear due to the root wounds (Grossnickle and El-Kassaby, 2015).

Indeed, climate change impacts (such as drought, high temperature, CO2 elevation, and the variations in the precipitation patterns) are the major causes of soil and water deterioration, hence, leads to reduce land productivity (Shukla et al., 2019; Raza et al., 2019).

Millions of hectares of arable lands are degraded and its productivity been reduced as a result of water deficit, high temperature and deterioration of soil characteristics (Saeed et al., 2019; Kumawat et al., 2020). Moreover, they are highly affected by heat and drought stress (Paudel et al., 2019). Normally, abiotic stress in semi-arid areas affects the plant physiology such as photosynthesis, germination, stunted seedlings, flowering, ripening stages and death of cells and tissues, in addition to plant survival, plant morphological and production parameters (Toscano et al., 2019). These effects were worsened by the climate change.

The almond and plum in Palestine were recently witnessed a remarkable decline, due to many obstacles and unlimited violations on environment as of growth in other sectors at the expense of the agricultural sector (land and water resources) (Albaba, 2017). About three quarters of the agricultural lands in west bank under full Israeli control (PCBS 2016, cited in National Agriculture Sector Strategy 2017-2022, (MOA, 2016) which make any improvement and development in these areas are very difficult. In addition, rainfall fluctuation and scarcity during past decades (Albaba, 2017), and the annual temperature rise by 0.8℃ after 1990 as a result of climate changes, and all of these factors have a direct impact on Palestinian environment and agricultural sector (Abu Hammad and Salameh, 2018). Drought, and long summer causes a rapid loss of the water content of the soil, which causes an increase in the percentage of deaths of fruit trees seedling and a decline in the agricultural area, which negatively effects on plant growth and productivity, simultaneously there is a lot of the obstacles and challenges that facing this sector according to the National Agriculture Sector Strategy 2017-2022, (MOA, 2016).

In 1970, the agricultural sector was the dominant sector in Palestinian economy, where it formed 36% of Gross Domestic Product (GDP) (The importance of agriculture (PCBS 2016; cited in National Agriculture Sector Strategy 2017-2022 (MOA, 2016). In 1994 the contribution of the agricultural sector reached 13% and kept dropping to 3.4% in 2015 (FAO, 2019). Therefore, there are endeavors to exploit all cultivable areas, through creating suitable environmental conditions to become more suitable for agriculture regardless of difficult environmental factors, to reduce the effects of the emerging challenges that cause stress on plants in the agricultural sector from fluctuating environmental factors as a result to climate change, the most important of which is the water fluctuation and scarcity, drought, long summer that may cause crops to fail. Therefore, a paradigm shifts in soil and water conservation, and its management is needed for agricultural sustainability (Kumawat et al., 2020).

Consequently, food security and agricultural sustainability can be achieved by providing holistic management of soil and water resources, through providing essential water to succeed the agriculture, especially in low-rainfall lands by finding solutions that help in increasing the water content in the soil through using improved technologies (Kumawat et al., 2020), which would reduce soil water losses and reduce production costs. Many efforts have been paid to explore the almond (Alimohammadi et al., 2013) and plum (Petri et al., 2018) response to drought at genetic level; this approach focuses on genes and pathways analyses for different genotypes and hybrids in order to evaluate their adaptation to water stress (Rubio-Cabetas, 2016). On agricultural practices level; starting from the nursery, the growing media of the seedling effected the survival opportunities, root development and vegetative growth of the future tree (Mondragón-Valero et al., 2017). Tillage systems, cover crops and fertilization are aspects of the agricultural practices that have been studied by Ramos et al. (2009) to measure their impact on almond productivity and soil properties. Indeed, it was revealed in Ramos et al. (2009) study that cover crops improve soil physical, chemical and biological properties and soil moisture content (SMC). Furthermore, the tillage frequency has accelerated the decomposition of the soil organic matter. Consequently, it was proposed that this improvement in the soil properties would be correlated to a higher almond productivity. Al-Douri (2020) reported the effect of foliar fertilization and plant growth regulator on almond seedling as a practice to improve rootstock for better grafting in addition to improve the seedlings characteristics (stem length, stem diameter, number of leaves and leaves area). Also, irrigation systems could influence almond and plum. Razouk et al. (2013) studied the regulated deficit irrigation (RDI) and found that almond RDI treatment T 75 for almond and T 50 for plum revealed the best fruit yield and agronomical traits. Chocanoa et al. (2016) studied the effect of different soil management practices on plum production and reported that biennial compost addition revealed the highest production. Many researchers indicated the positive effect of soil/water conservation techniques on the morphological characteristics and survival rate of almond and plum (Tavakoli et al., 2007; Abdullah, 2017; Oraee and Moghadam, 2013; Mehraj et al., 2014).

I. Study objectives

The objective of this study was to evaluate and compare the effects of using different soil moisture conservation techniques (mulch, superabsorbent hydrogel, half-moon harvesting technique, cocoon technology and control) on growth and survival rate for two species of fruit trees (almond and plum) under semi-arid conditions.

Chapter Two

2. Literature review.

2.1. Palestine environment.

Despite the small area of the state of Palestine that located between the Mediterranean Sea and Jordan River, it is characterized as one of the richest areas of the world in term of biodiversity (Pappe, 2006; Ighbareyeh et al., 2014). Historically, Palestine has been known as Canaan land (Ighbareyeh et al., 2014); its topography has several main geographical characteristics such as the coastal plain, semi-coastal region, the central highlands, the Galilee Mountains, the eastern slopes, the Jordan Rift Valley, and the Gaza Strip. Indeed, this geographical diversity led to huge diversity in climate (Tippmann, and Baroni, 2017), geology and soil (Strahorn, 1929), where it is reflected also on high diversity in flora, and fauna. Moreover, Palestine can be divided into several climatic zones that range from arid to sub-humid areas (Tippmann, R., & Baroni, L. 2017). The high variability in altitudes that ranges between 1,000 meters above sea level in the Central Highlands Region (FAO, 2009), to 260 meters below sea level in Jericho (Ighbareyeh et al., 2014) also contributed to the variability in climatic conditions. As a result, Palestine is full with enormous resources, including most kinds of organisms from wild plants or animals and natural resources (Ighbareyeh et al., 2014; Tippmann and Baroni, 2017)

The climate in Palestinian is described as predominantly of the eastern Mediterranean type that characterized by hot dry and long summer, cool and rainy winters with annual rainfall range between 100–700 mm (FAO, 2009). Rainfall and temperature are characterized by high variability between years and geographically between locations. In arid and semi-arid areas rainfall come as a strong storm in short period that caused severe surface runoff and soil erosion (FAO, 2009; Safi and Mohammad, 2019). At the Southern part of the Jordan Valley a different climatic conditions were prevailed, which characterized by dry steppe and the extreme desert conditions in the Dead Sea region (ARIJ, 2015). The eastern slopes of the West Bank can be classified as semi-arid to very arid area which directly effect on soil water conservation, then on survival rate and plant growth, while the western part of the West Bank is semi-arid to sub-humid (Tippmann and Baroni, 2017).

According to FAO (2009), the Palestine zoning regions (based on climate, topography, soil types and farming systems) includes: Jordan Valley Region, Eastern Slopes Region, Central Highlands Region, Semi-Coastal Region, and Coastal Plain (Appendix A.1 and Appendix A.2).

2.2. Taxonomy, origin and environmental requirements of Almond and Plum.

2.2.1. Almond (Prunus dulcis, syn, subg. amygdalus).

Almond belongs to Rosaceae (rose) family; it was originated in Asia, India and North Africa. While the archaeological studies in Palestine have indicated the earliest human settlement in the coastal plain of Palestine at 3300-1200 BC by the Canaanites, then they were expanded toward the mountains, where they established one of the most Canaanites cultural landmarks “the agricultural terraces”. Since that time farmers used these techniques to preserve soil and rain water for planting fruit trees, vegetables and field crops (Shtayeh, 2008; Al-Khatib, 2017)**.** However, the environmental condition for Mediterranean basin is suitable for planting and producing almonds (Ighbareyeh et al., 2014), especially in areas where the yearly rainfall about 600 mm (Yadollahi et al., 2011). Almond has strong and deep root system therefore it needs deep and fertile soils with pH ranging from 5.3 to 8.3 to grow and to give high yield (Ighbareyeh et al., 2018). Moreover, the average annual temperature for almond is 10.5 to 19.5 °C and the dormancy period requires temperature falls between 0 to 2.2 °C. Regarding Um El- Fahem var., its chilling requirement considered Medium (approximately 200 hours). Also, it's flowering period in Palestine from 4 Feb. to 26 Feb. Furthermore, the average weight of the kernel fruit is about 4 gm and the ratio between pulp and seed weight (pulp/seed weight ratio) is 60-70%. Besides, the suitable pollinizers for this variety that are available in Palestine are: 'Shefa', baat, gilad, koghav 54, koghba 53, (Holland et al., 2016; Yunos and Abdul-Hady, 2018).

2.2.2. Plum (Prunus salicina. L, var. Santa Rosa).

Plum belong to Rosaceae family, Santa Rosa is one of the cultivars of the Japanese plum (*Prunus salicina*) (Das et al., 2011) that are available in Palestine. However, this species is native to China and characterized by shallow root system therefore it requires well drained and aerated soil with good water holding capacity for growing and production (Kim, 2008). Moreover, Santa Rosa var. is a self-pollinated cultivar, hence it does not need a pollinizer, and it is considered a good pollinator for other plum varieties that need cross-pollination (Guerra and Rodrigo, 2015). The chilling requirement of plum ranged between 436 and 459 units. Moreover, it is categorized as early flowering cultivar that blooms in the period between 26th of February and 1st of March. (Ruiz et al., 2018).

2.3. Fruit trees in Palestine.

According to the 2012/2013 agricultural census (MoA, 2013), the number of agricultural holdings in Palestine is about 111,310, it is covering a total area of 1.38 million dunums (about 21% of the total area of the WB and Gaza Strip), of which the horticultural crops covered about 792,918 dunums with total productivity 84,840 tons that represents 16% of the total agriculture production. Also, the majority of the horticultural crops are rain-fed (88% of the total horticultural area and only 12% is irrigated) (Tippmann and Baroni, 2017).

In Palestine, the most abundance rootstocks for almond and plum cultivars are bitter almond and Myrobalan ((GF31 for plum) and (GF677 for almond)), and these rootstocks are the only used rootstocks in Palestine for different almond and plum cultivars so far. because they revealed a wide range of adaptability, tolerate the hard growth conditions, and tolerant to wide range of soil types.

In our experiment the rootstock for both species almond and plum are bitter almond, which is tolerant to drought stress from side and susceptible to root knot nematode, crown gall and phytophthora on the other side (Basheer-Salimia et al. 2020)

2.3.1. Almond.

According to the statistics of Ministry of Agriculture/ state of Palestine and PCBS 2007 to 2017, the available data about almond (both of hard and soft varieties) revealed a significant decline in total area that planted with almond in the West Bank and Gaza Strip. Where in 2007 there were about 44,305 dunums are planted with almond trees, and gradually this area decreased to 26,760 dunums in 2017. Hence, almonds constitute 2.4% of total cultivated agricultural land in the West Bank and Gaza Strip (19187 dunum bearing and

7573 dunum unbearing) of which 96.27% are rain-fed with an average production of 212.4 kg/dunum, in comparison to about 500 kg/dunum for irrigated. Whereas, the highest almond productivity was in Hebron governorate, constituting 41% of total production of almond in Palestine (West Bank and Gaza Strip), followed by Bethlehem governorate (13%), and Nablus governorate (12.6%) (PCBS, 2007; PCBS 2017; MOA, 2019).

Many studies revealed that climatic stress (e.g. drought, heat …etc.) has a direct effect on almond growth and productivity (Yadollahi et al., 2011; Ortiz et al., 2014; Leiva Gea et al., 2017; Ighbareyeh and Carmona 2018), it was reported that Palestine influenced by the global climate change, where the effects of high temperature and drought reduced the plants growth and development which led to lower production (Albaba, 2017; Abu Hammad and Salameh, 2018). Indeed, abiotic stress slows the vegetative growth in new orchards of stone fruit, but the plants can develop physiological responses and ecological strategies to cope with climate change, either by stress/ avoidance or tolerance. Short-term drought (for weeks) in juvenile plants permits observation of changes in some physiological processes (such as stomata changes in size and conductance, or photosynthetic rate) that are typical for progressive stages of drought (Yadollahi et al., 2011). However, the Prunus genus in general adapted to low water and can be grown under semi-arid areas, except that the severe stress of lacking water inhibits the total growth of the different root orders (McCutchan and Shackel 1992; Cochavi et al., 2019).

2.3.2. Plum.

The total plum cultivated area in West Bank and Gaza Strip in 2007/2008 was (23,608 dunum) (PCPS, 2009) and dropped in 2017 to 8266.3 dunums (6074,2 dunums bearing and 2192,1 dunums unbearing), of which 95.54% are rain-fed; While the area planted with plum trees was the highest in Hebron governorate that formed 41.87% of total plum area in Palestine, then Bethlehem governorate about 19% and Jerusalem governorate 13.5% (MOA, 2019). Generally, the average gross domestic production per dunum from rain-fed areas was 400kg/ dunum versus 648kg/ dunum in irrigated area at 2007/2008 in Palestinian territory. There is high variation between the productivity in rain-fed and irrigated orchard in year 2004/2005 that shows a higher yield of plum trees in the irrigated orchards (2300kg/dunum) compared to the rain-fed ones (281kg/dunum) (PCPS, 2006). In addition to the existence of differences between the average production/dunum between the governorates, where the total plum yield in Jenin 300kg/dunum in rain-fed area, while (500kg/dunum.) in Tulkarm Governorate, also 180kg/dunum in Nablus Governorate., and 350kg/dunum in Bethlehem Governorate (PCPS, 2006), this variation in productivity is due to soil and climatic condition impact (heat, drought, rainfall scarcity …. etc.) (Paudel et al., 2019; Saeed et al., 2019)

2.4. Soil moisture conservation techniques (SMCT) and water harvesting techniques (WHT).

2.4.1. Water conservation techniques.

Some of the most important purposes of using soil moisture conservation techniques, that it used as measures for achieving greater water use efficiency to enhance plant growth and produce more food with less water (Oweis et al., 2001; Al-Seekh and Mohammad, 2009; Safi and Mohammad, 2019; kumawat et al. 2020). Moreover, it used also to increase the period of moisture content in plant root zone after water harvesting (Al-Seekh and Mohammad, 2009 Kumari and Singh, 2016), to conserve the soil from erosion, moisture deficit and loss of fertility (Saeed et al., 2019), to increase the survival rate of seedlings (Abedi-Koupai and Asadkazemi, 2006), and to reduce water losses by runoff and evaporation while maximizing in soil moisture storage for crop production (Gachene et al., 2019).

"Water conservation includes all the policies, strategies and activities to sustainably manage the natural resource of fresh water to meet the current and future water demands (www.sciencedirect.com/topics/engineering/water-conservation -joined 1-July.2021)

Conservation of water for the agricultural uses could be achieved by wide range of techniques in response to the needs, climatic conditions, topography and socio-economic criteria. These techniques could be either for water harvesting in conservation facilities and tools (e.g. dams, cisterns, water box, cocoon …. etc.) that used later for any purpose (Oweis, 2001; Tapia et al., 2019), or for reducing the water lose due to evaporation (e.g. mulch) (kumawat et al., 2020) or drainage (superabsorbent hydrogel) (Pourjavadi et al, 2004). On the other hand, these techniques could preserve the water in the soil and preserve the soil as well at micro and macro levels, also it could be called soil and water conservation techniques (Oweis, 2001; Kumawat et al., 2020).

Generally, water harvesting techniques classified into two groups: micro and macro techniques. Micro-catchment methods also may be called on-farm systems include contour ridges, semi-circular /trapezoidal bunds, small pits, small runoff basins (Negarim), runoff strips, inter-row systems, meskat and contour-bench terraces; and macro-catchment methods e.g. wadi-bed systems include small farm reservoirs, wadi-bed cultivations and jessour. And off-wadi Systems include water-spreading, large bunds, hafaer or tanks, cisterns and hillside conduits. These techniques preserve water from runoff and soil from erosion (Oweis, 2001).

2.4.2. Cocoon.

It is a small water reservoir technology and innovative tool function to optimize water use in propagating and cultivating plants, and it is 99% biodegradable box (Abdullah, 2017). Cocoon hold 25 liters of water in basin that surround the young plant, and feed water to the soil at a slow but constant rate through capillary action via a short length of rope or a wick that connects the basin to the soil. The cocoon technique is only filled with water once at the time of planting (Land Life Company, 2015), especially in arid and desert areas including highly eroded land, and allowing the roots to grow deeper and more vertically, which ensures the vitality of the plants even after the box is removed, and also to establishing year-round sustainable agriculture, and almost no water loss during this period due to evaporation (Tapia et al., 2019). This technique was established in 2014 (Land Life Company, 2015) and few researches studied the sufficiency of this technique on Opuntia Cacti (Tapia et al., 2019), Mango (Petros et al., 2021) and reports by the mother company Land Life Company (LLC), 2015, 2016 and some institution reports (e.g. Abdullah, 2017; Union of Agricultural Committee (UAWC, 2017) on almond and olive seedling. Moreover, Groasis Waterboxx that is almost similar to cocoon as water saving techniques, but its structure and application way is little bit different (Tapia et al., 2019).

2.4.3. Superabsorbent hydrogel.

Superabsorbent hydrogels (S.HG) are a three-dimensional matrix (3D) constituted by linear or branched hydrophilic polymers that are chemical of physical cross linked, with the ability to absorb large quantities (swelling ratio (SR) > 400) of water or biological fluids (Pourjavadi et al., 2004). Further, it can keep their network stable even in the swollen state. Such characteristics result from the cross linked structure, which assures to S.HG stability in different media and environments (Pourjavadi et al., 2004). Based on polysaccharides applied in agriculture as soil conditioners and as nutrient carriers (Guilherme et al., 2015), were systematically optimized to achieve a hydrogel with swelling capacity as high as possible. Maximum water absorbency of the optimized final product was found to be 789 g/g (Pourjavadi et al., 2004).

2.4.4. Mulch.

Mulch is simply a protective layer of material to cover the top of the soil (Bahadur et al., 2018), to protect it from being eroded, increase infiltration, regulate soil temperature, reduce evaporation, increase soil fertility, improve the soil around plants, and thereby conserve soil moisture (Pang, 2010; Jabran, 2019). Mulches can either be organic-such as grass clippings, straw, bark chips, and similar materials and inorganic-such as stones, brick chips, and plastic (Bahadur et al., 2018).

2.4.5. Semi-circle bunds or half-moon: (water harvesting technique).

Half-moon, semi-circle bunds or Crescent-shape is commonly made of soil bund at gentle slope less than 5% or from stone bund in slope more than 15% , where it creates at downstream side of plant at facing upslope and have range around 30 cm soil width and the height is about 30-50 cm based on the slop rate (Oweis, 2001). Also, the radius of semi-circle bunds ranges from 2-12 m where the small half-moon used with trees and shrubs, while the largest and the widely spaced used in rangeland rehabilitation and depends on the magnitude of catchment area that needed to collect runoff water, where the seedling pit is excavated in the lowest point in side of half-moon (Mekdaschi Studer and Liniger, 2013).

2.5. The impact of soil moisture conservation techniques on the soil.

2.5.1. Soil preservation (erosion, nutrients leaching).

Soil is one of the critical life aspects. Its importance rose from being water storage, plant support, habitat for living organisms in addition to its rule in the elements cycles (Goebes et al., 2019). Soil erosion can occur due to many factors like land slope, rain, wind, characteristics of plant cover, human activities and even animal behaviors (e.g. grazing) (Gachene et al., 2019). Soil preservation includes preserving the soil properties (Schiettecatte et al., 2005; Gachene et al., 2019) and its components (e.g. minerals, moisture and organic matter) (Safi and Mohammad, 2019). Many factors can play rule in the selection of the suitable soil/water preservation technique like soil properties, slope, plant species, rain, socio-economic factors (Oweis et al., 2001), and environment (Tapia et al., 2019). Also, these techniques could be used either separately or jointly for soil preservation (Willy et el., 2014).

Saeed et al. (2019) reported the effect of soil/water conservation techniques on saving the soil particles from erosion (e.g. semi-circular earth bund or half-moon), thereby, increased the soil moisture content and improved the performance of the plants. Also. Rashid et al. (2016) reported that the highest soil moisture content was in the terraced blocks (15.1%) and that the lowest value was for the blocks without terraces (9.09%). Meanwhile, terrace structures (TS) was efficient in reducing gully formation and soil nutrients preservation.

Moreover, Oweis et al., 2001; Schiettecatte et al., 2005; Ali et al., 2017; Somasundaram et al., 2017; Bahadur et al., 2018; Jabran, 2019; Kopittke et al., 2019; Tamagnone et al., 2020 reported the positive impact of using soil moisture conservation techniques in decrease soil erosion through reduce the run-off impact and increasing the infiltration, while the soil erosion induces a significant depletion in soil fertility and crop production.

2.5.2. Soil moisture content (SMC).

As well known, all soil/water conservation techniques increase the soil moisture content compared to the control (Ali et al., 2017), but they are different basically on the principle of a donor area and a collector area (Ali et al., 2017), the way they work, the amount of conserved moisture, and the duration they can keep the moisture (Oweis, et al., 2001), the improvement of water use efficiency through better utilization of soil water are show to be the best way to increase plant growth under semi-arid areas (Lalitha et al., 2010). Kumawat et al. (2020) used the mulches to reduce evaporation, increase infiltration, regulate soil temperature, and thereby conserve soil moisture. Meanwhile, Petros et al. (2021) reported that cocoon preserves and supplies irrigation water slowly to the soil as far as the SMC decreased due to the dry season conditions, this technique is designed to reduce evaporation and prevent growth of weeds near of seedling base.

Also, Ali et al. (2017) reported in a comparison study to test three different soil/water micro harvesting techniques on mango trees, the significant superiority of half-moon technique over the V-shape and diamond-shape in term of soil/water conservation and yield. However, Tamagnone et al., (2020), evaluated the effects of half-moon (HM) and planting pits (PP) and found that H.M revealed (20.7% and 23%) water stress mitigation efficiency compared to 3.75% and 2.85% in PP. Also, it was reported that the RWHT retain runoff up to 87% and duplicate the infiltration compared to the control. Furthermore, soil/water conservation can variably prevent soil erosion and harvest the water from upper stream to the root zone, which later could be lost by evapotranspiration and infiltration. In contrast, to Superabsorbent Hydrogel (S.HG) has hydrophilic groups that holding a fluid in the root zone and release the fluid later under particular environmental conditions (Zhang et al., 2006; Dehkordi, 2016). And according to Bordado & Gomes (2007) and Nirmala and Guvvali, (2019) more than 90% of absorbed water by S.HG was available to plant roots. On the other hands, plastic mulch may reduce soil moisture loss due to weed consumption. Indeed, the plastic mulch used for weeds control, thus reduce the competition with the required crops on the moisture and nutrients (Qu et al., 2019).

2.5.3. Soil properties (physical, chemical and biological).

Soil properties are highly influencing the root development and properties and thus plant growth and development. Roots are affected by soil structure, depth, aggregates (Dehkordi, 2016), bulk density, porosity (Grossnickle and El-Kassaby, 2015), compaction, temperature, moisture content (Bahadur, et al., 2018), pH, electrical conductivity (EC), soil crispiness, salinity, water tension, available water (Dehkordi, 2016), and fertility (Bahadur et al., 2018; Qu et al., 2019).

Use of water harvesting techniques proved that they were effective in increasing soil moisture content into the root zone, the right design can reduce soil water stress to enhance crop growth (Tamagnone et al., 2020).

Bahadur et al., (2018) found that mulch improves soil properties, nutrients availability, controls weeds, reduces water evaporation from the soil and regulates soil temperature.

Regarding the soil hydrogel, it was reported that due to treating soil with S.HG improved the soil properties, SMC and plants growth and yield (Dehkordi, 2016). Furthermore, cocoon technology has a positive impact on SMC, soil structure and nutrients availability (Petros et al., 2021).

On the other hands, it is well documented that soil/water conservation techniques increase the soil macro (Karuku, 2018) and micro-organisms (Bahadur et al., 2018) activities, where the existing of such organisms considered an important indication for the soil health. The impact of plastic mulch (Lalitha et al., 2010), and Superabsorbent hydrogel (Mikiciuk, 2015) on soil properties is positively reflected on the biological activities in the soil (Bahadur et al., 2018). Plastic mulch increases the soil temperature (Lalitha et al., 2010) which may influence the presence of earthworms and nematodes (Pritchard, 2011). In addition, they were found that the oxygen level increased underneath the plastic mulch (Bahadur et al., 2018). Consequently, the presence of these faunae in such improved conditions encourages the organic matter decomposition and improves soil properties (Bahadur et al., 2018).

2.6. The effect of soil moisture conservation techniques on plant growth parameters and survival rate.

2.6.1. Plant growth.

It was reported in many studies that soil moisture conservation techniques have influences on plant height, stem diameter, leaf area and branch length (Stapleton et al., 1993; Jalili et al., 2011; Oraee and Moghadam, 2013; Mehraj et al., 2014; Land Life Company (LLC), 2015; Tavakoli, 2017; Tapia et al., 2019; Kumawat et al., 2020; Petros et al., 2021).

Stapleton et al. (1993) studied the effect of three different kinds of mulch, where it was reported that the black plastic mulch revealed the best plant growth (stem diameter) and seedling survival in almond seedling comparing to transparent polyethylene and control.

Mehraj et al. (2014) reported in a comparison study between different types of mulches the effect on plum seedling and found that maximum extension growth in plant height (62.50 cm) were in seedling under black polyethylene mulch compared to other kinds of mulch (transparent polyethylene, mowed grass, pine needles, saw dust and chinar leaves besides control).

Regarding the hydrogel, Jalili et al. (2011) studied the effects of two factors, super absorbent hydrogel (S.HG) (Tarawat A200) in four levels (0, 60, 100 and 125 g per 100 kg soil) and irrigation intervals (7, 12, 18 and 24 days) on almond seedling. The 60 g of super absorbent treatment showed significant increase in branch height in middle of growth season (July) in the first year. Moreover, in the second year, all treatments revealed significant differences in most of the growth parameter (plant height, trunk diameter, branches height, number of branches, average canopy cover diameter). Oraee and Moghadam, (2013) studied the effect of different levels of irrigation with superabsorbent hydrogel (S.HG) polymers on growth and plant characteristics of one species of plum, myrobalan (*Prunus cerasifera*) such as plant height, stem diameter and root characteristics. It was found that the highest plant height, number and surface area of the leaf, fresh and dry weight and diameter of plant was related to irrigation after 4 days with 3% polymer application and the lowest was related to irrigation after 12 days with no application of polymer (control).

Cocoon technique is a modern technology that has been recently introduced to the world since 2014 (Land Life Company (LLC), 2015) for that there are few studies about it. To the best of our knowledge there are no scientific studies that evaluated the impact of cocoon on almond and plum, although there were some reports showed (not scientific reports) that cocoon revealed good results for almond. Meanwhile, there are some studies on cocoon uses and its effect on development and growth of fruit trees, where Petros et al. (2021) studied five treatments, three of them are related to the cocoons under some adjustments, cocoon sprayed by tricel (T_1), cocoon painted by used engine oil (T_2), cocoon without tricel and oil (T_3), manually irrigated seedlings (T_4) and control (control was planted during rainy season in arid area) (T_5) to test the growth performance of mango seedlings at six months and twelve months after transplanting. The results showed significant difference due to the effect of the treatments on plant growth (plant height, branches length, stem diameter, number of leaves per plant). Moreover, cocoon was superior over the other treatments in improving seedlings growth. Also cocoon treatment without tricel and oil recorded the highest increase in plant height under dry season. On the contrary, Tapia et al. (2019) reported that the cocoon technique is not always universally applicable and showed opposite results on plant growth, through a study that they conducted to compare between the cocoon and water-box techniques on Opuntia spp. cacti plants.

Water harvesting techniques (e.g. terracing, half-moon, contour lines, trenching, dams ... etc.) is imperative to improve soil properties and plant growth and development (Kumawat et al., 2020).

The use of semi-circle bund increased significantly the branch length and stem diameter of almond seedlings during the first three years after planting comparing to the untreated seedlings (Tavakoli, 2007).

2.6.2. Survival rate.

A comparison study between black mulch and transparent mulch on almond were conducted to measure their efficiency in Verticillium wilt control and plant characteristics. It was found that the black mulch superior over the transparent mulch in term of survival rate (up to 97% almond survival rate) (Stapleton et al., 1993). Also, in the same study they were reported that there was no significant difference between the black mulch and the control, which could be related to the irrigation treatment that was combined with the mulching treatments.

Some reports have shown that the use of cocoon increased the survival rates of new planted seedlings like olive and almond (Land Life Company (LLC), 2015, 2016; Abdullah, 2017), mango (Petros et al., 2021), Opuntia cacti (Tapia et al., 2019) and it could be a promising technology that is able to provide the new planted seedlings with their water requirements during the dry periods (e.g., Land Life Company (LLC), 2015, 2016; Abdullah, 2017).

Union of Agricultural Committee (UAWC) (2017) conducted a demonstration to examine the cocoon and reported that seedlings survival rate was 75–95 % in olive and almond new planted seedlings. On the other hands, the survival rate of mango seedlings was higher than what was reported by UWAC, where the survival rate reached up to 100% (Land Life Company (LLC), 2019; Petros et al., 2021).

To the contrary, Tapia et al. (2019) indicated that cocoon technique was not suitable for Opuntia cacti seedlings (survival rate from 0%-20%). And this could be due to the short initial rooting depth of this plant.

Hydrogel absorbs large amount of water in root zone, hence, will considerably reduce drought stress on plant through providing the preserved water for plant roots and improving their survival rate. Moreover, when irrigation stopped for six days all of the control seedlings died compared to 57% and 71% survival rate in the hydrogel treatment (Abedi-Koupai et al., 2006).

Tavakoli (2007) reported that the survival rate of almond seedlings increased significantly by using the semi-circle bunds and small basin (up to 99%) comparing to the farmer’s practices (control). But he also combined their effects with the effect of the catchment area size and properties on almond survival rate and soil properties.

Chapter Three

3. Materials and methods.

3.1. Study site.

This study was conducted at Za'tara town which is located in the eastern part of Bethlehem governorate. It is located at an altitude of 577m above sea level (ARIJ GIS, 2009). The Land is gently sloping (2-3%) (Appendix B.1). The land use during the last 10 years was for field crops cultivation.

The area was classified as semi-arid. The amount of rainfall at the study site was highly fluctuated during the past two decades with an average yearly rainfall is about 324 mm (ARIJ GIS, 2009). However, according to Zatara rain monitoring station 2019 the rainfall during the study year (2018/2019) was extraordinary very high with 621 mm. About 35% of total annual rainfall was in February 2019 (Fig. 1). In addition, during the 41 rainy days there were three heavy rain events that constitute more than 40% of the total precipitation during the rainy season 2018/2019 (Fig. 2).

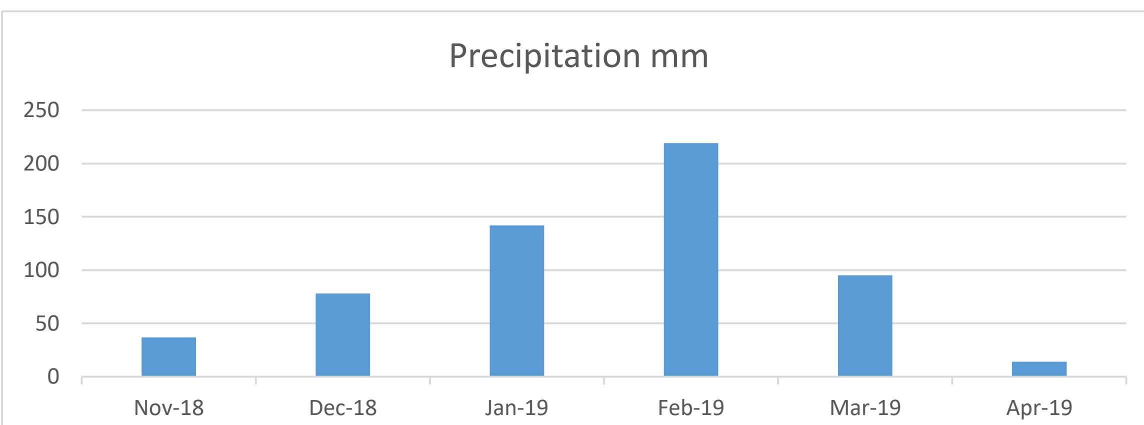

Figure (1): Monthly precipitation (mm) in the experimental area during November 2018 – April 2019. (Source: Za'tara Secondary School rainfall monitoring station).

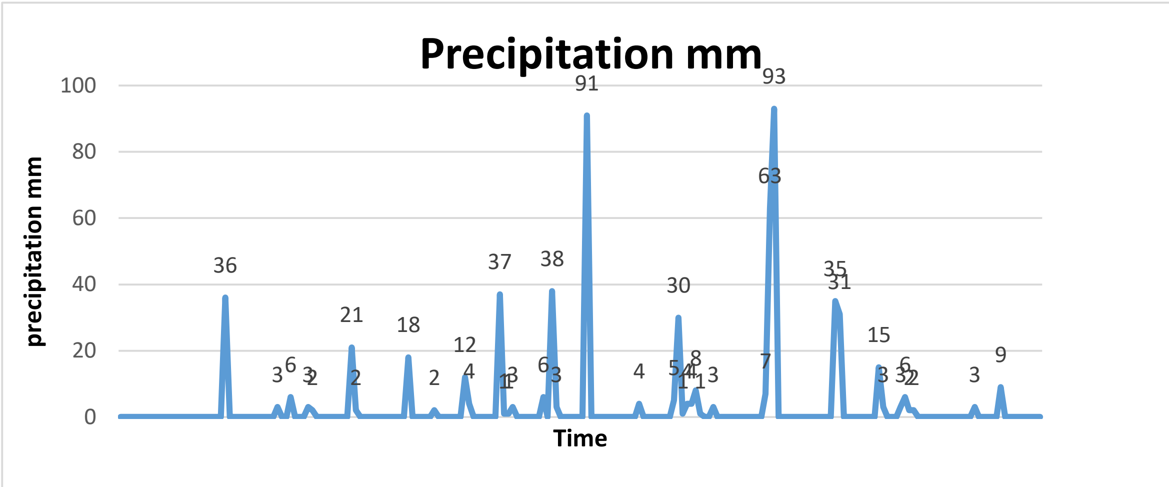

Figure (2): Daily rain (mm) in the experiment area November 2018 – April 2019. (Source: Za'tara Secondary School rainfall monitoring station).

The long term average annual temperature is 18 ˚C, and the long term average annual humidity is about 60 percent (ARIJ GIS, 2009). According to Palestinian Astronomical Society (2019), during the 2018/2019 year the maximum temperature was in May (32.9 ˚C), while the minimum temperature was in January(8.1 ˚C) (Fig. 3).

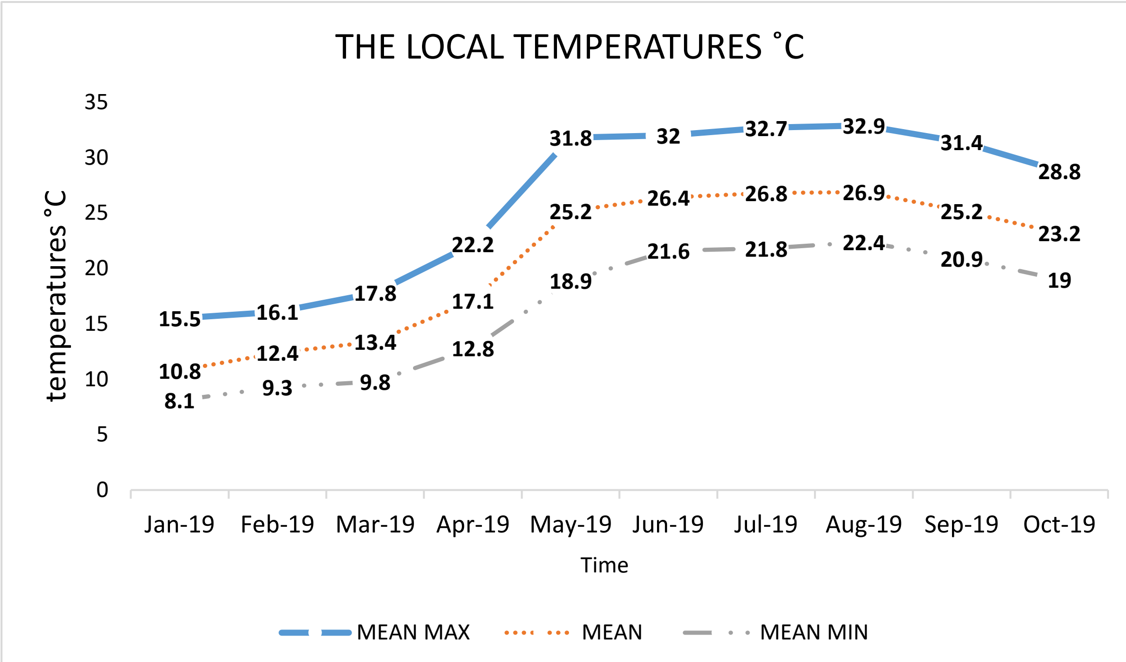

Figure (3): Minimum, maximum, and mean monthly temperatures °C in the experiment area during Jan-2019 – Oct- 2019. (the Source: The Palestinian Astronomical Society).

3.2. Land preparation.

The study land area is about 3 dunums (1.5 dunums for each species), which was conventionally ploughed in 22-Oct/2018 at 25-30 cm depth before the first rainfall. Each two dunums where allocated for one plant species and planned to plant the seedling in a 4 x 5 m². The holes were drilled by mechanical auger (appendix D. Photo 3). For each plant species, almond "var. Om Alfahem" and plum "var. Santa Roza", a seventy five seedlings of one year old uniform in size and vigor were brought from a licensed nursery and certificated according to the regulations of the Palestinian Ministry of Agriculture. The rootstock for both species was bitter almond. Moreover, the seedlings were bare rooted and free from mechanical injuries, pests and diseases and they were treated with systemic insecticide and fungicide in the field. The seedlings were planted in the field at January 2019. Other than the treatments applied, the traditional cultural practices were practiced after planting that included adding fertilizer (organic fermented sheep manure) 60 L manure /seedling. Also, during the period 10 to 14-April/2019, the grass was cut by using hand held mechanical grass cutter (STIHL/FS 260 C-E) and the mowed grasses were left on the ground, then the land was plowed on 10-May/2019.

3.3. Treatments and estimated parameters.

The two plant species under investigation, almond "var. Om Alfahem" and plum "var. Santa Roza", were each planted in an area of 1.5 dunums. For each species four different water conservation techniques (treatments) and the traditional method (control) were applied as shown in Table (1):

Table (1): The treatments and their Characteristics.

No.	Treatment	abbreviation	Characteristics
1	Cocoon (Appendix D, Photo 1)	Coc.	25 liters storage capacity
2	Half-moon bunds (Appendix D, Photo 3)	H.M.	$2m^2$ storage area
3	Mulch (Appendix D, Photo 4)	M.	$1m^2$/tree
4	Superabsorbent hydrogel (ZEBA) (Appendix D, Photo 5 and 6)	S.HG	60 g /tree according to (Jalili et al., 2011)
5	Control	Con.	without any interventions

Fifteen seedlings were assigned for each treatment in a completely randomized design to measure the effects of these treatments on soil moisture content, survival rate, and plant growth (plant height, stem diameter, leaf area, and branches length) of almond and plum seedlings in the first year after planting. The first measurement was recorded at the time of planting in January -2019, then the measurements for the whole parameters were taken monthly between July/2019 until October/2019.

3.4. Soil characteristics.

Soil sampling was carried out in May/ 2019; by collecting 3 representative samples collected from the land from different location by using manual soil auger from 30 cm soil depth. The samples were air dried at room temperature, then cleaned off from any unwanted materials (stones, plant residues), then crushed with a pestle and mortar and passed through a 2-mm sieve. Later the samples were analyzed in the laboratory according to the soil and water analysis manual (AL-Bakier and Tomeizh, 2011) as shown in Table (2). All soil analysis was conducted at the laboratory of the College of Agriculture at Hebron University.

Table (2): The parameter and methods used for soil analysis.

No.	**Parameters**	**Method**	**Reference**
1.	Soil texture	Pipette	Pansu and Gautheyrou (2006)
2.	Nitrogen (N)	Kjeldahl	Pansu and Gautheyrou (2006)
3.	Phosphorus (P)	(Olsen test) by Spectrophotometer	Marx et al., (1999)
4.	Potassium (K^+)	Flame photometer or/ atomic absorption	Brupbacher, (1968)
5.	Organic matter	Walkley-Black method (titration)	Combs and Nathan (1998)
6.	Acidity	pH-meter method	Whitney (1998)
7.	Salinity	Electrical conductivity meter	Whitney (1998)
8.	Soil moisture (SM)	Gravimetric method (or	Pansu and Gautheyrou(2006); AL-

		drying method in the oven)	Bakier and Tomeizh (2011)
9.	cation Exchange capacity (CEC)	Atomic absorption spectrophotometer	AL-Bakier and Tomeizh (2011)
10.	Sodium	Flame photometer	AL-Bakier and Tomeizh (2011)
11.	Zinc (Zn)	Atomic absorption	Whitney (1998); AL-Bakier and Tomeizh (2011)
12.	Manganese (Mn)	Atomic absorption	Whitney (1998); AL-Bakier and Tomeizh (2011)
13.	Calcium (Ca^{+2})	Atomic absorption	Whitney (1998); AL-Bakier and Tomeizh (2011)
14.	Magnesiun (Mg^{+2})	Atomic absorption	Whitney (1998); AL-Bakier and Tomeizh (2011)
15.	Nitrate ($NO3^{-}$)	Spectrophotometer	Whitney (1998); AL-Bakier and Tomeizh (2011)

The level of elements content within the soil (low, medium, high, or excessive, and sufficient or not) were determined according to soil test interpretation guide Marx et al. (1999) and Horneck et al., (2011).

3.5. Soil moisture content.

The mixed samples were collected monthly starting from May-2019 until August -2019. Based on the treatment, measurements were done at 25-40 cm away from the seedling trunk, and at 30 cm soil depth, with 3 replicates/ treatment. Also, the first soil sample was performed 20 days after the last rainfall then collected monthly. Soil moisture content was measured by drying method in the oven at 105 ˚C (overnight > 16 Hours) in soil and water lab. at College of Agriculture /Hebron University.

soil moisture was calculated as a follow:

$$\% \boldsymbol{Soil\ moisture} = \frac{(\boldsymbol{W2} - \boldsymbol{W3})}{(\boldsymbol{w3} - \boldsymbol{w1})} * \mathbf{100}\%$$

W1: Wight of container empty (g)

W2: Wight of wet soil + container (g).

W3: Wight of dry soil + container (g).

3.6. Plant height.

Plant height was measured monthly from Feb-2019 until the growth was stopped in Oct-2019, plant height was measured from the grafting point to the highest active bud for 3 replicate/ treatment by using the scale meter and expressed in (cm).

3.7. Stem diameter.

The average stem diameter were tacken for 3replicate/ treatment, 5 times at one month enterval through the experement period for the two species ware measured from time of planting then continued monthly from June -2019 until Oct.-2019 at 1cm above the grafting point by using manual caliper and expressed in (cm) (Appendix D, Photo 7).

3.8. Leaf area.

Seven mature green and fresh leaves/tree where randomly selected from different branches, and 3 replicates/treatment were measured with specialized leaf area meter (CI-202 area meter) (Appendix D, photo 8) in the plant production lab. at Hebron University and expressed in (cm^2). However, this parameter was measured once in July-2019, when the leaves were fully matured based on the climatic conditions of the site.

3.9. Branches length.

The first branches lengths were measured for 3 replicates (seedling) per treatment, and the length of every single branch in every replicate (seedling) was measured only one time by using metallic meter scale in June-2019. Then the average length of the branches was calculated for every seedling and expressed in (cm).

3.10. Survival rate.

The survival rate was recorded for the 15 seedlings/treatment, observations were taken 10 times through the study period, where the first observation recorded at 22-Feb.2019 and the last observation was in 21-Sep. 2019.

The survival rate was calculated through follow formula:

$$Survival\ Rate\ \% = \frac{N}{15} * 100\%$$

N: Number of the monthly survived seedlings.

15: Replicates (15 seedlings)

3.11. Data analysis.

Data were statistically analyzed using one-way analysis of variance (ANOVA), followed by Tukey’s HSD test that was used to compare the mean of individual parameter by SigmaStat 3.5, at 95% confidence.

Chapter Four

4. Results.

4.1. Soil analysis.

Soil analysis (Table 3) showed that the soil has clay texture (53.3%), slightly alkaline pH (pH=7.86), low organic matter content (1.89%), low salinity (EC= 0.75 ds/m) and low sodium content (103 ppm). Also, the cation exchange capacity (CEC) was 12.27 meq/100g soil which is within the range for clay soils (Foth, 1990).

Table (3): Soil chemical and physical properties at the study site.

pH	EC 1:2.5	Organic matter	Cation Exchange Capacity (CEC)	Soil texture				Sodium Na+
				Sand	Silt	Clay	Texture	
****	ds/m	%	meq/100g soil	%	Ppm	%		ppm
7.86	0.75	1.89	12.27	31.05	103	53.31	Clay	103

4.2. Soil moisture content.

The results of soil moisture in the experimental site showed significant variation due to the examined treatments (Fig. 4)

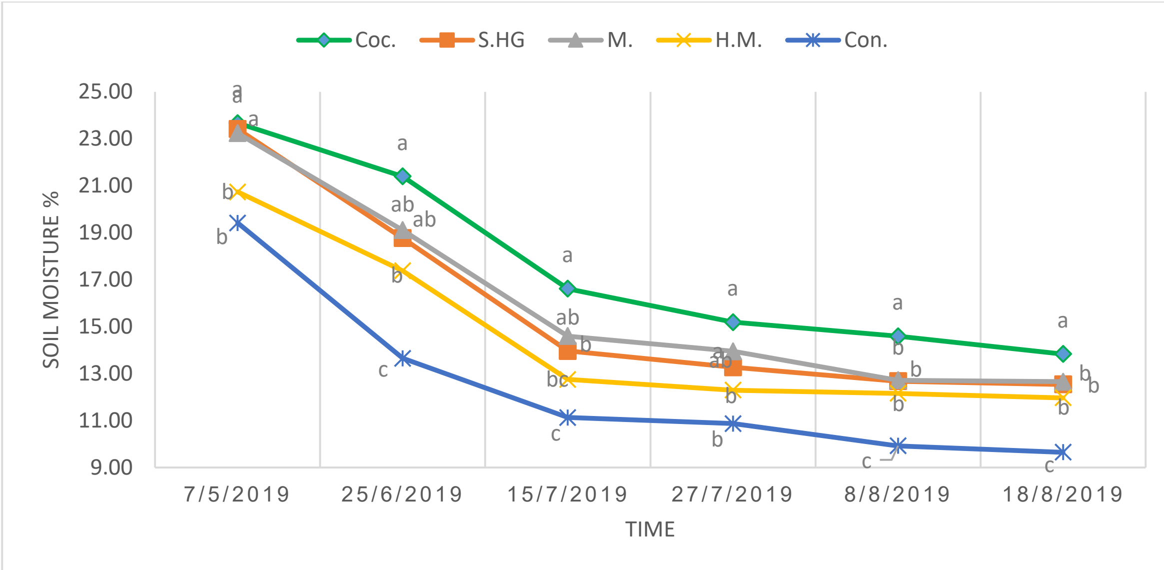

Figure (4): Average soil moisture content for the examined treatments (vertical comparison) in almond and plum site during the period from May-2019 till Aug-2019. Cocoon (Coc.), mulch (M.), superabsorbent hydrogel (S.HG), half-moon (H.M) and control (Con.) treatments.

Basically, the highest soil moisture values were observed in cocoon, superabsorbent hydrogel (S.HG) and mulch in May and June were the difference was insignificant among each other, but it was significantly higher than that in control and half-moon (HM) treatments (Fig. 4). Starting from the end of-June, a sharp decrease in soil moisture was observed in all treatments, at 18th of August all of the water conservation treatments were significantly have a higher soil moisture than control, where the cocoon treatment has significantly the highest SMC (13.83%) compared with mulch (12.66%), S.HG (12.54%) and H.M. (11.97%).

4.3. Almond results.

4.3.1. Increase in plant height.

The results showed a significant difference between the treatments in the average increase in plant height and it was significantly highest for the cocoon treatment (22.75 cm), followed by mulch treatment (14.5 cm) (Fig. 5).

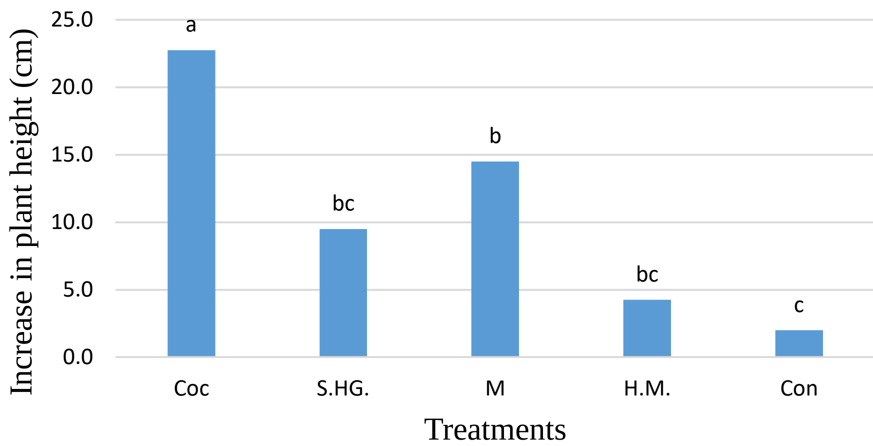

Figure (5): The average increase in almond seedling height (plant height vertically). Cocoon (Coc.), mulch (M.), superabsorbent hydrogel (S.HG), half-moon (H.M) and control (Con.) treatments.

Furthermore, there was insignificant difference between the S.HG (9.5 cm), the H.M. (4.3 cm) and control (2 cm).

4.3.2. Increase in stem diameter.

Regarding the plant stem diameter there was significant effect on the average increase in stem diameter due to the treatments in almond seedlings (Fig. 4.4).

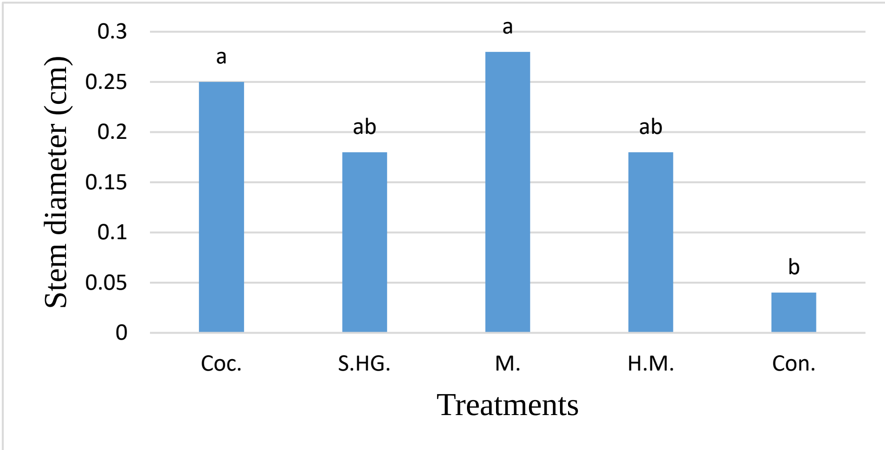

Figure (6): The average increase in stem diameters for Almond seedlings, at 1 cm above the grafting point. Cocoon (Coc.), mulch (M.), superabsorbent hydrogel (S.HG), half-moon (H.M) and control (Con.) treatments

Mulch and cocoon treatments presented the highest increase in stem diameter (0.28 cm and 0.25cm respectively) followed insignificantly by the H.M and S.HG that revealed the same results (0.18 cm). However, the control revealed significantly the lowest value.

4.3.3. Total branches length.

Total branches length was significantly affected by the treatments (Fig. 7).

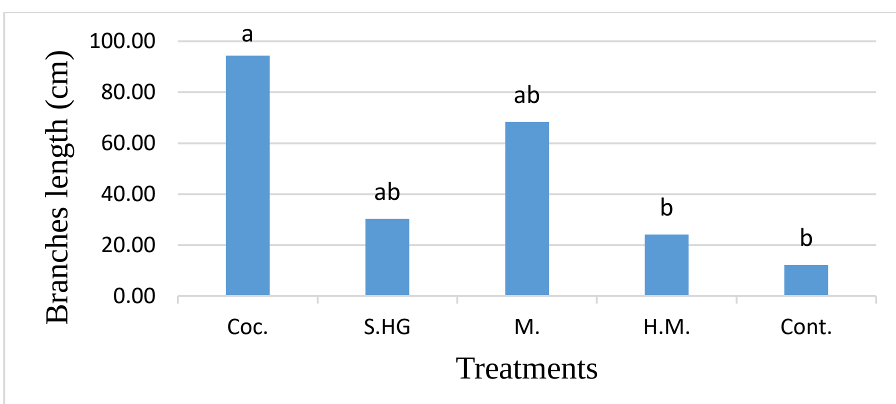

Figure (7): The average branches length for almond seedlings. Cocoon (Coc.), mulch (M.), superabsorbent hydrogel (S.HG), half-moon (H.M) and control (Con.) treatments.

Cocoon showed the highest value for the average total branches length and it was significantly higher (94.33 cm) than H.M and control. H.M and control presented insignificantly lower values than the mulch and S.HG treatments.

4.3.4. Leaf area.

The highest value was revealed by the cocoon (4.83 cm^2), followed insignificantly by S.HG, mulch and H.M (4.61, 3.86, and 3.32cm^2, respectively). On the other hands, the result showed significantly higher average leaf area than the control that revealed the lowest value (1.7 cm^2) (Fig. 8). Also, the H.M and the control treatments showed insignificant difference.

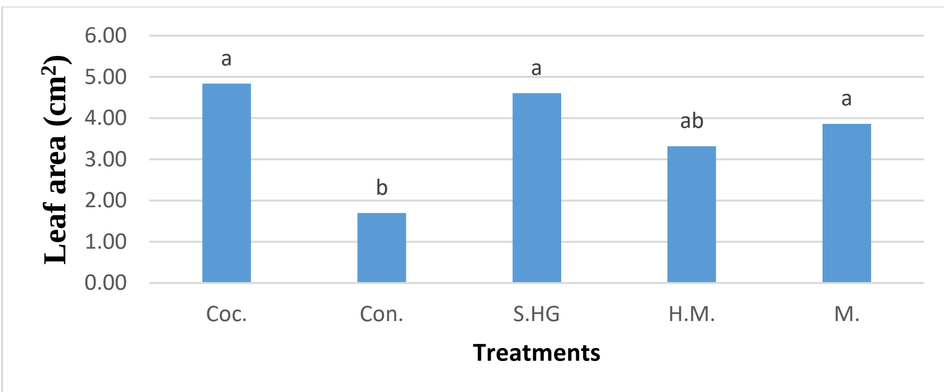

Figure (8): The average leaf area of almond per one leaf. Cocoon (Coc.), mulch (M.), superabsorbent hydrogel (S.HG), half-moon (H.M) and control (Con.) treatments.

4.3.5. Survival rate.

The results showed that cocoon technique superior the other treatments in term of survival rate (fig. 9), where 66.7% of the almond seedlings were survived by the end of September/2019. Black plastic mulch followed cocoon and it revealed 40% survival rate until the end of September/2019, while H.M and S.HG. have only 13.3% survival rate for both. Moreover, the sharpest decline in survival rate was recorded for the control, where most of the seedlings were died in the beginning of May (20% survived) and all of them were died in August. Generally, most of the death in almond seedlings for all treatments except cocoon was occurred before June/2019, after that time the survival rate dropped slowly for all treatments (Fig. 9).

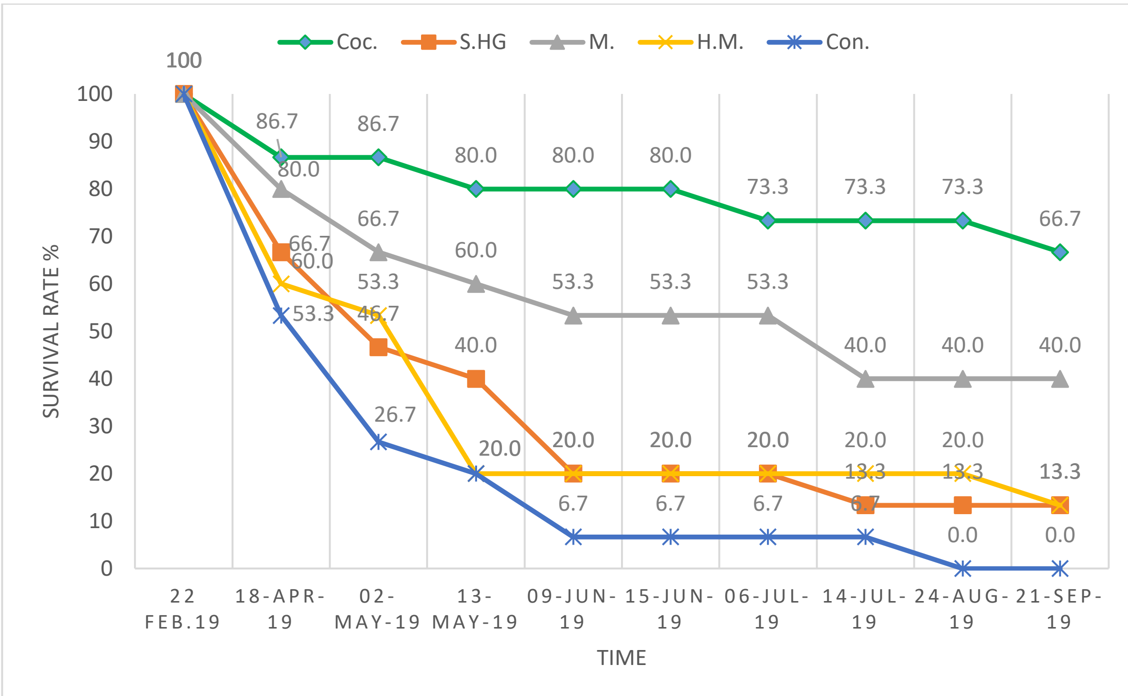

Figure (9): The survival rate in almond seedlings, (vertical comparison). Cocoon (Coc.), mulch (M.), superabsorbent hydrogel (S.HG), half-moon (H.M) and control (Con.) treatments.

4.4. Plum results.

4.4.1. Average increase in plant height.

The cocoon showed significantly the highest increase in the average plant height (35.33 cm) followed by S.HG, mulch, H.M and control (10 cm, 9.67cm, 6.67cm, and 0.67cm respectively) which have no significant variation among each other (Fig. 10).

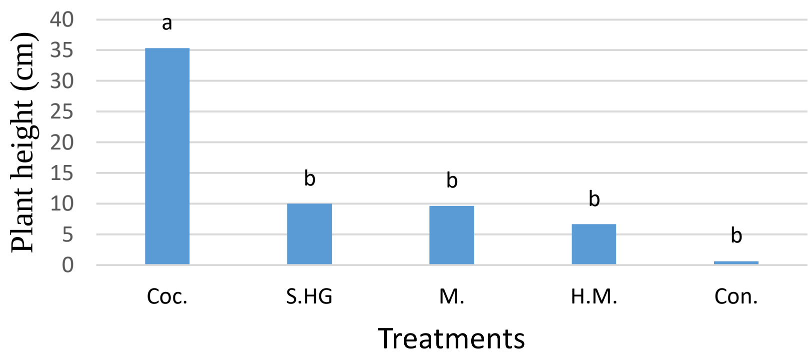

Figure (10): Average increase in plant height (cm) of plum seedling. Cocoon (Coc.), mulch (M.), superabsorbent hydrogel (S.HG), half-moon (H.M) and control (Con.) treatments.

4.4.2. Average increase in stem diameter.

Regarding the increase in plant stem diameter the results showed a significant effect due to the treatments (Fig. 11).

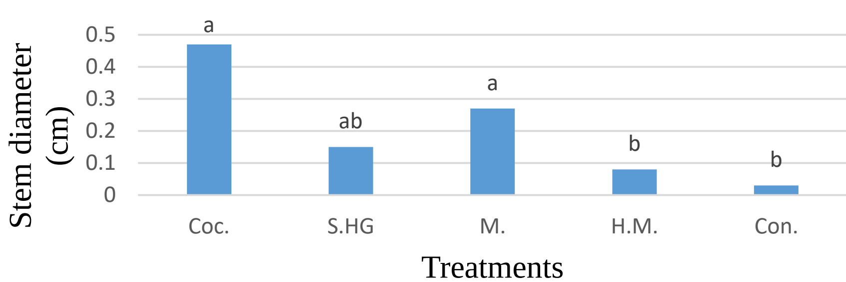

Figure (11): The average increase in stem diameter for plum seedlings, at 1cm above the grafting point. Cocoon (Coc.), mulch (M.), superabsorbent hydrogel (S.HG), half-moon (H.M) and control (Con.) treatments.

The cocoon and mulch treatments showed significantly higher increase in the average stem diameter (0.47cm, and 0.27 cm, respectively) compared with the H.M. and control treatments.

4.4.3. Total branches length.

The total branches length was significantly affected by the treatments (Fig. 12).

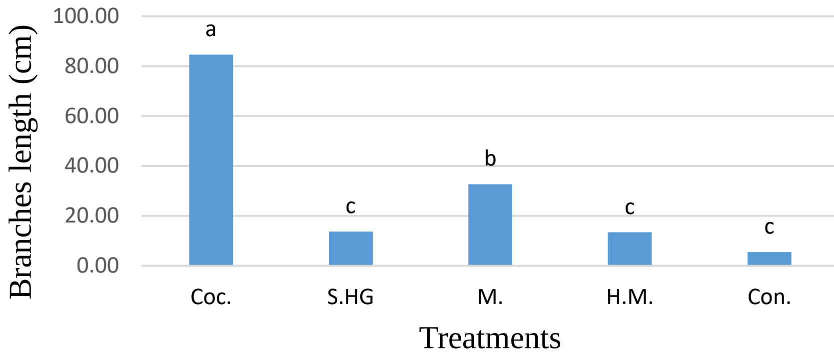

Figure (12): Total branches length in plum experiment per seedling. Cocoon (Coc.), mulch (M.), superabsorbent hydrogel (S.HG), half-moon (H.M) and control (Con.) treatments.

The average total branches length in cocoon treatment (84.60 cm) where showed significantly higher than other treatments, followed by mulch (32.67 cm), which also showed significant differences with S.HG, H.M. and control (13.67, 13.40 5.47 cm, respectively).

4.4.4. Leaf area.

Regarding the leaf area, the cocoon treatment resulted in significantly the highest average leaf area (9.41 cm^2) compared with other treatments (fig. 13). However, superabsorbent hydrogel, H.M. and control presented the lowest values of leaf area without significant differences between them (Fig. 13).

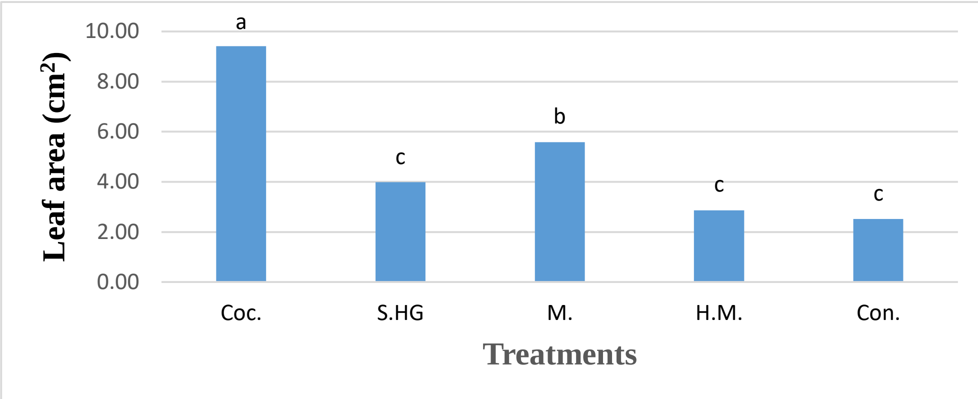

Figure (13): Average plum leaf area (cm^2) in each treatment. Cocoon (Coc.), mulch (M.), superabsorbent hydrogel (S.HG), half-moon (H.M) and control (Con.) treatments.

4.4.5. survival rate.

Our results showed that generally a sharp decrease in survival rate was started directly after planting for all treatments (fig. 14) until the beginning of May.

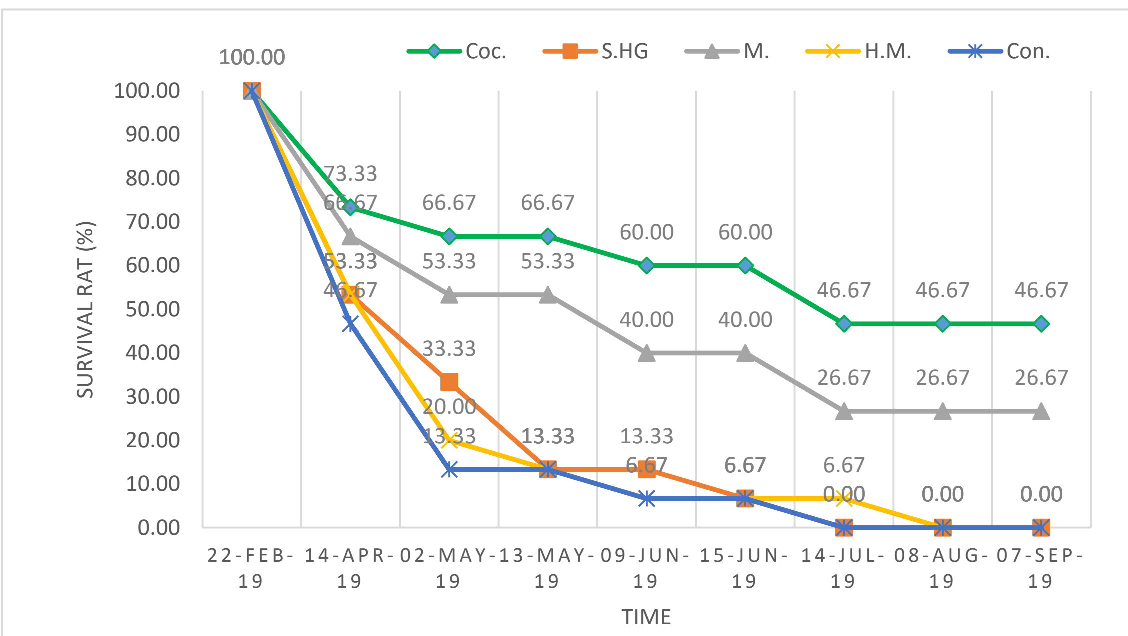

Figure (14): Plum seedling survival rate (vertical comparison). Cocoon (Coc.), mulch (M.), superabsorbent hydrogel (S.HG), half-moon (H.M) and control (Con.) treatments.

Although cocoon showed the highest survival rate, followed by mulch through all experimental period. In September, 46.67% of the plum seedlings were survived in the cocoon treatment and 26.67% in mulch treatment (Fig. 14). It was notable that survival rate testified a sharp decline in control, S.HG. and H.M. where they almost lost about 50% of the seedlings in April, while the values of survival rate in cocoon and mulch were dropped gradually. Moreover, all the plum seedlings were died at mid-July for control and S.HG. treatments and in August for H.M. treatment.

Chapter Five

5. Discussion.

The limited water resources and lack of accessibility to the ground water in some parts of the world perform a serious challenge for agriculture and development in arid and semiarid areas (Yazar et al., 2014). For that, the development of water harvesting and water conservation techniques is crucial practice to benefit from the rain water that could be lost due to the surface flow or evaporation. Indeed, use of water harvesting techniques and water conservation encourage the rain-fed agriculture and reduce the pressure on the scarce freshwater resources (Yazar et al., 2014).

Some of the most important purposes of using soil moisture conservation techniques, that it used as measures for achieving greater water efficiency to enhance plant growth and produce more food with less water (Al-Seekh and Mohammad, 2009; Kumari and Singh, 2016; Safi and Mohammad, 2019); Moreover, to increase the period of moisture content in plant root zone after water harvesting (Al-Seekh and Mohammad, 2009; Kumari and Singh, 2016); to conserve the soil from erosion, moisture deficit and loss of fertility (Saeed et al., 2019); to increase the survival rate of seedlings (Abedi-Koupai and Asadkazemi, 2006); and to reduce water losses by runoff and evaporation while maximizing soil moisture storage for crop production (Gachene et al., 2019).

5.1. Soil moisture content.

Insufficient water in the new orchards of stone fruit cause slowing of vegetative growth in which maximum growth is needed to speed up the development of the orchards canopy. Hence, the measuring soil moisture is one of the most important criteria that must be done, due to their relation with the direct development of plant growth and its apparent effect on accelerating vegetative growth and increasing the size of root system, which is reflected on all plant physiology (Pérez-Pastor et al., 2014). In addition, knowing the soil moisture is essential to determine the suitable time for supplemental irrigation for the seedling.

In spite of the high rainfall during the study year (621 mm), the rain was distributed unevenly, where the heavy rain during short times was obvious (40% of the rain was fallen heavily in three separated days). On the other hands, temperature records showed that the lowest degree was recorded in January 2019 (8.1 ºC) and the maximum in August 2019 (32.9 ºC) (Palestinian Astronomical Society, 2019).

Hereafter, the atmospheric and soil temperature play its role in accelerating moisture evaporation from the surface layer (Yang et al., 2018). Moreover, evapotranspiration is accelerated by high temperature which may lead to low water use efficiency (Gesch at al., 2016).

The variation in soil moisture content among the soil moisture conservation techniques that were under investigation in this study may be due to the differences in the mechanism of moisture conservation for each technique used (amount and duration of moisture that they can keep (Oweis et al., 2001). The superiority of cocoon, mulch and S.HG over H.M and control through the study period might be related to the fact that the half-moon only works as a water harvesting technique, and there is no mechanism to reduce evaporation.

Despite that, half-moon showed a higher soil water content value than the control, which could be due to its ability to collect more water in the storage area (soil profile) and thus longer time to evaporate (Tamagnone et al., 2020). Another possible explanation for the dominance of cocoon, mulch and S.HG over H.M and control is the soil type, where the heavy clay soil in our experiment site is able to form a deep cracks when it dries (Whitmore and Whalley, 2009) which encourage water evaporation from the soil especially in the absence of soil moisture conservation techniques (Fattah et al., 2018).

The superiority of cocoon treatment (Fig. 4) is related to the fact that soil water loss by evaporation from soil is reduced by this technique due to the design of the cocoon that composed from covered basin inside the soil that surrounding the plant roots, which also prevent growth of weeds near the seedling base (Petros et al., 2021). In addition, cocoon can preserve the water from loss due to many factors like temperature, wind and rapid infiltration (Union of Agricultural Committee (UAWC), and Fanack and Land Life Company (LLC), 2017; Land Life Company (LLC), 2015; Abdullah, 2017; Tapia et al., 2019). Furthermore, the cocoon supplies water to the soil slowly and continuously via extended wick that passes from the water basin of the cocoon to the seedling root zone and transport the water by the capillary action (Tapia et al., 2019).

The slight variations among the cocoon technique and mulch until the end of July might be due to the ability of the mulch to work as protective layer to cover the top of the soil (Bahadur et al., 2018), to protect it from being eroded, regulate soil temperature, reduce evaporation, and thereby conserve soil moisture in the upper layer of soil beneath the mulch (Jabran 2019; Pang 2010). While in case of cocoon, there is a large amount of water is supplied to the cocoon structure in addition to the rain water that normally infiltrated to the soil profile around the structure.

Our results showed that S.HG treatment kept relatively high amount of soil moisture until June /2019, after that it started to decrease to below 19% (Fig. 4). Similar results were found by Bordado & Gomes, (2007); Nirmala & Guvvali, (2019); Liao et al (2016) and Demitri et al. (2013) were their results showed that the S.HG retained water during the rainy season and more than 90% of the absorbed water by S.HG was available to plant roots (Bordado and Gomes, 2007; Nirmala and Guvvali, 2019), then the soil starts drying and in parallel the S.HG starts gradually releases the retained water to the soil (Liao et al., 2016) through the diffusion mechanism (Demitri et al., 2013), which may explain the closeness of the S.HG soil moisture values in the period between April and the end of June/2019 (Fig. 4). Furthermore, the efficacy of S.HG during the first duration of the experiment could be related to the soil type, where S.HG is reported By Yu et al. (2017) to be more efficient in the clayey soil (higher water preserving). Also, Yu et al., (2017) found that the S.HG that mixed with fine textured soil that include 18.5% -34.4 % clay content preserved 51% higher water content than loamy sand soil (7.5%-12.5% clay content). Additionally, soil pH could affect the S.HG water preservation capacity due to the fact that when soil pH around 7 or little bit above revealed the best efficacy for S.HG (Dehkordi, 2016) which fit with the pH result in our experimental site (pH= 7.86). Later, the decline of the S.HG soil moisture values that appeared clearly at the beginning of July/2019 might be related to the lack of the function of S.HG as a water retaining aid for irrigation due to the absence of supplementary irrigation (Nnadi and Brave, 2011) which upon time leads to desorb the water from the S.HG particles to the soil until they dry together as a result of the high temperature and evaporation rate (Bakass et al., 2002).

In addition to many factors that may accelerate the loss of the conserved water from S.HG material and it's biodegradation, such as time of application and the amount and types of S.HG that added to the soil (Dehkordi, 2016; Nirmala and Guvvali, 2019). Moreover, temperature, pH and light may influence the S.HG efficacy (Siyamak, 2020; Abu Ghyadah and Alokely, 2021) and lead to S.HG biodegradation through collapse of hydrogels network via erosion and bacterial activities (Thombare et al., 2018) and cause breakdown of the polymer into smaller fragments and ultimately loss of functional properties in these materials (Mignon et al., 2019; Siyamak, 2020).

5.2. Plant growth parameters for almond and plum.

Plant growth parameters are commonly used by the researchers in order to evaluate the plant response to the environmental conditions (Jalili et al., 2011) or to the experimental treatments (Hunt et al., 2002). In our experiment four parameters for almond and plum were evaluated and studied, including plant height, stem diameter, total branches length and leaf area. These parameters are controlled by the plants genes and could be variously affected by biotic and abiotic stresses (e.g. drought, high temperature and salinity stress….. etc.). The significant differences within the growth parameters during the experiment life span could be related to the wide-range impact of the under investigation treatments on soil moisture content, water absorption (Yu et al., 2017), nutrients availability (Macci et al., 2012), soil physical, biological and chemical properties (Ramos et al., 2009) and roots distribution (Ighbareyeh et al., 2018).

As soil water conservation techniques (cocoon, mulch and S.HG) work to increase the soil water content available to plants, accordingly, this increase in the content of plant available water can, under conditions of climate change, mitigate abiotic stress; and then improve plant growth compared with other treatments.

Dehkordi (2016) reported that high soil moisture causes an increase in nutrient absorption and osmotic moisture of soil and decrease in transplanting stresses that ultimately cause improvement in plant growth parameters.

5.2.1. Plant height.

Our results showed, that the highest increase in the height of almond (22.75 cm) and plum (35.33 cm) seedling was in cocoon treatment, this might be related to the higher moisture content (Abdullah, 2017). The higher moisture content facilitates the nutrients absorption, which lead to better plants growth (Bakass, 2000; Kargar, 2017; Nirmala and Guvvali, 2019).

The reduction in seedlings height in (control, half-moon and S.HG treatments) could be related directly to the drought effect, where the control treatment had significantly lower soil moisture than cocoon and consequently the control treatment showed the lowest increase in almond and plum seedlings heights (2, and 0.67 cm, respectively). Moreover, moisture shortage reduces cells elongation and growth. Accordingly, the xylem and phloem vessels could be blocked up which obstructing the translocation process in the plant (Oraee and Moghadam, 2013).

In our experiment the plant height was significantly affected by soil moisture level. Indeed, drought stress and soil moisture reduction led to decrease the water potential to a lower level that is required for cell elongation and consequently shorter internodes and stem height (Oraee and Moghadam, 2013).

5.2.2. Stem diameter.

Measuring of stem diameter is one of the main important parameters that indicates the influence of the examined treatments on plants. Regarding the stem diameter, the highest values that were revealed by mulch and cocoon in almond (0.28, 0.25 cm, respectively) and in plum (0.27, 0.47 cm, respectively) were associated with higher soil moisture content in these two treatments compared to the other treatments. Gohari et al. (2021) studied the effect of different levels of drought stress on different varieties of almond seedlings and found that seedlings that were subjected to sever drought stress revealed lower stem diameter.

Stem diameter is one of the plant growth indices were measured to determine the effects of deferent soil moisture conservation techniques. Our results showed that stem diameter significantly affected by soil moisture levels as shown in mulch and cocoon treatments (Fig. 6 and 11) where they showed the highest stem diameter respectively, which is associated with the highest soil moisture content in almond and plum experiments, notably, in our experiment the reduction in soil moisture content in all treatments was accompanied with reduction in stem diameter, which associated with it, Nezami et al. (2008) reported that the decrease of soil water content to 60 and 30% field capacity (FC) caused a 20 and 46% respectively reduction in stem diameter, as compared to the control.

5.2.3. Total branches length.

The length of the first major lateral branches from the main stem is a convenient measure for distinguishing a laterally spreading from a vertically growing stem (Archibald and Bond, 2003).The highest average total new branches length in almond and plum were shown in Cocoon (94.33 and 84.60 cm respectively) and mulch (69 and 32.67 cm respectively) treatments, which can be explained as the effect of high soil moisture which lead to reduce the effect of abiotic factors such as soil cracking and high temperature (Stapleton et al., 1993; Whitmore and Whalley, 2009; Raza et al., 2019). This also explains the lowest branches length growth in control treatment 12.17 cm in almond and 5.47 cm in plum.

Many studies were reported that the longitudinal growth of branches in young almond seedlings was highly affected by the different genotypes and morphological trails which have different response to drought stress (Gohari et al., 2021). Or even at the level of difference in irrigation intervals, as shown in Zamani et al. (2002) study on different irrigation regimes on almond seedlings, where their results appeared that plant growth (include branches length) reduced with increase the intervals between irrigation times.

5.2.4. Leaf area.

All treatments in almond study showed significantly higher leaf area than control except H.M treatment (Fig. 4.6, 4.11). This might be due to that almond generally considered drought tolerant (Westwood, 1993) and the treatments provide the necessary amount of moisture for the almond seedlings. In addition, Zokaee-Khosroshah et al. (2014) reported that the almond leaves area response to drought stress is varied among the almond species. While the high significant values of cocoon (9.41 cm^2) in plum compared with other treatments may be due to sensitivity of the plum to drought stress and the effects of the examined techniques in increasing the soil moisture content, where plum characterized by shallow root system, therefore it requires well drained and aerated soil with good water holding capacity for growing (kim, 2008). Keeping in mind that the reduction in leaf area is one of the avoidance mechanisms that is utilized by the plants to reduce water loss (Gikloo and Elhami, 2012).

The level of drought stress might have great effects on leaf area of fruit trees. Zokaee-Khosroshah et al. (2014) found a significant variation in the total leaves area as a result of drought stress effect. leaf area decreased by increasing the drought and water stress (Daneshmandi and Azizi, 2008; Hu et al., 2020). According to Romero et al. (2004) the Leaf area at the time of maximum stress was significantly lower for water-stressed trees than unstressed trees in other treatments. which could be related to the reduction of water uptake in the leaves cytoplasm, which consequently minimize cell expansion and thus leaf area (Parkash and Singh, 2020).

Moreover, reduction of the leaf area in fruit trees is one of the main factors that cause reduction in photosynthetic process (Marino et al., 2018). Nortes et al. (2009) reported a significant reduction in the photosynthetic capacity of young branches of almond trees under mild to moderate soil water deprivation. Not only that, but also water stress directly disturb the photosynthetic process by damaging the chloroplast membrane and disturbing the hormonal and chemical activities in the plant cell (Parkash and Singh., 2020). Moreover, the heat stress that accompanies the drought stress leads to increase the leaf temperature (Udompetaikul at al., 2011), which also disturbs the photosynthesis process (Karimi at al., 2015).

5.3. Survival rate for almond and plum.

Usually, most of the seedlings mortality occurred during the initial life stage of orchards establishment due to many stress factors (Grossnickle, 2005).

In our study the superiority of cocoon technique in almond and plum experiment in term of survival rate (66.8%, 46.67%, respectively) until Aug-2019 is directly related to the higher soil moisture content (Fig. 4.1), and this results are in agreement with (Petros et al., 2021). Moreover, control, H.M and S.HG treatments survival rates declined sharply starting after May/2019 (Fig.

9+14), this could be interpreted by the lower soil moisture content in these treatments.

Environmental factors are the most important that may lead to seedling mortality such as high temperatures, drought, water stress.... etc. Also, root diseases could reduce the survival rate after transplanting, in addition to the poor agricultural practices (Grossnickle and El-Kassaby, 2015). Macera et al. 2017 indicated that the seedlings after 10 months from transplanting could become more tolerable to unfavorable conditions with less mortality and may develop a root system that has a better capacity to absorb nutrients and water from the soil.

The decrease of the survival rate to about less than 80% in all treatments in the two experiment (almond and plum) just in the first three months after planting although soil moisture content is still high could be explained by the bare rooted seedling that was used in our experiment. Grossnickle and El-Kassaby (2015) were reported that the survival rate in bare-root seedling was 10 % to 20 % lower comparing with container seedlings). Moreover, many studies revealed that container seedlings were more tolerant to water stress (Mena-Petite et al., 2004; Rose and Haase, 2005; Jutras et al., 2007), planting stress (Gwaze et al., 2006; Wilson et al., 2007), also, it is showed more tolerant to the environment harshness (Rodrı´guez-Trejo and Duryea, 2003; Renou et al., 2007; Wilson et al., 2007) more than bare-root seedlings directly after planting. The tested soil in our experimental site was clayey soil that contains 53.31% clay, 31.05% sand, and 15.64% silt; it’s high clay minerals content and heavy textured, in such soil, low soil moisture causes deep cracking in the soil (NovaAk, 1999; Whitmore and Whalley 2009). Also, Haghnazari et al. (2015) indicated that cracks volume increased as far as the soil get dryer. Indeed, soil cracks increase surface evaporation and make the soil more influenced by the air temperature (Song et al., 2016). Furthermore, the root may be snapped due to high cracks expands force (Whitmore and Whalley, 2009). In techniques subjected to higher water loss from the soil such as control, H.M., and S.HG. which were lower than that in cocoon and mulching techniques that lead to less mortality as a result of decreasing evaporation and conserving soil moisture content for long period.

Chapter Six

6. Conclusions.

1- Under semi-arid conditions, the soil moisture conservation techniques and water harvesting techniques can improve the survival rate and plant growth in fruit trees seedling by using the suitable technique.

2- The need for irrigation for fruit trees seedling that planted under control and water harvesting technique (half-moon) treatments started from April (last rains), and due to increase the mortality through the summer should continue irrigation until first rains next season. The suitable time for irrigation mulch treatment start from beginning of May. While the cocoon may only need filling the basin one time more in mid of June to keep the survival rate more than 80% in case of bare-root seedling.

3- For almond and plum, Cocoon is highly recommended in such environmental conditions due to the fact that this technique revealed the highest results in term of SMC, survival rate and growth parameters.

4- Also, black plastic mulch revealed good results and it could be recommended in such environmental conditions due to the lower time consuming, lower implementing efforts and lower cost.

5- The hydrogel materials are not efficient in the drought conditions in the absence of supplementary irrigation, or according to the usage instructions of the producer.

6- Further studies are needed to evaluate the effects of these techniques on fruit trees seedling in bags or containers.

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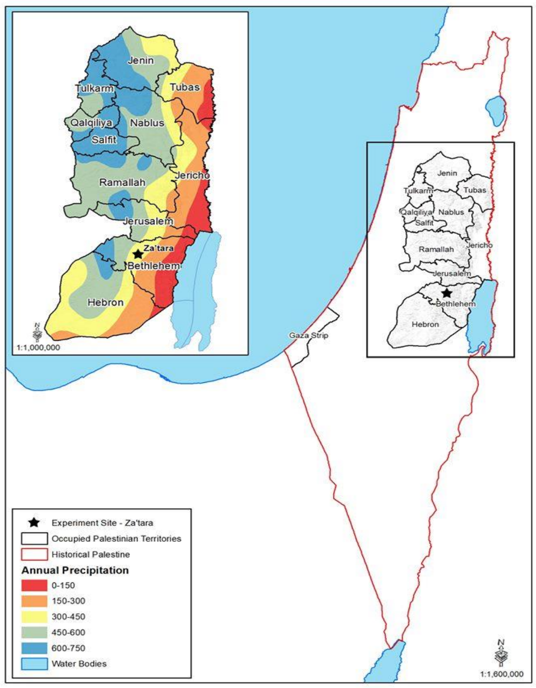
Appendices.

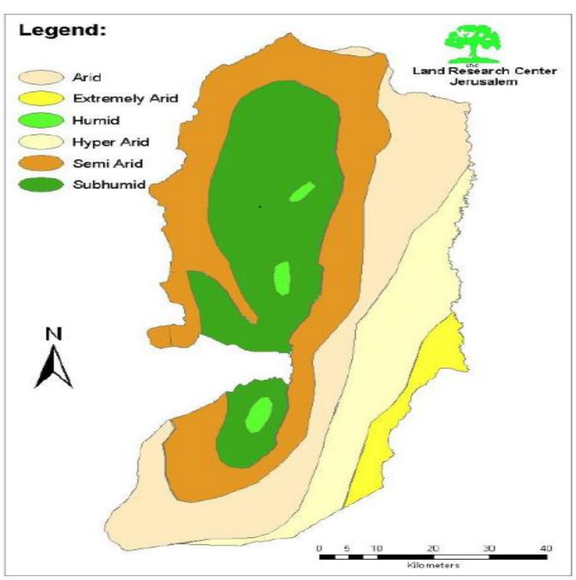
Appendix A:

Zones of annual precipitation in West Bank /Land Research Center (LRC) GIS and remote sensing data basis.

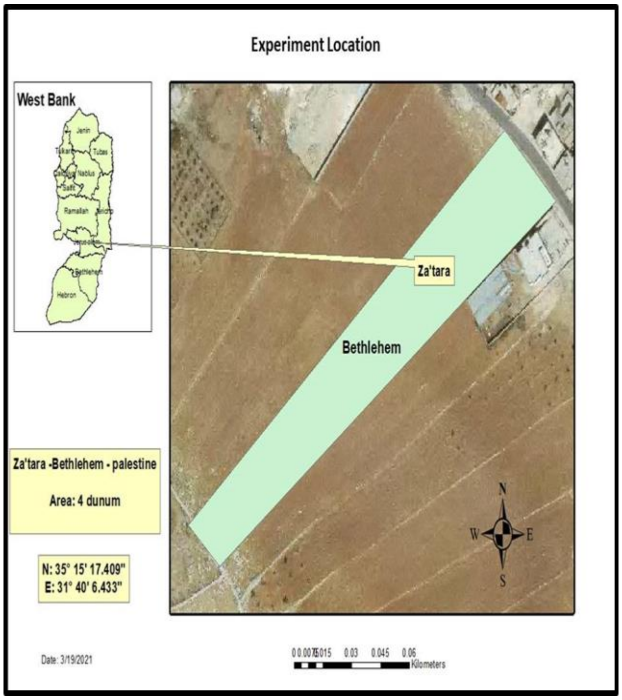


Appendix B:

Climate classification of the West Bank Source: ClimaSouth Technical Paper No.2 -the economics of climate change in Palestine (2017)- Prepared by (Tippmann and Baroni, 2017).



Appendix C: Study site, Za'tara village (GIS Photo).



Appendix D:

Show photos for the treatments that applied at the field, land preparation and planting.

Photo 1. Cocoon installation

Photo 2. Land planning

Photo 3. Half-moon

Photo 4. Plastic mulch installation.

Photo 5: Superabsorbent hydrogel material.

Photo 6. Commercial form for S. HG material

Photo 7. The marker 1 cm above the grafting

Photo 8. Leaf area measuring instrument

Appendix E:

The soil mineral content of experimental site.

Nitrogen N	Nitrate NO3-	Phosphorus p	Calcium Ca	Magnesium Mg	Potassium K+	Zinc Z	manganese Mn
g/kg soil	%	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)
3.15	15.39	39.07	1844	227.15	275.36	2.32	51.33

Abstract in Arabic

الملخص باللغة العربية

تأثير تقنيات حفظ رطوبة التربة على نمو بعض اصناف اشتال الفاكهة وقدرتها على النجاة

نفذت هذه الدراسة في بلدة زعترة الواقعة في المنحدرات الشرقية لمدينة بيت لحم خلال العام 2019/2018. تصنف منطقة الدراسة على أنها شبه جافة. تهدف الدراسة إلى تقييم ومقارنة تأثيرات استخدام تقنيات مختلفة تحفظ رطوبة التربة، على أشتال اللوز والبرقوق تحت الظروف شبه الجافة.

أجريت هذه الدراسة باستخدام تصميم عشوائي كامل (CRD) في تربة طينية. تم اختبار أربع تقنيات للحفاظ على رطوبة التربة بالإضافة للشاهد (الشرنقة، بوليمرات فائقة الامتصاص، غطاء بلاستيكي أسود، الهلاليات) لقياس تأثيرها على معدل البقاء على قيد الحياة، ارتفاع النبات، قطر الساق، مساحة الأوراق، طول فروع اشتال اللوز (*Prunus amygdalus var.* Um Al-Fahm) والبرقوق (*Prunus salicina var.* Santa Rosa)بالإضافة إلى محتوى رطوبة التربة خلال السنة الأولى بعد زراعة الأشتال في الأرض الدائمة.

في البداية لم تظهر النتائج في شهر أيار/2019 أي فروق معنوية في قراءات رطوبة التربة بين تقنيات الشرنقة والغطاء البلاستيكي الأسود والبوليمرات فائقة الامتصاص. إلا ان تلك التقنيات تفوقت معنويا على تقنية الهلاليات والشاهد. ومع ذلك، فقد كانت تقنية الشرنقة هي الأعلى خلال فترة التجربة إلى أن أصبحت هي الأعلى معنويا مقارنة بكل المعاملات في شهر آب/2019.

بالنسبة للوز، أظهرت نتائج هذه الدراسة تأثيرا إيجابيا معنويا لجميع معاملات حفظ رطوبة التربة مقارنة مع الشاهد، حيث تفوقت تقنية الشرنقة على المعاملات الأخرى من حيث معدل البقاء (66.8٪) تليها تقنية الغطاء البلاستيكي الأسود (40٪). بالنسبة لارتفاع النبات، كانت أعلى زيادة ناتجة عن استخدام تقنية الشرنقة (22.75 سم) تليها معاملة التغطية بالغطاء البلاستيكي الأسود (14.5 سم). كما ان استخدام تقنية الشرنقة أعطى أقصى قيمة لطول الفروع (94.33 سم)، تليها تقنية الغطاء البلاستيكي الأسود (68.30 سم). كان قطر النبات هو الأعلى بالنسبة لتقنية الغطاء البلاستيكي الأسود تليها معاملة الشرنقة (0.28 سم و0.25 سم على التوالي). كما أن تقنية الشرنقة اعطت أعلى مساحة ورقة (4.83 سم^2) تليها تقنية البوليمرات فائقة الامتصاص، والغطاء البلاستيكي الأسود، ثم الهلاليات (4.61، 3.86 و3.31 سم^2 على التوالي) وذلك دون أي فروق معنوية بينها.

عموماً، كان هناك تقارب كبير في نتائج البرقوق واللوز لمعدلات البقاء، وارتفاع النبات، وقطر النبات، وطول الفرع للمعاملة التي تم فحصها، اما مساحة الأوراق فأن تقنية الشرنقة أعطت (9.41 سم^2) وتحتل اعلى قيمة بفروق معنوية مقارنة بجميع التقنيات الأخرى.

في الختام، بالنسبة للوز والبرقوق، يوصى بشدة استخدام الشرنقة في مثل هذه الظروف البيئية نظرًا لحقيقة أن هذه التقنية كشفت عن أعلى نتائج من حيث نسبة رطوبة التربة ومعايير النمو ومعدل البقاء على قيد الحياة.

أيضًا، أظهر الغطاء البلاستيكي الأسود نتائج جيدة ويمكن التوصية لاستخدامه في مثل هذه الظروف البيئية نظرًا لأنها بحاجة الى اقل وقت وجهد للتنفيذ وانخفاض التكلفة.

الكلمات المفتاحية: شرنقة، هيدروجيل فائق الامتصاص، غطاء بلاستيكي اسود، هلاليات، معدل البقاء على قيد الحياة لأشتال اللوز والبرقوق، معايير نمو أشتال اللوز والبرقوق.