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College of Graduate Studies & Academic Research

The Effects of Different Vegetation Cover on Runoff and Soil Erosion

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Dedication

I dedicate this thesis to my great parents, without there endless love and trust I would have never been able to study.

Acknowledgement

For his supporting me with power, patience, and help to preparation of this thesis, I would thank my God.

I am deeply indebted to my supervisor Dr. Ayed Mohammad for his trust, tireless support in hard time, patient proofreading of this entire thesis. Without his help and encouragement, this work would not be possible. In a similar way I would like to thank members of my committee whom attended my defense: Dr. Yousef Amro and Dr. Ahmad Hammad. Their advice and patient is appreciated.

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Abstract

In this study the effect of different vegetation types on runoff generation and soil erosion was investigated. The study was carried out about 10 Km to the North-West of Hebron city, at the western slopes of the Central Highland of West Bank. To understand the effect of different vegetation types on runoff and sedimentation five treatments were implemented; afforestation planted with *P, halepensis* (F), natural vegetation dominated with *S. spinosum* (W.S), natural vegetation where *S, spinosum* was removed (W/o.S), cultivated land (C) and deforestation (Df).The variables that were measured in each plot; runoff after each rainfall event, sedimentation at the end of the rainy season, chemical and physical soil properties, soil water content, in addition to plant cover, density, and biomass. the results indicated that there are significant and important differences in runoff generation and sediment production from different types of vegetation cover. Afforestation and natural vegetation dominated with *S.spinosum* treatments had the lowest amount of runoff with an average of 2.02 and 1.08 mm, respectively compared with other treatments. Removing *S. spinosum* were increased the total amount of runoff and sedimentation significantly compared with afforestation and with *S. spinosum* treatments. Also, on deforestation (DF) treatment the runoff (4.03 mm) increased significantly compared with afforestation. The highest amount of sedimentation was found in cultivated land and deforestation, compared with other treatments.

The fluctuation in soil water content was appeared during the two seasons. Afforestation and *S. spinosum* treatments have the highest percent of organic matter as well as the highest amount of soil water content

compared with other treatments. Removing the *S. spinosum* and deforestation decrease the soil water content at the two depths (15 and 30 cm).

The results showed that Afforestation and natural vegetation dominated with *S. spinosum* have a key rule in preventing or decreasing the risk of runoff and soil erosion.

Change in plant community was appeared after removing *S. spinosum*. The plant density, percent of herbaceous (grasses and forbs) cover and herbaceous biomass increased significantly after removing *S. spinosum* compared with natural vegetation dominated with *S. spinosum*. In addition, land cultivation increased the grasses and forbs biomass significantly, but not the plant density compared with natural vegetation dominated with *S. spinosum*.

Although, two years are insufficient time to evaluate the influence of removing *S. spinosum* on water runoff and soil erosion, due to high climatic variability and complex relationship between the factors that affect the amount of water runoff and soil erosion, but the result, herein can constitute the first step toward more detailed and future comprehensive studies to the benefit of the inhabitants at the study area.

Introduction

Palestine resides at the intersection between three continents, Africa, Asia and Europe and between different ecological zones, which make a unique variety in its ecosystem. In addition, the topography, climatic variation (rainfall, temperature and humidity), and human activity (such as overgrazing, fire and deforestation) affecting on the variety and form of natural vegetation in Palestine. However, despite the presence of different variety of ecosystem in Palestine, the mismanagement of the natural resources (such as soil, water and vegetation) and exposing these resources to sever damage (such as overgrazing, pollution deforestation and soil salinity) for a long period of time, lead to increase the risk of degrading of these resources.

As a result of soil erosion, runoff, loss of vegetation cover and pollution, Palestinian rangeland degradation was prevailed. Many studies showed that maintenance of suitable and stable vegetation cover decrease the risk of soil erosion, runoff and land degradation and improve the soil water conservation. Unfortunately, there is limited scientific data and information about the Palestinian rangeland characteristics.

Therefore, this study was conducted to investigate the influence of different vegetation cover on runoff generation and soil erosion at Soreif site which is located 10 Km North West of Hebron city.

Chapter One

Literature Review

1.1 Land Degradation

Land degradation is not a local problem, but it is a global phenomena. According to Global Environment Facility (2003), land degradation occurs in most of the countries of the world but it is especially serious in Africa where 36 countries face dryland degradation and desertification. The United Nation (UN), at the Convention to Combat Land Degradation (CCD) defined land degradation as reduction or loss of the biological and economic productivity and complexity of terrestrial ecosystems, including soils, vegetation, other biota, and the ecological, biochemical and hydrological process that operate therein, in arid and semi-arid lands, resulting from various factors including climatic variations and human activities.

The main causes of land degradation includes: inappropriate land use, mainly unsuitable agricultural practices, overgrazing, and deforestation.

Vogiatzakis (2006) studied the Mediterranean ecosystem and concluded that all Mediterranean – type ecosystems are susceptible to degradation and species loss due to human activity, which include deforestation, the expansion of pastoral agriculture, the loss of arable agriculture in some regions, urbanization, tourism, pollution and the introduction of alien species and difficulties of agreeing and implementing conservation strategies because of complex land ownership and control.

1.1.1 Land degradation and overgrazing

Land Degradation consists of many components, each of which interlocks with many other components.

One of the most important factors that increase the risk of the land degradation is overgrazing. Overgrazing in a semiarid ecosystem affects both biotic and a biotic parameters that altering soil properties and plant community, which lead to land degradation and desertification (Zaady et al, 2001). Zaady et al, (2001) also reported that grazing have immediate effects on the plant community and habitat structure, the species density decreased, vegetation community composition was affected and exposed soil surface increased. Snyman et al, (2005) and Al-seikh (2006), they investigated the rangeland degradation in semiarid areas and they found that rangeland degradation usually leads to increase soil compaction due to decrease in plant cover, reduce aggregate stability, reduce soil fertility, and decrease the soil water content in all soil layers; due to higher runoff as a result of lower plant cover accompanying rangeland degradation. Moreover, McGinty et al, (1979) reported that the rangeland under heavy, continuous grazing had lowest infiltration rate and higher sediment loss than rangeland under the 4-pasture deferred – rotation grazing system or the livestock exclusive, which was related to differences in plant biomass and soil depth, and depression storage. In addition, decrease the canopy cover percentage as a result of overgrazing lead to rapid water erosion in rangeland which cause low productivity and decline in plant biodiversity of rangeland and lead to desertification by altering plant communities and soil properties. In Palestine, the rangeland covers about 32 % of the total area of West Bank and Gaza strip. These areas were exposed and still expose to sever overgrazing, which lead to decrease the forage production and dominated with unpalatable plant mainly *S. spinosum*, which is considered as an indicator for rangeland degradation (Mohammad 2000 and Al-Joaba 2006).

1.2 Natural Vegetation in Palestine

Geographical location of Palestine at the intersection between three continents, Africa, Asia, and Europe, and between ecological zones, Irano-Teranian, Mediterranean, Sahara Arabian, and Sudan (Zoohary 1948) make a unique variety in its ecosystem.

Palestine is included within the subtropical climate zone (Zoohary1948) designated by a rainy and mild winter and hot dry summer. This type of climate manifests in Palestine three well marked variants: Mediterranean, Steppa, and desert climate. The main ecological factor designating this variation is the amount of rainfall, ranging in the Mediterranean between 300 to 1000 mm, in the Steppa between 200 and 300, and in the Desert between 25 to 200 mm.

Topography, climatic variation, overgrazing, deforestation, and many other factors are affecting on the variety and form of natural vegetation in Palestine. The natural vegetation of winter (rainfall environment) belong to two main types: deep – rooted perennial trees or sclerophytous shrubs adapted to stand with the long summer drought,; and quick – growing annual grasses, legumes and other herbs capable of growing and produce seeds within the period of winter rainfall and lower temperature (Whyte, 1950). Natural resources especially soil, water and vegetation covers in Palestine exposed to sever damage such as: overgrazing, deforestation and fire for a long period of time as a result of absent or mismanagement for these resources especially during the occupation periods. All these factors increase the risk of loss the vegetation cover and soil, and so land degradation. Mohammad (2000) mentioned that the presence of high number of plant species at the West Bank as a result of variation in topography, rainfall and temperature. Also Mohammad (2005) and Al-Joaba (2006) found that the dominated species in the Southern part of West Bank are: *Sarcopoterium spinosum, Asphodelus aestivus, Eryngium crecum, Stiba bulbosa, and Anthemis spp and Bromus spp*. The rangeland condition at the Southern part of West Bank is poor because of sever erosion, low vegetation cover and presence of large percentage of weeds (*Sarcopoterium sp*) (Mohammad 2005). In addition, in two experiments carried out by Mohammad (2000 and 2005) to estimate the rangeland productivity and botanical composition in Southern Part of West Bank (Al-Dahria and Al-Samoo) he reported that the vegetation productivity was low, 98.5 $Kg.du^{-1}$ in Eastern slopes, 71.1 $Kg.du^{-1}$ in Al-Dahria and 92.9 $Kg.du^{-1}$ in Al-Samoo, also the plant cover percentage were: 83 %, 54 % and 57 % in Eastern slops, Al-Dahria and Al-Samoo, respectively. In addition, Al-joaba (2006) and Mohammad (2005), studied the natural vegetation characteristics at different environments and range improvement practices at Southern West Bank, and they identified about 115 different plant species, in addition, there is an increase in the poisonous and unpalatable plants in rangeland (Mohammad 2005). Al-joaba (2006), found that plant dry biomass and density decrease as a result of overgrazing in southern part of West Bank.

1.3 Soil Erosion

Soil erosion is considered the main land degradation process which enhances desertification and affects vegetation and thus soil regeneration. Soil erosion considered as a global problem because of its environmental consequences including sedimentation and pollution in many areas of the world. Effects of soil erosion may be divided into two categories on – site and out- site (off-site). On – site effects are important for agricultural field and causes breakdown of soil structure (Oztas et al., 2003), loss of fertile soil, loss of seedling and reduction of soil depth. Off – site effects include sedimentation downstream, salutation of reservoir, and contamination of drinking water supplies. The process of water – induce soil erosion includes the detachment of soil particles and then transports it by overland flow. Many factors affect the amount of surface water runoff such as rainfall intensity, slope gradient, and slop length; but generally the rainfall and slope length affected sediments concentration (Chaplot et al 2003).

1.4 Vegetation Cover and Runoff

Most rainwater falls on the soil, either directly or indirectly through stem flow or leaf drainage. A small part remains on the leaves (interception) and eventually evaporates. However, water that reaches the soil surface is stored (infiltrated) into the soil profile or travel downhill as surface runoff. The amount of water that infiltrate into the soil profile or go as runoff depend on many factors such as soil characteristic (Oztas et al., 2003), type of vegetation cover (Chirino et al., 2006) and root system (Gyssels et al., 2005). Several studies under different environmental conditions have demonstrated the positive effect of vegetation cover on the reduction of water erosion. A common method to decrease the water runoff generation and soil erosion is by maintaining a stable and suitable vegetation covers, to enhance soil stability in soil form, (Dunjo et al., 2004, Chaplot et al., 2003, Reid, et al 1999, Kothyari et al., 2004, Zhong et al., 2004, Tromble 1976, and Mohammad 2005).

After precipitation, some water intercepted by plant cover, and new spatial distribution of rainfall takes place due to the throughfull and stem flow pathways. Vegetation control soil erosion by means of its canopy, roots and litter components, but erosion also influence vegetation in terms of composition and structure of the plant community as well as growth pattern (Gyssels et al ., 2005). Loss of vegetation cover lead to formation of the soil seals that increase runoff and erosion through the early stages of seal development (Singer et al 1998).

The importance of vegetation cover in runoff and erosion control is appeared by many ways; such on the following:

1.4.1 Plant interception and surface runoff

Interception can be defined as the capture of precipitation by the plant canopy and its subsequent return to the atmosphere through evaporation or sublimation. The amount of precipitation intercepted by plants varies with leaf type, canopy architecture, wind speed, available radiation, temperature, and the humidity of the atmosphere. These phenomena (interception) decrease the risk of soil erosion and surface runoff through breaking the impact of raindrops and slowing overland flow and prevent raindrop splash and absorbing their energy. On the other hand, plant cover protects soil from erosive action of runoff water by offering resistant to the movement of water and shielding the soil from its effects.

Effectiveness of reducing soil splash is proportional to how much vegetation covers present at the time of rain occurs (Xin et al., 2004).

1.4.2 Type of vegetation cover and surface water runoff

The amount of surface water runoff and soil erosion is depending directly on the type of vegetation cover (forest land, shrub land, grass land, or combination between different types of plants). Vacca et al., (2000) studied the runoff and soil erosion in three areas under different land use (abandon grazing land, burened machia, and *Eucalyptus sp*), they found that there are different amount of runoff and soil erosion between the different land use were the highest runoff found under *Eucalyptus sp* (135 mm), followed by abandon grazing land (45.25 mm) and burned machia (30.45 mm). Also, Reid et al., (1999), mentioned that the total runoff was significantly different among three patches; being highest from the bare intercanopy patches, intermediate from the vegetated intercanopy patches, and lowest from the canopy patches. In other study, decrease the canopy cover frequency as a result of overgrazing lead to rapid water erosion in rangeland (Oztas et al., 2003). Gyssels et al., (2003), studded the influence of crop roots and shoots on soil losses; and he concludes that there is a shift in importance between both with times: in the early plant growth stage roots seemed to be of more importance with respect to reducing soil loss by concentrated flow because the above - ground vegetation mass is still very limited at the growth stage. Moreover, once shoots start to develop abundantly, they overrule the effect of the roots in reducing soil erosion rates. Also, if the crops are harvested at the end of the growing season, the vegetation cover protection returns to zero, whereby the died roots that remained at the upper soil layer will provide extra resistance to the soil until the field is tilled and planted again. However, plant roots penetrating the soil layer macrospores that improve water movement and gaseous diffusion; and so increase soil infiltration capacity which reduce the volume of surface runoff and consequently soil erosion (Gyssels et al 2005). Moreover, to reduce soil loss significantly more root densities are needed.

FAO (1988) reported that; one of the most common methods for rehabilitation of the degraded land to reduce the risk of soil erosion is afforestation. In Mediterranean areas traditionally land cover changes was encouraged with the establishment of tree cover *Pinus halepensis* (Alpinno pine) in natural or degraded ecosystem in order to reduce soil erosion and increase the vegetation structure. Xin et al (2004) reported that increase the number of native plant species could reduce soil erosion and increase soil antiscourability significantly due to enhancement of rootlets with increasing species number and characteristics of root system of different species. Moreover, the soil erosion was likely reduced by higher aboveground biomass rather than the number of species in plant community. When soils are dry, runoff generated only on very degraded and crusted surface; this runoff is quickly reinfiltrated in close soil patches with higher infiltration rates (Calvo-Cases et al 2003). Gyssels et al (2005) concluded that for splash and interrill erosion vegetation cover is the most important vegetation parameter, where for rill and ephemeral gully erosion plant roots are at least as important as vegetation cover.

From the beginning of last century, *P. halepensis* has been extremely used in afforestation, because of its role in succession after degradation of the soil. Ariza (2004) found that *P, halepensis* improve the soil mainly by doubling the organic matter content, which increase aggregate stability and prevent erosion.

Afforestation as a management practice has improved the structure of the natural communities through the addition of pine stratum in order to establish apluri-stratified forest; however species richness was reduced as well as plant diversity in these afforested semi-arid areas (Ariza 2004). Alternatively, these positive effects can be achieved through recovery of the natural vegetation, which can be managed with these aims.

Chirino et al., (2006) found that in semiarid climate afforestation with *Pinus halepensis* stratum does not significantly reduced erosion on long term scale (30 year) in comparison to the natural vegetation without trees. On the other hand, Sorriso-Valvo et al (1995) found that at the south facing slopes with little ground vegetation, runoff generation was rapid and peak sediment more when they compared with north facing slopes with good vegetation cover.

In Palestine, as a result of the absence of natural resource management, most of the forests were exposed to deforestation especially during the occupational period, and the rangeland exposed to overgrazing, which lead to increase the risk of soil erosion and lost of vegetation cover (Mohammad 2005). As a result most of the rangeland of West Bank especially in Central high land and eastern slop dominated with unpalatable dwarf shrub *S. spinosum* (Al-joaba 2006 and Mohammad 2000). On the other hand, this shrub seams to be important for conservation of soil and decrease the risk of soil erosion (Mohammad 2000).

1.5 Soil Moisture

In semi-arid areas vegetation suffers longer periods of water deficit that controls the vegetation growth, structure and complexity, and its role on soil protection and water conservation.

Arid and semiarid regions, from the view of plant ecology, those in which an insufficiency of water frequently limits or prevents plant growth or survival (Fowler 1986). Many factors affect the soil water such as topography of the land, soil texture, elevation, and type of vegetation cover (Fu et al., 2003). Al–seikh (2006), mentioned that topography (aspect and slope) play an important role that influence soil moisture storage. Sarah et al (2004) found that increase of water application will improve soil structure.

Parienteh (2002), mentioned that under shrubs (*Sarcopoterium spinosum* and *Echinops polyceras*) microenvironment there is a high soil moisture content as a result of relatively high infiltration rate under the shrubs that collect the overland flow from the upslope, and the shading effect. These conditions due to the development of soil structure under shrub rather than between shrubs, leading to high infiltration rate under shrubs and high soil moisture content. On the other hand, Bellot et al (2004) reported that *Pinus halepensis* had negative effect on soil moisture, and that effect increase with tree density. Positive correlation of moisture content with clay content can be explained by the properties of clay to retain more moisture over a larger range of matric potentials than sand or silt.

Water harvesting techniques are methods to increase soil water content. (Al-seikh 2006 and Abu hammad 2004), reported that WHT have a significant effect to increase soil water content.

1.6 Change in plant community following clearing of shrub (*Sarcopoteriom spinosum*) and cultivation the land.

Competition defined as a reduction in fitness due to shared use of a resource in limited supply (Gurevitch et al 2002).

Human activity such as removal of shrub and trees, aimed to decreasing woody cover while increasing herbaceous yield, began in the Mediterranean region in historical times, and continued ever since.

Most of the rangeland of Eastern Mediterranean countries dominated with *Sarcopoterium spinosum*, thorny and unpalatable dwarf shrub. Many studies show that there is an increase in the abundant, frequency and density of the herbaceous plants after clearing the shrubs (Liat et al 1999, Facelli et al 2002 and Strenberg et al 1999). Generally, when plants are grown without close neighbors, they are much larger than similar individuals surrounded closely by other and often have a very different morphology or form.

Strenberg et al (1999), studied the dynamics of Mediterranean vegetation after clearing and herbicide treatments; and he mentioned that; significant increase in species richness and diversity observed after cleared treatment, which probably due to the increase in resources availability (light and water) as perennial dominants were removed. Moreover, annuals and geophytes competently suppressed by perennials could establish themselves, thus increasing the number of species at the site. Following clearing, tall annual species such as *Avena strerilie* were probably recreated from seed bank and gained dominance due to reduced competition with perennial vegetation (mainly dwarf shrub sp) (Strenberg et al 1999). In addition, Liat et al (1999), reported that the abundance of many different species increase as a result of clearing of the shrubs. On the other hand, Facelli et al (2002) mentioned that presence of shrub canopy inhibits the growth of annual species, probably through reduce light availability.

Shrubs may play important and positive effects to annuals through factionary effect of shrub roots on annual plants growing out side the canopy, these effects vary in time and space (Facelli et al 2002). Emmerson and Facelli (1996) found that in drier years there were higher abundances of annual plants under shrubs, whereas there was little evidence for this when rainfall was slightly above average, so during the dry years of low rainfall, shrubs may create a microenvironment with less water stress. Facelli et al (2002), reported that during the stressful periods and under heavy grazing, some annual population may be unable to replenish there seed – banks in open area , and individuals growing under shrub canopies may contribute to maintenance the population in the long term. Moreover, Mohammad (2005) mentioned that *Sarcopoterium Spinosum* had an important role in protecting many plants hiding inside the canopies of this shrub, especially under overgrazing conditions. The overall higher abundance of annual species under shrubs may be important for the long-term persistence of environmental species during the stressful periods or under heavy grazing some annual population may be unable to replenish their seed-bank in open space, and individuals growing under shrub canopies may can contribute to maintain the population in the long term. It is important to bear in mind, however, that competition may be infrequent and yet has an important role in structuring communities and regulating populations. Two frequency with which significant correlation are found in desert communities, as compared with more mesic ones, indicates that desert shrubs usually compete with relatively fewer neighbors than do plants in more mesic environments (Fowler 1986). Competition can reduce plants biomass and growth rate and decrease its ability to survive and reproduce.

1.7 Objectives

1- To evaluate the effect of different vegetation cover on runoff and soil erosion.
2- Monitoring the changes in plant community after cultivation the land and after the removal of *Sarcopoterium spinosum*, and its consequences on runoff and soil erosion.
3- To evaluate the effect of different vegetation cover on soil water content.

Chapter Two

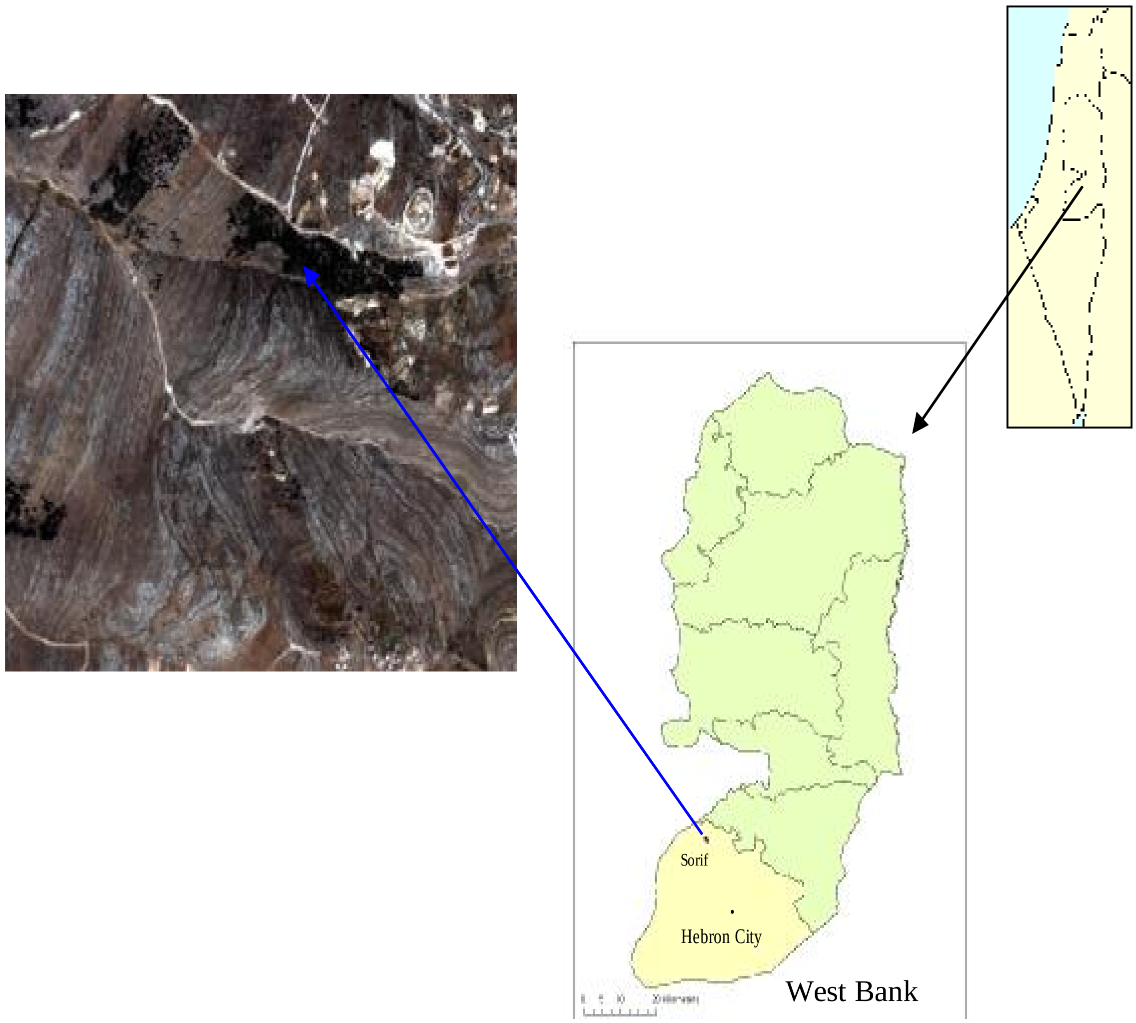
2.1 Materials and Method

This research is part of large project "Monitoring and Evaluation of water harvesting Techniques at the Southern Part of the West Bank", funded by USDA Forest Service , USAID Middle East Regional Cooperation (MERC) and US State department. It was implemented by College of Agriculture at Hebron University.

2.2 Study Site

2.2.1 Soreif Site

The study was carried out near Soreif town about 10 Km to the North-West of Hebron city, at the western slopes of the Central Highland of West Bank. The geographical position is 35.06 East and 31.63 North with elevation 670 m above see level, covering an area of about 40 ha (Map 1). The study topography is characterized by high mountains with steep slopes ranged between 10 to 13%. The climate is Mediterranean climate, with rainy winter and long hot dry summer. The timing of precipitation traditionally occur from October to April. The mean annual precipitation ranges from 400-500 mm according to the Hydrological Group; however, it is important to note that there is no earlier meteorological data available for the site, but a computerized meteorological station was built there recently.



Map (1) Study site

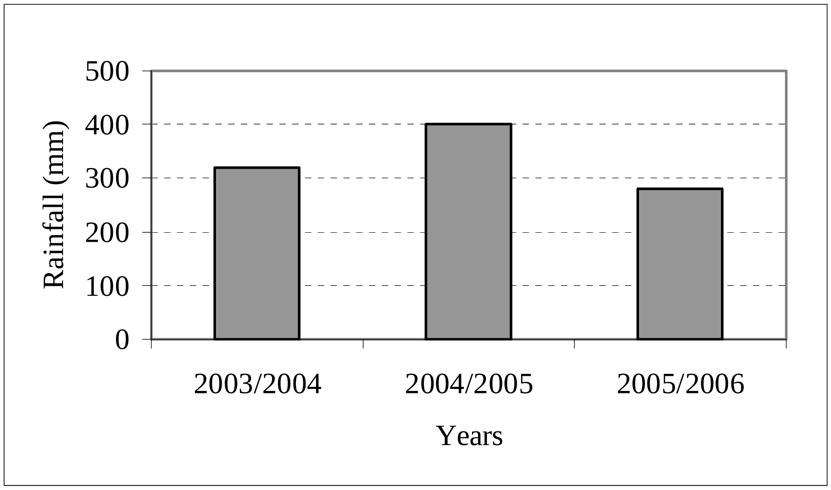


Figure (1) Annual rainfall (mm) at the study site during three years 2003/2004, 2004/2005 and 2005/2006

2.2.2 Soil description in study site

According to Awadallah and Owaiwi (2005) modified after Ravikovitch (1992) soil data from Dan (1976), the soil association in this site is belong to Brown Rendzinas and Pale Rendzinas. Al-Seikh (2006) found that the soil relatively contain large amount of clay (39 %), small amount of calcium carbonate (7-20 %), and medium amount of organic matter (3.5-5 %).

According to Al-Qadi (2004) (Personal communication), the study site was covered with natural trees such as *Crataegus spp, Suaeda spp, and Quercus spp*. But, during the British occupation, this region, as many part of Palestinian territory suffering from overgrazing and cutting of the woodland for many uses such as, burning of lime and manufacture of charcoal. However, in 1960 during the Jordanian Administration many areas planted mostly with *Pinus halepensis* to decrease the risk of land degradation in the region. This region was exposed to the risk of overgrazing after Israeli occupation. Because of the cutting of trees and overgrazing, the area is relatively bare land and covered with scarce and scattered vegetation.

The most common and dominant species are *Sarcopoterium spinosum*, *Avena sterilis, Lolium sp, Bromus fasciculatus, Crepis aspera, and Aegilops binuncialis* according to AL-Joaba (2006).

2.3 Treatments under investigation

Plots representing with different vegetation types were assigned at the study site, these include:

- Natural vegetation with *Sarcopoterium spinosum* as dominated species (W.S).
- Natural vegetation where the *Sarcopoterium spinosum* was removed (W/o.S).
- Cultivation practices, where all the vegetation cover was removed and cleared (C). The land was plowed before the start of the rainy season without planting anything inside the microchatchment.
- Afforestation (*Pinus halepensis)* planted in 1960, (F).
- Deforestation areas (Df). The trees (*Pinus halepensis*) were cutting during the last 20 years ago, and at this time it is open to grazing.

2.4 Data Collection and experimental design

2.4.1 Soil Chemical and Physical Properties

The aim of this experiment was to evaluate the effect of different vegetation cover on some soil characteristics such as: electric conductivity (EC), pH, available Potassium (K^+), available Phosphorus (P), Nitrate (NO_3^-), Amoniom (NH_4^+), calcium carbonate (CaCO3), organic matter and bulk density was measured in each treatment. Soil samples were obtained from the upper 10 cm of the top soil of each treatment. Completely randomized design with 3 replicates for each soil analysis was used to compare between treatments.

The electrical conductivity (EC) was measured in a saturated past (1:2.5) (Skooge and West, 1976; FAO 1980), the soil pH was also determined by using an electrode pH-mater for a saturated soil past (1:2.5) using distilled water. Organic matter was determined by using the Walky and Black method (Nelson and Sommers, 1982). The Olsen method was used to determine extractable Phosphorous using a molybdate reaction for colorimetric detection (Olsen and Sommers, 1982), and CaCO3 content determined by using the calcimeter instrument. Bulk density determined by clod method (Kim, 1995), and pipette method was used to determine soil particle size distribution (Bouwer, 1986).

2.4.2 Soil moisture

The aim of this experiment was to assess the soil water content under different vegetation cover. Gravimetric method was used to assess the soil water content. Samples of soil were taken from two depths (15 and 30 cm) from each vegetation type. We use these two depths because the soil depth in the study site does not more 50 cm and most of the root system concentrated at these two depths. Completely randomized design was used with four replicates of soil sample were used from each treatment at each soil depth to compare between the treatments. Measurements were taken periodically from April to September each 15 to 25 days in two years 2005 and 2006.

2.4.3 Vegetation Attributes

Vegetation measurements conducted during the peak development stage of the plant in April. All plant species were identified during the study period according to (Al-Eisawi 1998, Burnie 1995, Alsheikh et al 2000, and Botanical garden of Israel, **www.flora**. Israel).

Plant characteristics (cover, density, and biomass) were evaluated in all treatments as the following:

2.4.3.1 Ground cover

To evaluate the ground cover percentage in each treatment, permanent Line-intercept Transect method was used according to (Bonham 1989). In each microcatchment two lines (about 10 m length) was established across each experimental plot. Whatever (plant by species, rock or bare soil) found under the line was recorded (Figure 2).

Figure (2) Line intercept method was used to assess ground cover percentage at each treatment.

The percentage of plant cover was calculated as the following:

$$\% \text{ of Plant cover} = \frac{\text{Total intercept length of a plant}}{\text{Total intercept length of ground cover}} * 100\,\%$$

$$\% \text{ of soil cover} = \frac{\text{Total intercept length of a soil}}{\text{Total intercept length of ground cover}} * 100\,\%$$

$$\% \text{ of rock cover} = \frac{\text{Total intercept length of a rock}}{\text{Total intercept length of ground cover}} * 100\,\%$$

In each treatment 4 lines were used to evaluate the percent of ground cover. Completely randomize design was used to compare between percent of ground cover (plant, soil and rock) in each treatment.

2.4.3.2 Plant Biomass

For each treatment, eight 0.25 m^2 square plot quadrates were used to estimate plant biomass in each treatment. The square plots were randomly allocated and all part of plant (current year growth) of each species were collected and placed in labeled paper bags. To assess dry biomass all samples were taken to the lab, fresh weight were recorded, the samples were then placed in the oven to dry at 65 ^oC for 48 hours and dry weight were recorded. Plant biomass was determined in Kg/ha. Completely randomized design was used to compare between treatments.

2.4.3.3 Plant density

It is defined as the number of individuals per unit area. With the aim to estimate plant density, eight 0.25 m^2 square quadrates were allocated randomly in each treatment. In each quadrate, the number of individuals of each species was documented.

2.4.3.4 Surface Runoff and Soil Erosion

At each vegetation type; two replicated microcatchment (50 m^2 each) were constructed to evaluate and measure surface water runoff and sedimentation (Figure 3). A total of 10 plots, with 5*10 m per plot were selected in each vegetation cover type for runoff-erosion measurements.

Cement block (20 cm height) was used to bind each runoff plot (microcatchment) to prevent run-on from the adjacent area. Plastic pipe was used to convey the runoff water to 0.7 m^3 tank. The amount of runoff was measured after each main rainstorm event, after allowing the sediments to settle down. A Rain gauge was used to measure the amount of rainfall in the study site during the study period. In addition, the accumulative sediments at the bottom of each tank were measured one time at the end of the winter season after air drier of sediments.

Figure (3) Microcatchment used to measure runoff and sedimentation.

Chapter Three

3. Results

3.1 Soil properties

The results from fig (4) show a significant difference in the percentage of organic matter between treatments. Although, the amount of organic matter that was measured in all treatments was relatively high, but organic matter was significantly higher in treatments with *S. spinosum* (WS) and forest (F) compared with other treatments. No significant differences were founded between treatments without *S. spinosum* (W/0.S), cultivation (C) and deforestation (DF).

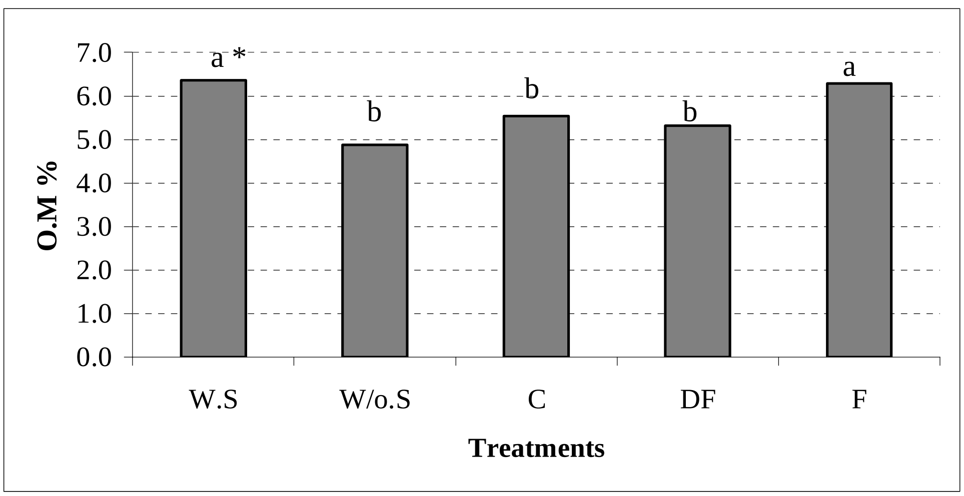


Figure (4) Organic matter percentage in the treatments: with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df), and forest (F).

*Columns with the same letter are not significantly different, according to Fisher LSD test at $P \leq 0.05$.

The results in table (1) indicated a significant difference in the pH value between the treatments. Deforestation significantly has higher pH value (7.29) compared with other treatments except with cultivation treatment.

The highest EC values were found in the forest and with *S. spinosum* treatments and it is significantly different compared with other treatments. EC was significantly lower in deforestation (0.44) and after removal of *S. Spinosum* (0.47) compared with other treatments. On the other hand, no significant differences in $NH4^+$, potassium K, and available phosphorus found between treatments. The highest amount of Sodium (39.68 ppm) was found in forest site, although there were no significant differences between the treatments. A significant difference in the concentration of NO_3^- was found in forest site compared with deforestation site (13.8 ppm vs 8.9 ppm, respectively). In addition, no significant differences in the concentration of $NO3^-$ were found between sites with *S. spinosum*, and without *S. Spinosum*, (10.8 ppm vs 5.8 ppm, respectively). The highest percent of CaCo3 (22.3 %) was found in cultivated treatment and the lowest one (13 %) in deforestation treatments.

Table (1) Soil chemical properties in all treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df), and forest (F) during the study period.

Treatments	pH (1:2.5)	EC (dsm^{-1})	NH_4^+ (ppm)	P (ppm)	$CaCO_3$ %	Na^+ (ppm)	K^+ (ppm)	NO_3^- (ppm)
F	7.05 b*	0.71 a	5.94 a	12.3 a	16.7	39.68 a	379.98 a	13.8 a
DF	7.29 a	0.44 d	7.47 a	12.2 a	13	38.66 a	407.64 a	8.9 b
W.S	7.06 b	0.61 ab	8.5 a	10.2 a	18.6	33.56 a	407.89 a	10.8 ab
W/o.S	7.06 b	0.47cd	5.86 a	7.7 a	15.4	35.57 a	373.64 a	5.8 b
C	7.21 ab	0.55 bc	6.26 a	9 a	22.3	38.12 a	313.5 a	6.8 a

* Means followed by the same letter in the same column are not significantly different. According to Fisher LSD test at $P \leq 0.05$.

3.1.1 Soil Texture

Results show that the amount of clay is relatively high in all treatments (table 2). The lowest amount of clay (45.27%) was found in cultivation treatment and the highest amount of clay content found in deforestation (58.17%). In addition, the percentage of silt is relatively similar in all treatments. On the other hand, the highest amount of sand was found in cultivation treatment (38.77%), and the lowest amount of sand was founded in deforestation site (26.21%) compared with other treatments.

Table (2) Percentage of clay, silt, and sand in all treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df), and forest (F) during the study period.

Treatments	**%Clay**	**%Silt**	**%Sand**
F	55.13	17.68	27.19
Df	58.17	15.61	26.21
W.S	54.16	14.87	30.97
W/o.S	54.63	11.84	33.53
C	45.27	15.96	38.77

3.2 Vegetation Characteristics

3.2.1 Ground Cover

About 120 species was identified during the study period (Appendix A). The results in table (3) demonstrate that there is a significant difference in percentage of ground cover (plant, soil, and rock) between the different treatments during the two seasons of years 2005 and 2006. Also, there is a difference between years in plant cover, which is higher in 2006 than 2005. In year 2005 removing *S. spinosum* have significantly higher percentage of plant cover compared with cultivated land. On the other hand, no significant differences in plant cover percentage were found between treatments without *S. spinosum* and with *S. spinosum* during the two years of 2005 (71.4%, 64.1%, respectively) and 2006(90.5% and 82.8% respectively). In addition, no significant difference in plant cover percentage was found between deforestation and forest treatments during the two seasons 2005 and 2006. However, cultivation has significantly higher percentage of bare soil during the season 2005 compared with other treatments. Also, during the year 2006 cultivation treatment had significantly higher percentage of bare soil cover compared with treatments without *S. spinosum* and deforestation treatment (table3).

Results in table (3) show significantly higher percentage of rock cover in deforestation treatments compared with other treatments during the two seasons of years 2005 and 2006. Nevertheless, no significant difference in percentage of rock cover found between treatments with *S. spinosum*, without *S. spinosun* and cultivated land during the years of the study (table3).

Table (3) Percentage of ground covers (plant, soil, and rock) in the treatments: without *S. spinosum* (W/0. S), with *S. spinosum* (W.S) Cultivation(C), deforestation (Df), and Forest (F), during the two season of years 2005 and 2006.

Ground Cover	**Plant Cover %**		**Soil Cover %**		**Rock Cover %**	
Treatments	2005	2006	2005	2006	2005	2006
W/0.S	71.4 a*	90.5 a	16.4 bc	3.4 c	12.2 c	6.2 b
W.S	64.1 ab	82.8 a	23.8 b	6.6 ab	12.1 c	10.6 b
C	49.3 b	86.4 a	34.6 a	8.2 a	16.1 bc	5.4 b
Df	55.1 ab	70.6 b	14.4 bc	4.9 bc	30.6 a	24.5 a
F**	70.2 a	72.6 b	9.5 c	7.1 a	24.5 ab	11.7 b

* Means followed by the same letter in the same column are not significantly different. According to Fisher LSD test at $P \leq 0.05$.
****** In the forest treatment the plant cover is the canopy cover not the ground cover.

3.2.2 Effect of removal of *S. spinosum* and cultivation the land on plant characteristics

The results in tables (4, 5, and 6) show significant differences in plant characteristics (plant cover percentage, biomass and density) during the two seasons of years 2005 and 2006.

3.2.3 Plant Cover Percentage

The data in table (4) show a significant increase in grasses and forbs cover percentage when the *S. spinosum* was removed during the two seasons of 2005 and 2006.

By removing the *S. spinosum* forbs increased from 11.5 % and 19 % in 2005 and 2006 respectively up to 51.6 % and 61.6 % in 2005 and 2006 respectively, while grasses increased from 3.7 % and 6 % in 2005 and 2006 respectively up to 16.4 % and 21.9 % in 2005 and 2006 respectively. Removing the *S. spinosum* cause more increase in forbs than grasses cover percentage. Moreover, the grasses cover percent was significantly increased in cultivation treatment compared with treatment with *S. spinosum* during the two years 2005 and 2006 (table 4). However, no significant increase in forbs cover percentage was found between cultivation treatment and with *S. spinosum* treatment during the two seasons of 2005 and 2006 (table 4). Re growth of *S. spinosum* after removal and cultivated treatment was very clear. In years 2005 and 2006 with *S. spinosum* treatment has 49 and 57.8 percent shrubs (table 4).

Table (4) Percentage of vegetation (grasses, forbs, and shrubs) cover in treatments without *S. spinosum* (W/0.S), with *S.spinosum* (W.S) and cultivation (C) during two years 2005 and 2006.

	Grasses		**Forbs**		**Shrubs**	
Treatments	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
W/0..S	16.4 a*	21.9 b	51.6 a	61.6 a	3.3 b	7.0 b
W.S	3.7 b	6.0 c	11.5 b	19.0 b	49.0 a	57.8 a
C	23.0 a	58.1 a	21.3 b	27.1 b	5.0 b	1.2 b

* Means followed by the same letter in the same column are not significantly different. According to Fisher LSD test at $P \leq 0.05$.

The results in table (5) show that *Avena sterilis*, *Bromus* species, *Lolium sp* and *Piptatherum miliaceum* have the highest cover percentage of grasses during the two years 2005 and 2006 in treatment with *S. spinosum*. On the other hand *Avena sterilis and Brachypodium distachym* have the highest grass cover percentage after removing the *S. spinosum* during the two seasons of years 2005 and 2006 (table 6). However, *Brachypodium distachym, Avena sterilis and Lolium sp* have the highest grass cover percentage after land cultivation during the two seasons of 2005 and 2006 (table 5).

Table (5) Percent of grasses cover in treatments with *S. spinosum* (W.S), without *S.spinosum* (W/o.S) and cultivated land(C) during 2005 and 2006.

	W.S		**W/o. S**		**C**	
Grasses cover %	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
Aegilops genculita	0	0.18	0.7	0.5	0.7	1.6
Avena sterilis	0.68	1.82	3.7	5.2	5.5	3.1
Brachypodium distachym	0	0.36	5.4	11.2	6.8	29.7
Bromus diandrus	0.2	1.08	0.7	0.1	0	0
Bromus fasciculatus	0	0.14	1.6	2	0.2	0.4
Bromus lanceolatus	0.62	0.46	0.6	0.8	0.4	0.4
Bromus tectorum	0	0	0	1	0	0
Cynosurus echinatus	0	0	1.1	0.47	0.5	0
Lolium sp	1.01	0.2	1.8	1	4.7	22.5
Phalaris	0	0.16	0.8	0.2	0.8	0.5
Piptatherum holciforme	0	1.29	0	0	0	0
Piptatherum miliaceum	1.03	0.34	0	0	2.2	0
Stipa capensis	0	0	0	0	1	0

The results in table (6) indicate that *Lactuca virosa, Lotus corniculatus* and *Urospermum picroides* have the highest percentage of forbs cover in treatment with *S. spinosun* during the two seasons 2005 and 2006. On the other hand, the highest forbs cover percentage are *Trifolium stellatum(28.5%), Crupina crupinastrum and Trifolium scabrum* during the two season of 2005 and 2006 after removing of *S. spinosum* (W/o.S) (table 6). However, *Hedypnois cretica, Rhagadiolus stellatus and Sinapis arvensis* have highest forbs cover percentage after cultivation during the two years 2005 and 2006 (table 6).

In general more forbs species were recorded than grasses in the different treatments.

Table (6) Percent of Forbs cover in treatments with *S. spinosum* (W.S), without *S.spinosum* (W/o.S) and cultivated land (C) during 2005 and 2006.

	W.S		**W/o.S**		**C**	
Forbs cover %	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
Adonis sp	0	0	0	0.05	0	0
Ajuga orientalis	0	0	0.05	0	0	0
Allium neapolitanum	0	0.2	0.03	0.11	0.1	0.2
Anagallis arvensis	1.5	3.5	0.05	0	0.1	0.4
Astomaea seselifolium	0	0	0	0	0.1	0
Biscutella didyma	0	0.1	0	0.27	0.3	0.1
Carduus argentatus	1.1	0.2	0.23	0.61	0	1.4
Carlina curetum	0	0.8	0	2.77	0.2	0.7
Carlina libanotica	0.4	0	0.65	0	0	0
Carthamus tenuis	1	0.2	1.89	0.7	0.5	0.3
Chaetosciadium trichospermum	0	0.2	1.59	0.65	0.1	0.8
Cichorium intybus	0	0	0.07	0.41	0.1	0
Cichorium pumilum	0	0	0	0	0	0.1
Coronilla scorpiodes	0	0.1	1.03	1.23	0.1	0.7
Crepis aspera	0.1	0.1	0.07	0	0.8	0.9
Crupina crupinastrum	0	0.4	5.55	10.7	1	0.7
Crucianella macrostachya	0	0	0	0.33	0	0.5
Cruciata articulata	0.3	0.1	0	0	0.1	0.2
Cyclamen persicum	0.2	0.3	0	0	0.1	0.1
Echinops polyceras	0	0	0.05	0.2	0	0
Evax contracta	0	0	0	0	1.5	0.2
Gynandriris sisyrinchium	0.1	0.2	0.1	0.41	0.2	0
Hedypnois cretica	0	0	0	0	3.3	6.5
Heliotropium arbainense	0	0	0	0	0.4	0.3
Hippocrepis unisiliquosa	0	0.2	0	0	0	0
Iris postii	0	0.1	0	0	0	0
Lactuca virosa	2.1	0.7	1.52	2.86	0.6	0.9
Lagoecia cuminoides	0.2	0.4	0.21	0.2	0	0

Lagousia falcate	0	0	0	0	1.2	1.3
Lathyrus cicera	0.2	0.1	0	0	0	0
Leontodon tuberosus	0	0	0.91	1.44	1	0.3
Linum corymbulosum	0.2	0.3	0	0	0	0
Linum strictum	0	0.1	0.2	0.37	0	0
Lomelosia palaestina	0	0.3	0	0	0	0
Lotus corniculatus	1.7	1.3	1.85	2.24	0.3	0
Malabaila secaul	0.3	0.2	0.52	0.23	1.1	0.2
Medicago sativa	0.2	0	0.45	0.3	0	0
Medicago scutellata	0.3	0.3	0.16	0.19	0.1	0.1
Mercurialis annue	0.5	0.6	0	0	0	0.1
Micromeria sinaica	0	0	0.38	0.31	0	0
Onobrychis caput-galli	0	0	0.18	0.23	0.6	0
Ononis orthopodiodes	0	0	0	0.23	0	0
Plantago afra	0.3	0.3	0.2	0.11	0	0
Rhagadiolus stellatus	0	0	0.5	0.3	2.5	5.2
Salvia palaestina	0	0.2	0	0	0	0
Scandix pecten-veneris	0.2	0.2	0	0	0.8	0.8
Scorpiurus muricatus	0	0	0	0	0	0
Sinapis arvensis	0.1	0.2	0.01	0	3.1	3.4
Smilax aspera	0.2	0.3	0	0	0	0
Theligonum cynocrambe	0	0	0.05	0.8	0	0
Tragopogon coelesyriacus	0.1	0.3	0.3	0.19	0.1	0.1
Trifolium campestre	0.5	0.7	0.73	0.59	0.3	0.1
Trifolium purpureum	0.3	0.3	0	0	0.1	0.2
Trifolium scabrum	0.6	1	2.39	4.35	0.2	0.2
Trifolium stellatum	0	0	28.56	28.96	0.2	0.1
Trigonella stellata	0.1	0.1	0	0	0	0
Urospermum picroides	0	4.3	0	0	0	0

The results in table (7) show that the *S. spinosum* and *Asparagus stipularis* have the highest shrub cover during the two years 2005 and 2006 in natural vegetation (with *S. spinosum*). Also, in table (7) show that the *Sarcopoterium spinosum* regrowth *and Helianthmum lippii* have the highest shrubs cover percentage during the two years 2005 and 2006 after removing of *S. spinosum*. The highest shrubs cover percentage are for *Sarcopoterium spinosum and Rubia tenuifolia* after cultivation the land (table 7).

Table (7) Percent of shrubs cover in treatments with *S. spinosum* (W.S), without *S.spinosum* (W/o.S) and cultivated land (C) during 2005 and 2006.

	W.S		**W/o.S**		**C**	
Shrubs cover %	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
Alcea setosa	0	0	0.1	0	0	0
Asparagus stipularis	0.37	1.09	0	0	0	0
Cistus creticus	0	0	0.4	0	0	0
Helianthemum lippii	0	0	0.2	2.1	0	0
Phangnalon rupestre	0.05	0.52	0	0.4	0.2	0
Rubia tenuifolia	0.45	0.39	0	0.2	0.9	0.2
Sarcopoterium spinosum	49.0	55.9	2.5	3.8	4	1

3.2.4 Plant biomass

A significant increase in forbs and grass biomass when *S. spinosum* was removed during the two seasons 2005 and 2006 (table 8). While, no significant differences were found in grass biomass after removing *S. spinosum* (674.5 Kg/ha) and cultivated land (682 Kg/ha) during 2005, but there is a significant increase in grass biomass during 2006 (559 Kg/ha and 2090 Kg/ha) after removing *S. spinosum* and the cultivated land respectively. However, forbs biomass significantly increased after the removing of *S. spinosum* compared with cultivated natural vegetation land. Shrubs biomass have significantly decreased when *S. spinosum* was removed or under cultivated land during the two seasons of 2005 and 2006 (table 8). Removing *S. spinosum* had a direct effect on plant community and structure and it was reflected in the differences in plant biomass.

Table (8) Average plant (grasses, forbs, and shrubs) biomass (Kg/ha) in treatments with *S.spinosum* (W.S), without *S. spinosum* (W/o.S) and cultivation (C) in two season of a years 2005 and 2006.

	Grasses		**Forbs**		**Shrubs**	
Treatments	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
W.S	151.5 b*	258.2 b	324 b	243.5 b	2207 a	2198.5 a
W/0.S	674.5 a	569.5 b	1476 a	1403.7 a	107.5 b	63 b
C	682 a	2090 a	515.5 b	899.8 a	33 b	15 b

* Means followed by the same letter in the same column are not significantly different. According to Fisher LSD test at $P \leq 0.05$.

The result in table (9) show that *Piptatherum holciforme, Bromus* species and *Lolium sp* have the highest grass biomass during 2005 , while in 2006 *Brachypodium distachym, Piptatherum holciforme* and *Bromus sp* have the highest grass biomass in treatment with *S. spinosum*. On the other hand, the following species have the highest grass dry biomass after removing of *S. spinosum*: *Avena sterilis*, *Brachypodium distachym* and *Aegilops geniculata* during the two seasons of 2005 and 2006. However, *Brachypodium distachym, Lolium sp* and *Aegilops genculita* have the highest grass dry biomass in cultivated treatment during the two seasons of 2005 and 2006 (table 9).

Table (9) Average grass biomass (kg/ha) for each species in treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S) and cultivated land (C) in 2005 and 2006.

	W.S		**W/o.S**		**C**	
Grasses (Kg/ha)	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
Aegilops geniculata	0	0	100	10	30	326.5
Avena sterilis	10	8	376.5	390	121.5	91.5
Brachypodium distachym	15	55.5	96.5	112.5	263	1738.5
Bromus diandrus	0	0	22	10	0	0
Bromus fasciculatus	10.5	85..2	0	0	0	0
Bromus lanceolatus	8.5	39.5	12	7	27.5	102.5
Bromus tectorum	0	0	0	0	11	0
Cynosurus echinatus	0	0	18	19.5	0	0
Lolium sp	7	0	39	20.5	217.5	460
Phalaris sp	0	0	0	0	11.5	9.5
Piptatherum holciforme	100.5	78	0	0	0	0
Total	**151.5**	**258.2**	**674.5**	**569.5**	**682**	**2090**

The data show change in the grass dominant species after removing the *S. spinosum* which affect directly on plant dry biomass. The result in table (10) show that *Urosperrum picroides* had the highest dry forbs biomass followed by *Lotus corniculatus* and *Trifolium campestre* during the two seasons 2005 and 2006 in treatment with *S. spinosum*. On the other hand, *Trifolium stellatum*, *Crupina crupinastrum*, *Trifolium scabrum* and *Lotus corniculatus*, have the highest dry biomass after removing of *S. spinosum* during the two seasons of 2005 and 2006. While, the highest forbs dry biomass were for *Hedypnois cretica*, *Rhagadiolus stellatus*, *Crepis aspera and Crucianella macrostachya* after cultivating the land during the two seasons of 2005 and 2006.

Table (10) Average plant biomass (Forbs) (kg/ha) for each plant species in treatments with *S. spinosum*(W.S), without *S. spinosum* (W/o.S) and cultivated land (C) in 2005 and 2006.

	W.S		**W/o.S**		**C**	
Forbs (Kg/ha)	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
Anagallis arvensis	0	0	0	0	27.5	3
Carduus argentatus	0	0	35	44	7	0
Carlina libanotica	0	0	6.5	0	0	0
Carthamus tenuis	21.5	0	0	0	0	0
Carthamus tenuis	0	0	20.5	16.5	0	0
Chaetosciadium trichospermum	38.5	6	55.5	75	0	0
Cichorium intybus	0	0	0	0	30	3
Coronilla scorpiodes	11	3	0	0	0	0
Crepis aspera	0	0	0	0	33.5	151.5
Crucianella macrostachya	0	0	0	0	94.5	0
Cruciata articulata	44	0	0	0	0	0
Crupina crupinastrum	0	0	327	280	7.5	0
Cyclamen persicum	9	0	0	0	0	0
Eryngium sp	0	0	0	0	5	2
Evax contracta	0	0	0	0	6	2
Hedypnois cretica	0	0	0	0	156	208.2
Hippocrepis unisiliquosa	0	0	0	2.5	0	0
Lagoecia cuminoides	12	6	8	12	5	10.5
Lagousia falcata	0	0	0	0	10.5	0
Leontodon tuberosus	31	0	66	54.5	0	0
Linum strictum	0	0	25	20	0	0
Lotus corniculatus	29.5	43	80.5	40.5	7.5	2
Medicago sativa	0	0	0	0	5	0
Medicago scutellata	0	0	0	0	10	0
Ononis orthopodiodes	0	0	0	9	0	0
Pallenis spinosa	0	0	5	0	0	0
Plantago Afra	0	0	5	12	11	5
Rhagadiolus stellatus	21	0	6	3.5	24.5	189.5
Scandix pecten-veneris	0	0	0	0	0	7

Sinapis alba	8.5	28.5	0	0	0	0
Stipa capensis	0	0	0	0	67	60
Tordylium officinal	19	10	25	24	24	2
Tragopogon coelesyriacus	0	0	29.5	25	0	0
Trifolium campestre	22.5	33.5	65.5	50	0	0
Trifolium purpureum	0	0	20.5	20	8.5	3
Trifolium scabrum	0	0	122.5	167	0	0
Trifolium stellatum	19	6	553	496.5	0	0
Urosperum picroides	38	107.5	20.5	81	0	49
Total	**324.5**	**243.5**	**1476.5**	**1403.5**	**515.5**	**899.5**

The results in table (11) show that the highest shrub dry biomass was for *S. spinosum* (2207 kg/ha) and *Phangnalon rupestre*, during the two seasons of years 2005 and 2006 in treatment with *S. spinosum*. However, regrowth of *Sarcopoterium spinosum* and *Helianthemum lippii* have the highest shrub dry biomass in 2005 and 2006 after removing *S. spinosum* treatment (table 11). In addition, *Sarcopoterium spinosum and Rubia tenuifolia* have the highest dry biomass after cultivating the land (table 11).

Table (11) Average plant biomass (shrubs) (kg/ha) for each plant species in treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S) and cultivated land (C) in 2005 and 2006.

	W.S		**W/o.S**		**C**	
Shrubs (Kg/ha)	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
Alcea setosa	0	0	12	0	0	0
Helianthemum lippii	0	0	19.5	13	0	0
Phagnalon rupestre	0	52	0	21	0	0
Rubia tenuifolia	20.5	0	0	25	15	13
Sarcopoterium spinosum	2186.5	2146.9	76	4	18	2
Total	**2207.5**	**2198.9**	**107.5**	**63**	**33**	**15**

3.2.5 Plant density

After removing *S. spinosum* different changes in plant community (plant biomass, cover, and density) were appeared.

The results in table (12) show a significant increase in plant density (plant/m^2) when the *S. spinosum* was removed during the two seasons of 2005 and 2006. However, no significant difference was found in plant density between cultivation and with *S. spinosum* treatments in the two years 2005 and 2006 (table 12).

Table (12) Average plant density (plant/m^2) during 2005 & 2006 for treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.s), and cultivation (C).

Treatments	**2005**	**2006**
W.S	104.5 b*	86 b
W/o.S	565 a	358 a
C	118.5 b	187 b

* Means followed by the same letter in the same column are not significantly different. According to Fisher LSD test at $P \leq 0.05$.

The results from table (13) indicate that the highest species density of grasses in treatment with *S. spinosum* is *Bromus fasciculatus, phalaris sp, and Linuim strictum.* However, when *S. spinosum* was removed; *Avena sterilis, Brachypodium distachym, Bromus fasciculatus, and Lolium sp* have the highest grasses density (table 13); and in cultivated land, *Brachypodium distachym*, *Lolium sp and Aegilops genculita* have the highest density (table 13) during the two seasons of years 2005 and 2006. Forbs density was also different between the treatments. In treatment with *S. spinosum* the highest forbs species are *Erodium acaule,, Trifolium campestre and Picroides urosperm* (table 14). While, after removing the *S. spinosum*;

Trifolium stellatum, Trifolium scabrum and Crupina crupinastrum have the highest forbs density (table 14). In addition, after cultivating the land *Hedypnois cretica, Rhagadiolus stellatus, and Crepis aspera* have the highest forbs density during the two seasons 2005 and 2006 (table 14). The highest shrub density that found in the treatments with *S. spinosum*, without *S. spinosum* and cultivated land are *Sarcopoterium spinosum*, *Phangnalon repestre* and *Rubia tenuifolia* respectively during the two seasons of years 2005 and 2006 (table 15).

Table (13) Average plant density (grass) (plant/m^2) for each plant species in the treatments With *S. spinosum* (W.S), without *S. spinosum* (W/o.S) and cultivated land (C) during 2005 and 2006.

	W.S		**W/o.S**		**C**	
Grasses (Plant/m^2)	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
Aegilops genculita	0	0	4	10.5	13.5	2
Avena sterilis	2.5	0	37	22.5	5	5.5
Brachypodium distachym	6	0	91	58	56	29
Bromus diandrus	5	0	3	5	0	1
Bromus fasciculatus	19	2.5	24	4	2.5	0
Bromus lanceolatus	0	0	4.5	4	4	5.5
Lolium sp	0	0	4.5	8	50.5	16
Phalaris sp	4	7	0	1	1	1
Piptatherum holciforme	1.5	0	0	0	0	0
Piptatherum miliaceum	0.5	4.5	0	0	0	0
Poa bulbosa	0	0.5	0	0	0	0

Table (14) Average plant density (forbs) (plant/m^2) for each plant species in the treatments With *S. spinosum* (W.S), without *S. spinosum* (W/o.S) and cultivated land (C) during 2005 and 2006.

	W.S		**W/o.S**		**C**	
Forbs (Plant/ m^2)	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
Adonis palaestina	0	0	0	0	0	1
Allium neapolitanum	0.5	0.5	0	0	0	0
Allium stamineum	0	0	0.5	0	0	0
Anagallis arvensis	1	3.5	0	0	0	2.5
Anthemis sp	0.5	0	0	0.5	0	0
Atractylis comosa	0.5	0	0	0	0	0
Carthamus tenuis	0.5	0.5	0	1	0	0
Chaetosciadium trichospermum	0.5	5.5	3	11.5	1	0.5
Cichorium intybus	0	0	0	0	0	1.5
Corianduam satirum	0	0	0	0	0	2.5
Coronilla valentina	0	2	0	0	0.5	0
Crepis aspera	0	1	0.5	1	3	3.5
Crupina crupinastrum	0	0	25.5	30.5	0	1
Crucianella macrostachya	1	0	0	0	0	0
Cruciata articulata	0	2.5	0	0	0	0
Cyclamen persicum	0	0.5	0	0	0	0
Cynosurus ecginatus	0	0	0	0	0	1.5
Erodium acaule	2.5	13.5	0	0	0	0
Erodium gruinum	0	0	0	0	0	0.5
Evax contracta	0	0	0	0	0	3.5
Galdious illyricous	0	0	0	1	0	0
Gynandriris sisyrinchium	0	1	0	0	0	0
Hedypnois cretica	0	0	0	0	17	0
Helianthemum lippii	0	0	1.5	0	0	0
Hippocrepis unisiliquosa	1	0	0.5	0	0	0
Lactuca virosa	0	0	0	0	0.5	0
Lagoecia cuminoides	1	8.5	5	5.5	3	1
Lagousia falcata	0	0	0	0	2	4
Leontodon tuberosus	1.5	0	0	1.5	0	2

Linum strictum	1.5	24	13	0.5	0	0
Lomelosia	0	0	0	0	0	1.5
Lotus corniculatus	4.5	2	2	5	0	0
Malabaila secaul	0	0	0	0	0.5	2.5
Medicago sativa	0	1	0	15.5	0	0.5
Mercurialis annue	2.5	0	0	0	0	0
Notobasis syriaca	0	0	0.5	3	0	1
Onobrychis caput-galli	0	0.5	0	0.5	0	0
Ononis orthopodiodes	0.5	0	3	1	0	0
Pallenis spinosa	0	0	0	1	0	0
Paronychia argentea	0	0	0.5	0	0	0
Plantago afra	0	0	0	3.5	0	2.5
Plantago lanceolata	0	0.5	0	0	0	0
Rhagadiolus stellatus	0	1	6	2	8.5	12
Scandix pecten-veneris	0	0.5	0	0	3.5	0
Scorpiurus muricatus	0	0	0	0.5	0	0
Sinapis alba	0.5	0.5	0	0	1.5	2
Sinapis arvensis	0	0	0.5	0	0	0
Tordylium officinal	0	1.5	0	4	0	0
Tragopogon coelesyriacus	0	0	0.5	0	0.5	0
Trifolium campestre	7.5	3.5	1.5	17	1	1.5
Trifolium purpureum	0	0	0	0	0	1
Trifolium scabrum	2	0.5	40.5	57.5	1.5	1
Trifolium stellatum	3	2.5	75	273	0	0
Trigonella berythea	0	0	0	0.5	0	0
Urospermum picroides	8	4	6	4.5	2	0

Table (15) Average plant density (shrubs) (plant/ m^2) for each plant species in the treatments With *S. spinosum* (W.S), without *S. spinosum* (W/o.S) and cultivated land (C) during 2005 and 2006.

	W.S		**W/o.S**		**C**	
Shrubs (Plant/ m^2)	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
Cistus creticus	0	0	0	0.5	0	0
Helianthemum lippii	0	0	0	1	0	0
Micromeria sinaica	0	1	0	0	0	0
Phagnalon rupestre	2	0.5	1.5	0	0	0
Rubia tenuifolia	0	0.5	1.5	0	0.5	1.5
Sarcopoterium spinosum	7.5	7	1	3.5	1	7

3.3 Surface Runoff

The results in figures (5 and 6), show that there are significant differences between the treatments in the amount of surface runoff during the two rainy seasons in 2004/2005 and 2005/2006. Afforestation (*P. halepensis*) and natural vegetation dominated with *S. spinosum* have significantly the lowest amount of total runoff (2 and 1.7 mm during 2004/2005 and 1.7 and 2.5 mm during 2005/2006, respectively) compared with other treatments during the two seasons. Deforestation treatment had significantly the highest total runoff (4.1 and 4.4 mm during 2004/2005 and 2005/2006, respectively) compared with other treatments (figures 5 and 6). In addition, during the second season 2005/2006 the deforestation and without *S. spinosum* treatments have significantly the highest amount of runoff (figure 6).

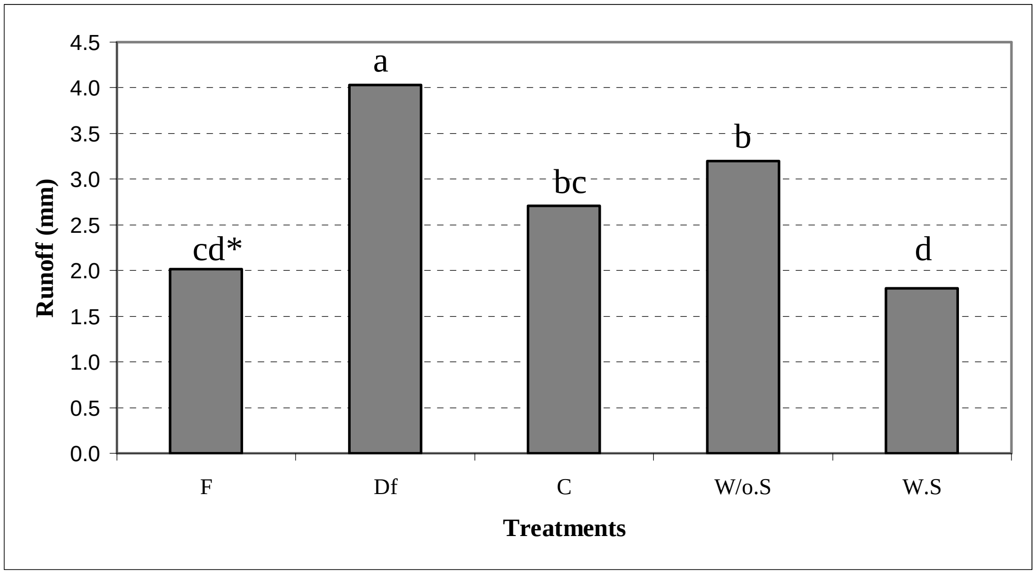


Figure (5) Total amount of runoff (mm) in all treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df), and forest (F) during 2004/2005.

*Columns with the same letter are not significantly differences, according to Fisher LSD test at $P \leq 0.05$.

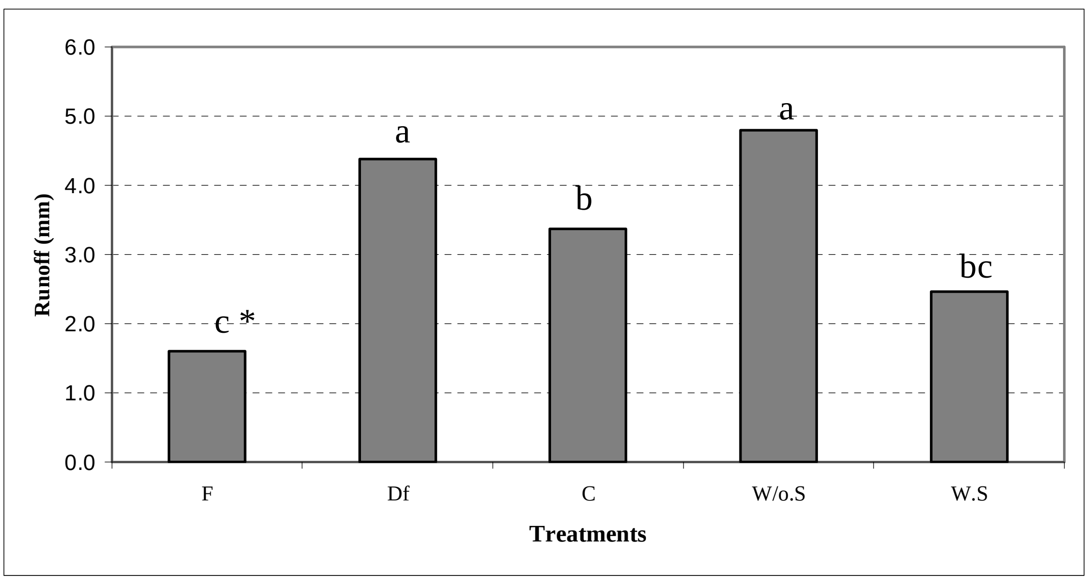


Figure (6) Total amount of runoff (mm) in all treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df), and forest (F) during 2005/2006.

*Columns with the same letter is not significantly different, according to Fisher LSD test at $P \leq 0.05$.

3.3.1 Relationship between each rainfall event and amount of runoff

Generally, when the amount of rainfall increase the amount of runoff also increased, which also depend on many other factors such as type of vegetation cover, soil moisture, soil texture and others. The results in figure (7) show that deforestation site had the highest surface runoff in each rainfall event during the year 2004/2005. On the other hand, treatment with *S. spinosum* had the lowest amount of surface runoff in all rainfall events except the last one during the rainy season 2004/2005. Although, the lowest amount of surface runoff for each rainfall event was recorded on forest treatment during the season 2005/2006 compared with other treatments in most rainfall events (figure 8). In addition, figure (8) show that the treatments without *S. spinosum* and deforestation have the highest amount of surface runoff in each rainfall event during the year 2005/2006.

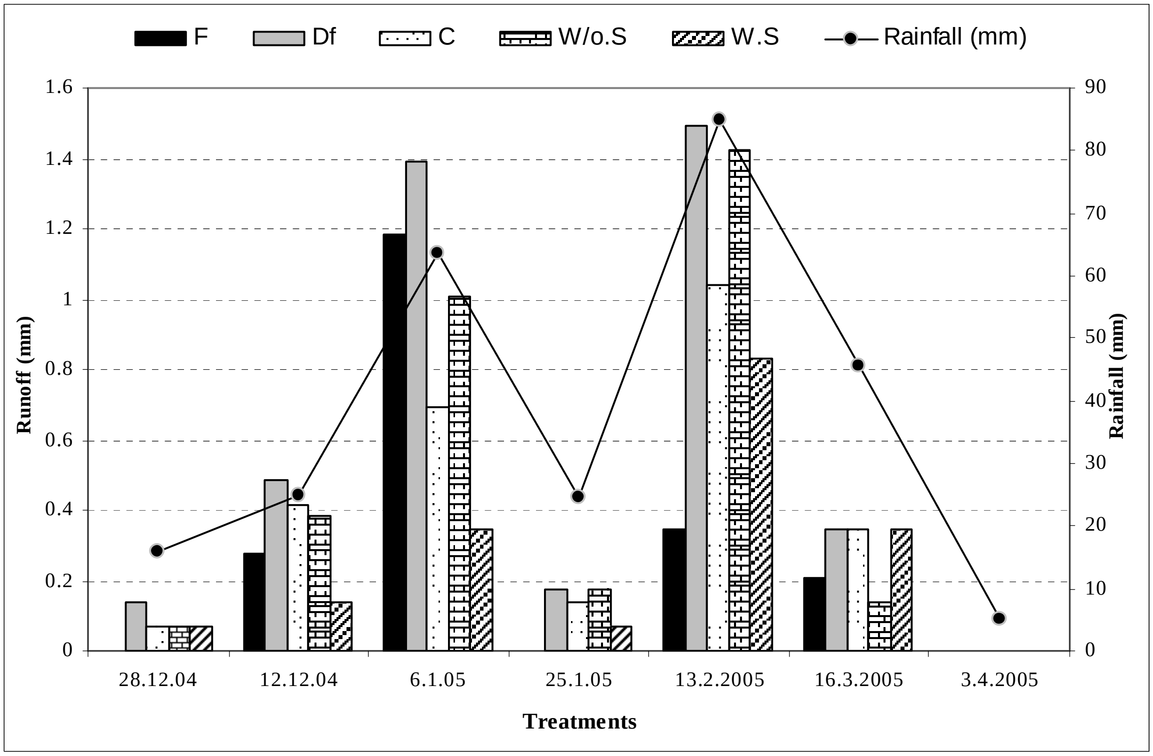


Figure (7) Relationship between each rainfall (mm) event and amount of runoff (mm) in all treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df), and forest (F) during the winter season in 2004/2005.

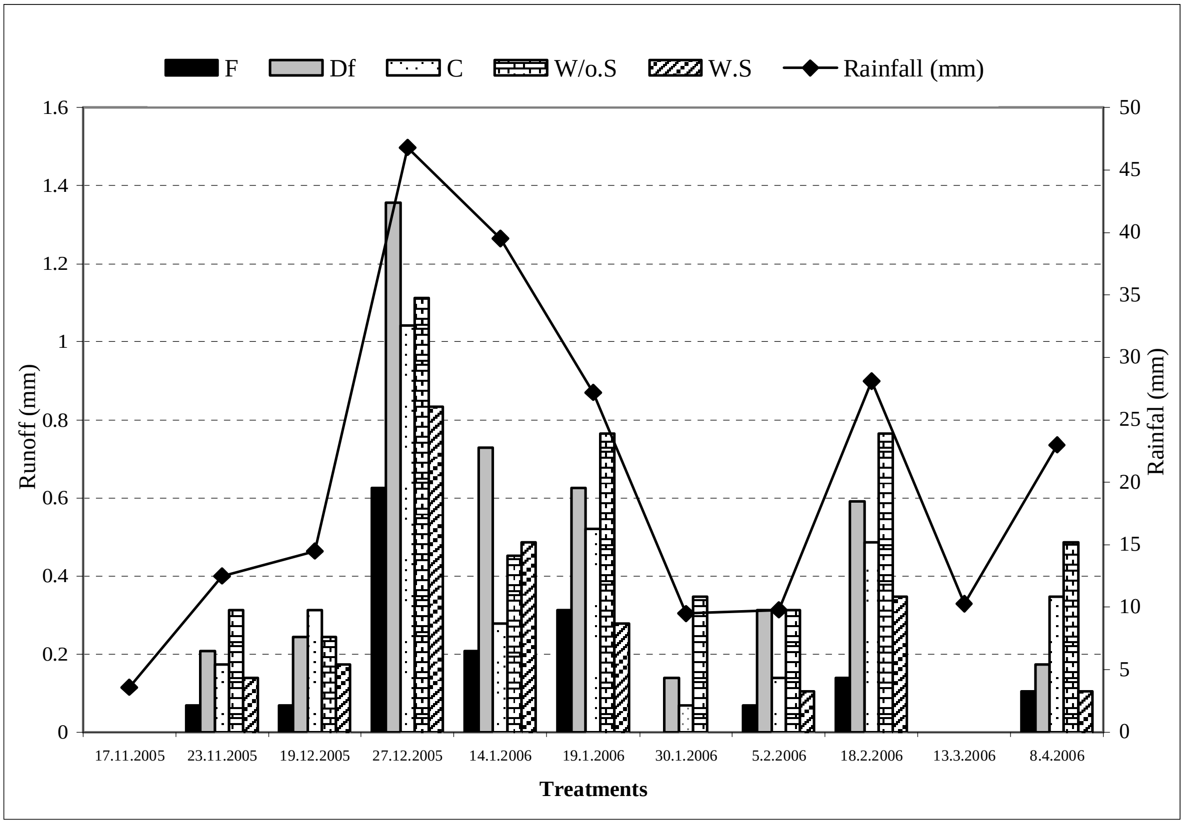


Figure (8) Relationship between each rainfall (mm) event and amount of runoff (mm) in all treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df), and forest (F) during the winter season in 2005/2006.

3.3.2 Soil erosion

Our results demonstrated that soil erosion (sedimentation) were significantly different between the treatments during the two seasons 2004/2005 and 2005/2006. Treatments with *S. spinosum* and forest were significantly have the lowest amount of accumulative sedimentation compared with other treatments during the two seasons 2004/2005 and 2005/2006 figures (9 and 10). Although, in year 2004/2005 the results indicate that there is no significant difference in the accumulative sedimentation found between cultivated land, without *S. spinosum* and deforestation. On the other hand, in year 2005/2006, cultivated land had significantly the highest amount of sediment compared with other treatments except deforestation site.

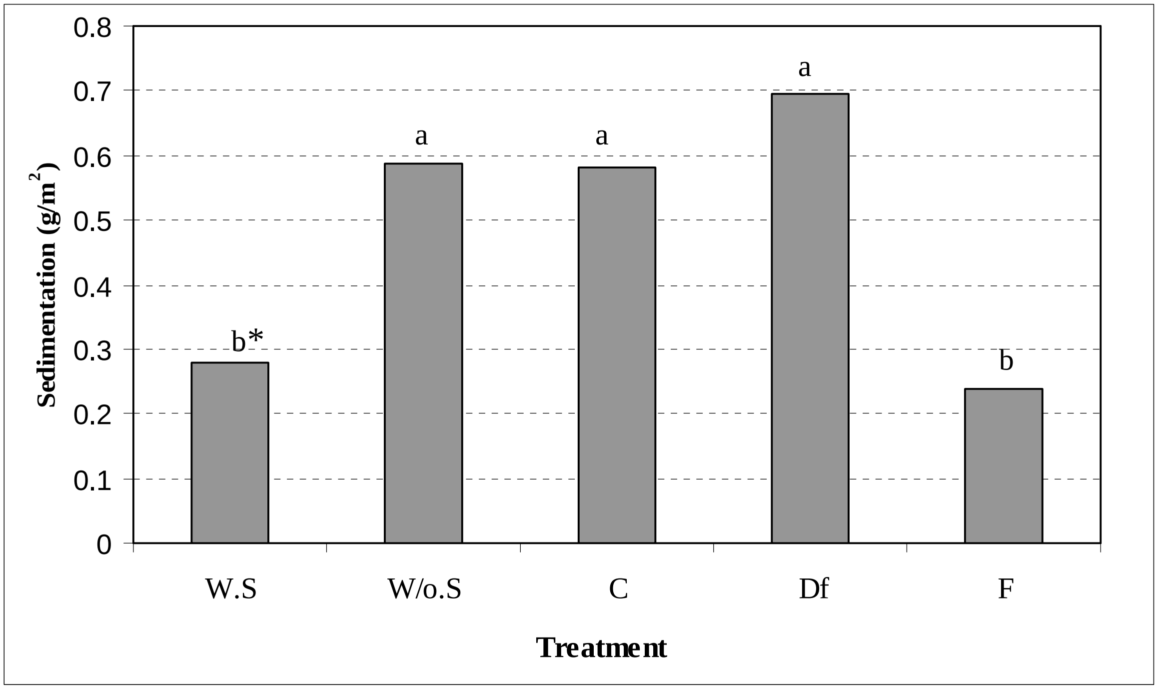


Figure (9) Total amount of sedimentation (g/m^2) during 2004/2005 in treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df) and forest (F).

*Columns with the same letter are not significantly different, according to Fisher LSD test at $P \leq 0.05$.

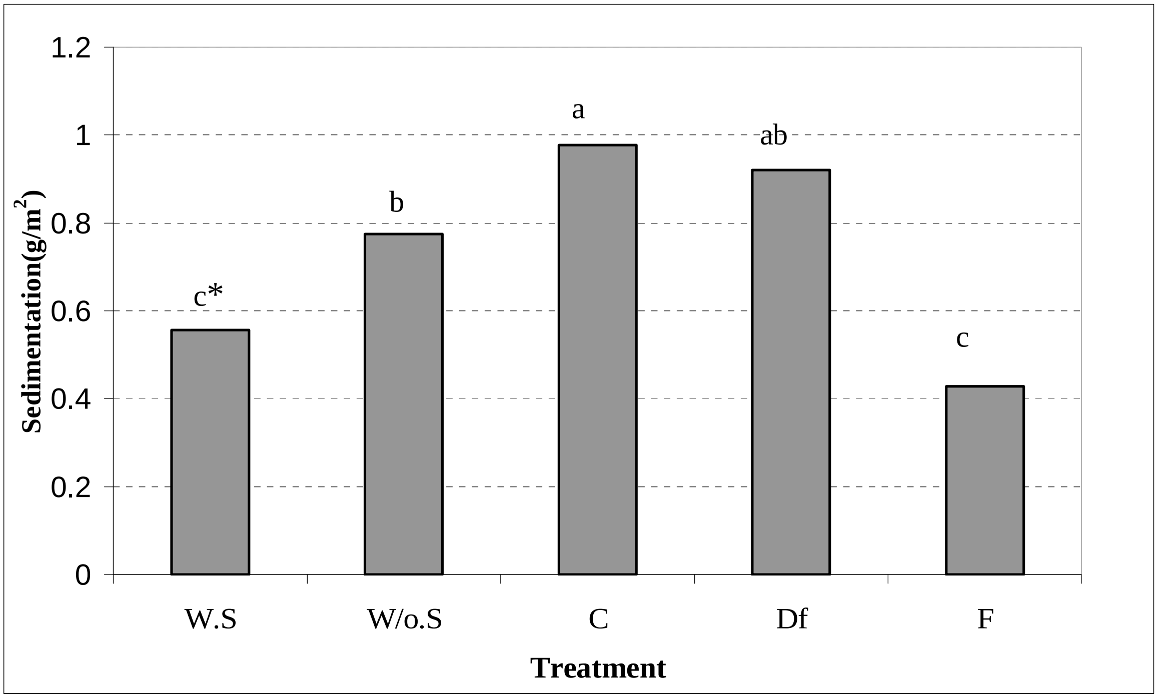


Figure (10) Total amount of sedimentation (g/m^2) during 2005/2006 in treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df) and forest (F).

*Columns with the same letter are not significantly different, according to Fisher LSD test at $P \leq 0.05$.

3.3.3 Relationship between total surface runoff and sedimentation

The results in figures (11 and 12); explain the relationship between the total amount of surface runoff (mm) and accumulative sedimentation (g/m^2).

A close relationship between the amount of water runoff and sedimentation in most treatment were appeared (Figure 11 and 12). Increase the amount of surface runoff lead to an increase in soil erosion especially during the main storm events in rainy season (winter) in most treatments during 2004/2005 and 2005/2006.

However, these relationships are inconsistent in all treatments which reflect the influence of other factors such as type of vegetation cover. In the cultivation treatment the amount of runoff is less than on treatments without *S. spinosum* (w/o.S) and deforestation (Df) during 2004/2005, despite that the accumulative sediment is the highest compared with these treatments (Figure 11).

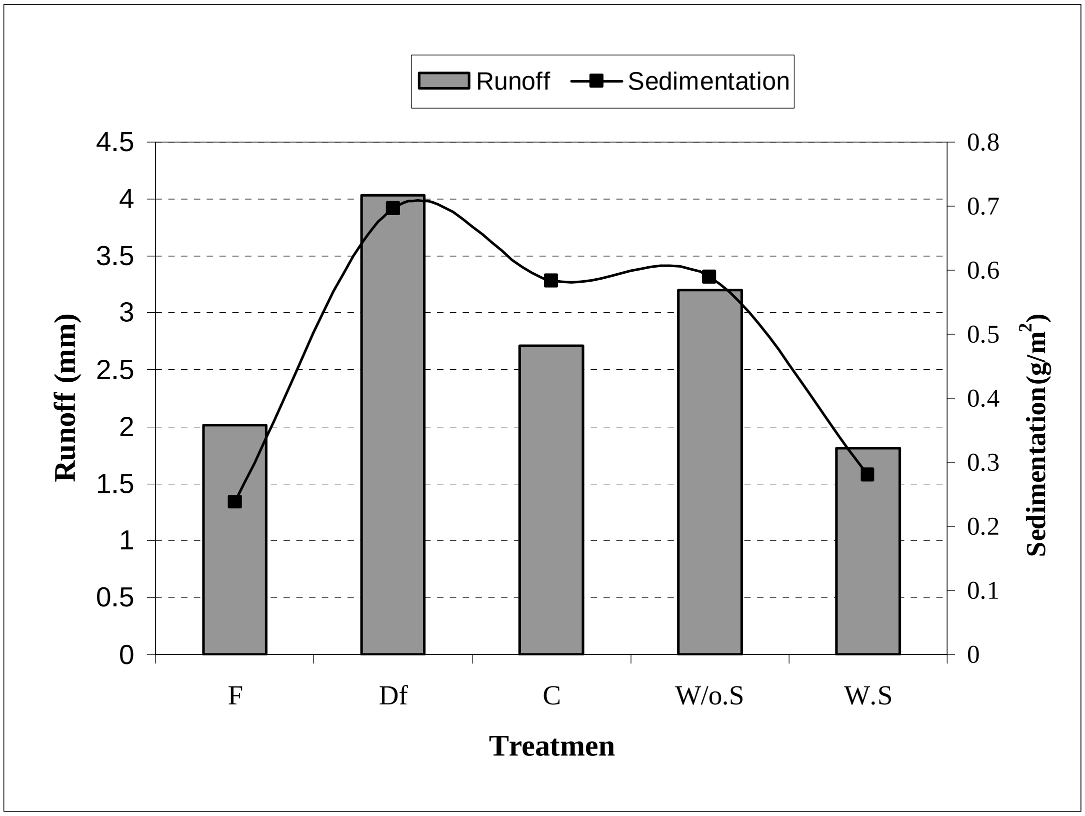


Figure (11) Relationship between total amount of runoff (mm) and accumulative sedimentation (g/ m^2), during winter season of 2004/2005 in treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df) and forest (F).

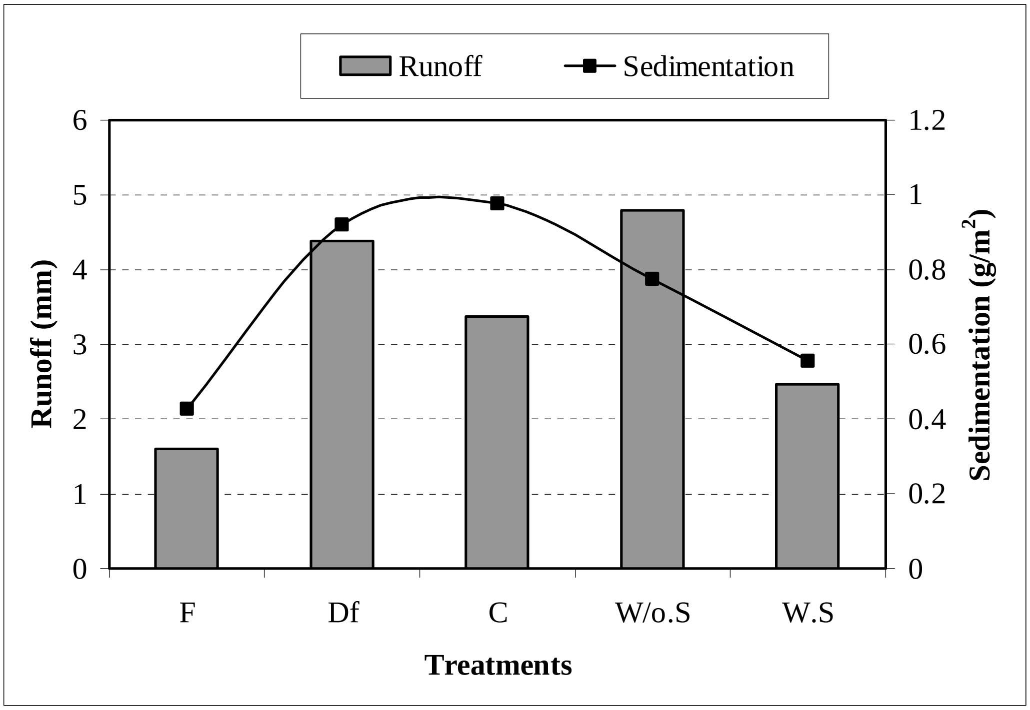


Figure (12) Relationship between total amount of runoff (mm) and accumulative sedimentation (g/ m^2), during winter season of 2005/2006 in treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df) and forest (F).

3.4 Soil water content

Soil water content (volumetric soil moisture) in all treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivated land (C), forest (F), and deforestation (Df), was measured starting from the end of rainy season (winter) in April until October during the years 2005 and 2006.

The results show that there is a significant difference in soil moisture at the two tested depths (15 and 30 cm) between the different treatments during the rainy seasons and summer seasons of years 2005 and 2006 (tables 16, 17, 18 and 19). There is a decrease in soil moisture during the summer season from the beginning of the first reading (April) to the last reading in (October) at the two depths (15 and 30 cm) in the two years 2005 and 2006 (tables 16, 17, 18, and 19).

Cultivated land had significantly the highest soil moisture content in the first reading at depth (15 cm) during the two seasons 2005 and 2006 (40.9 and 30, respectively) compared with other treatments except with *S. spinosum* treatment (tables 16 and 18). In addition, deforestation treatment had significantly the lowest soil moisture content in the first and last reading at two depths (15 and 30 cm) during the two years 2005 and 2006 compared with other treatments. On the other hand, treatment with *S. spinosum* had significantly the highest soil water content in the first and the most (mid and last) reading at the two depths (15 and 30 cm), in year 2005 compared with other treatments (tables 16 and 17). In years 2005 and 2006 no significant differences in soil moisture was found between the treatments during the first reading at depth (30 cm), except in deforestation treatment in year 2005 which have lower soil water content (tables 17 and 19). Depletion in soil moisture was vary between treatments; in some treatments depletion of soil moisture during the summer season was very slow (treatments with *S.*

spinosum and forest) compared with other treatments (deforestation and without *S .spinosum* treatments) at the two depths.

Table (16) Soil moisture at 15 cm soil depth during 2005 in treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df) and forest (F).

Measurements date	**W.S**	**W/o.S**	**C**	**F**	**DF**
30/3/2005	39.2 ab*	34.5 b	40.9 a	34.4 b	25.1 c
20/4//2005	31.4 b	26.5 c	36.1 a	30.4 b	21.8 d
7/5/2005	28.7 a	23.4 a	29.2 a	27.1 a	19.9 a
21/5/2005	26.2 a	22.7 b	25.1 cb	24.7 ab	17.1 c
9/6/2005	28.3 a	19.0 c	24.3 b	23.9 b	16.3 c
26/6/2005	24.3 a	19.5 b	22.9 a	22.6 a	13.0 c
16/7/2005	22.4 a	19.0 a	17.9 ab	19.3 a	13.3 b
3/8/2005	21.0 a	13.9 cd	15.6 bc	17.4 b	11.9 d
23/8/2005	18.3 a	13.5 ab	13.8 ab	17.3 a	10.3 b
10/9/2005	17.5 a	14.5 a	14.3 a	16.2 a	9.3 b
1/10/2005	17.9 a	14.0 b	13.4 b	16.4 ab	9.5 c

* Means followed by the same letter in the same row are not significantly different. According to Fisher LSD test at $P \leq 0.05$.

Table (17) Soil moisture at 30 cm soil depth during 2005 in treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df) and forest (F).

Measurements date	**W.S**	**W/o.S**	**C**	**F**	**DF**
30/3/2005	39.2 a*	36.5 a	39.8 a	34.2 a	24.8 b
20/4//2005	32.8 b	25.4 cd	38.3 a	28.9 bc	21.5 d
7/5/2005	28.0 a	24.9 a	29.3 a	27.9 a	21.1 a
21/5/2005	27.9 a	23.9 a	27.8 a	26.7 a	18.4 b
9/6/2005	28.6 a	21.5 b	27.6 a	25.5 a	19.8 b
26/6/2005	26.4 ab	22.6 c	27.1 a	24.3 bc	20.0 d
16/7/2005	24.7 ab	21.6 c	24.2 b	26.4 a	18.2 d
3/8/2005	22.5 a	18.5 bc	20.1 ab	21.7 ab	15.9 c
23/8/2005	21.1 a	18.1 ab	17.8 ab	21.3 a	12.8 b
10/9/2005	20.2 a	17.8 a	17.7 a	19.4 a	13.8 a
1/10/2005	21.2 a	17.2 b	17.1 b	17.8 b	11.6 c

* Means followed by the same letter in the same row are not significantly different. According to Fisher LSD test at $P \leq 0.05$.

Table (18) Soil moisture at 15 cm soil depth during 2006 in treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df) and forest (F).

Measurements date	**W.S**	**W/o.S**	**C**	**F**	**DF**
2.5.2006	30.4 a*	27.1 b	30.0 a	27.5 b	23.4 c
22.5.2006	27.2 a	22.0 bc	21.3 c	23.3 b	18.0 d
13.6.2006	25.3 a	20.4 b	20.4 b	22.3 ab	16.7 c
2.7.2006	23.9 a	17.4 b	18.1 b	22.0 a	15.9 b
26.7.2006	21.9 a	15.9 bc	17.8 b	17.6 b	14.0 c
15.9.2006	18.8 a	16.9 ab	16.0 bc	14.4 c	11.3 d

* Means followed by the same letter in the same row are not significantly different. According to Fisher LSD test at $P \leq 0.05$.

Table (19) Soil moisture at 30 cm soil depth during 2006 in treatments with *S. spinosum* (W.S), without *S. spinosum* (W/o.S), cultivation land (C), deforestation (Df) and forest (F).

Measurements date	**W.S**	**W/o.S**	**C**	**F**	**DF**
2.5.2006	30.6 a*	28.4 a	30.4 a	27.8 a	25.7 a
22.5.2006	28.7 a	23.1 c	25.6 b	24.2 bc	19.8 d
13.6.2006	27.9 a	22.6 b	23.2 b	23.6 b	18.6 c
2.7.2006	26.3 a	20.9 c	21.7 c	22.5 b	16.7 d
26.7.2006	23.3 a	20.1 b	19.8 b	21.0 b	16.1 c
15.9.2006	18.4 a	18.5 a	18.9 a	18.9 a	12.9 b

* Means followed by the same letter in the same row are not significantly different. According to Fisher LSD test at $P \leq 0.05$.

Chapter Four

4. Discussion

4.1 Soil properties

The organic matter amount reflects the percentage of plant residues and soil organisms that have lived and died in the soils. At the same time, its basic functions are the development and maintenance of soil structure, water holding capacity, nutrient and organic carbon storage, and the maintenance of biological activity (Fu, et al 2003).

The data from figure (4) showed that soil organic matter significantly higher in forest and with *S. spinosum* treatments compared with other treatments, these results probably related to the fact that under the trees of *P. halepensis* the needle of the trees decomposed and add high amount of organic matter; this result agree with study done by Ariza (2004) she concluded that afforestation with Aleppo pine (*P. halepensis*) improved the soil by doubling the organic matter content in the soil. In addition, in natural vegetation dominated with *S. spinosum* the organic matter is high probably due to the dominance of the shrub (mainly *S .spinosum*) which increase the amount of organic matter by adding and decomposition of plant litter. Similar results obtained by Al-seikh (2006), he found that organic matter content in the shrub land dominated with *S. spinosum* was the highest compared with other treatments. However, in other treatments the amounts of organic matter lower due to different causes. Cultivated land has lower organic matter because by cultivation most of the vegetation cover was cleared and removed which is the source of the organic matter. Similar results also found by (Al-seikh 2006 and Fu et al 2004), where they found that in cultivated land the amount of organic matter was lower than that in natural vegetation. In addition, the tillage practices increase and enhance the biological activity and so increases the decomposition rate of the organic matter (Dunjo et al 2003).

Soil pH considered as one of the most important parameter for the soil because it affects directly on the growth of the plant and other soil parameters. In all treatments the pH values are within the range for optimal plant growth condition (6-7.5) (Marx et al 1999). The significantly highest soil pH found in deforestation and cultivated treatments compared with other treatments, might be related to low soil moisture and low amount of organic matter (Rezaei et al 2005). In treatments with *S. spinosum* (W.S), forest (F) and without *S. spinosum* (W/o.S) no significant difference in soil pH was found (Table 1).

The EC was significantly highest in the forest treatment compared with other treatments. The afforestation did not affect the soil major nutrients (N, P, Na) content, that its effect on the pH and electrical conductivity was negligible and that it significantly improved the organic matter conditions (Ariza, 2004)

No significant differences were found in soil available NH_4^+, P, Na^+ and K^+ between treatments.

The data from table (2) show that the clay particles are relatively high in all treatments. The lowest amount of clay particles found in cultivated treatment. Changes in soil texture require very long time, and it was not expected to be changed within the period of this study.

4.2 Ground cover percentage

Change in plant community (plant density, biomass composition, and percent cover) after any type of disturbance take a long time as a result of many factors; climatic factors, soil, and plant – plant interaction.

The data in table (3) show that removing *S. spinosum* has lead to significantly higher percent of plant cover in year 2005 compared with cultivated treatment, which might be related to the removal and clearing the vegetation cover when the land was cultivated and the plants, mainly, the herbaceous perennial have no chance for regowth and extend over the land. On the other hand, no significant difference in plant cover percentage was found between the treatments with *S. spinosum* and without *S. spinosum* during the two seasons of 2005 and 2006. However, the cultivated land had significantly higher percent of bare soil compared with other treatments in season 2005, which might be explained by the removing of the vegetation cover from the land. During the second season the cultivated treatment still had significantly higher percent of bare soil compared with deforestation and with *S.spinosom* treatments (table 3) which is related to the fact that regrowth of plant take much time to return to its stability after cultivation. The significantly high rock cover percent in deforestation treatment during the two seasons might be explained by the fact that these sites exposed to sever damage, leaving the soil surface uncovered and so induce soil erosion as a result of deforestation and overgrazing fore a long period of time.

4.3 Effect of removal of *S. spinosum* and cultivation on plant characteristics

Human activity such as removal of shrubs and trees, aimed at decreasing woody cover while increasing the herbaceous yield began in the Mediterranean region in historical times and continued ever since.

The change in natural vegetation after disturbance (human activity) by aboveground shrub removal (*S. spinosum*) and cultivating the land was investigated to understand the dynamic of vegetation cover after the disturbance practices.

All vegetation parameters (density, biomass and plant cover percentage) were increased mainly for herbaceous plants by removing the *S. spinosum*. Removing the *S. spinosum* made available new resources and site for other vegetation component especially annual community.

4.3.1 Plant cover percentage

Although total vegetation cover did not increase significantly but vegetation cover of different plant group were changed significantly. A difference in plant cover between years was found during the study period. Plant cover was higher in 2006 than that 2005, which might be related to different causes such as rainfall, temperature, disturbance of the soil, and plant competition. Therefore, it is clear that there are no stability in plant community between years.

The results in table (4) show that when the *S. spinosum* was removed, this disturbance affect directly on the percent cover of grasses and forbs, which increased significantly during the two seasons of 2005 and 2006. This increase could be due to increase in resource availability (light, nutrient, space and water) and dispersal the seed or enhancement the seed bank from the soil, which means that competition between *S. spinosum* and herbaceous plant community (grasses and forbs) was decreased. These results agree with Strenberg et al (1999) who reported that the species richness and diversity was significantly increased after clearing the *S. spinosum* which means increase the percent of plant cover. Also, agree with Perevolotsky et al (2001), they reported that after removing the *S. spinosum* the cover percentage of perennial grasses increased.

The results in table (5) show that *Avena sterilis*, *Bromus sp*, and *Lolium sp*, have the highest grass cover percent in the two years 2005 and 2006 after removing the *S. spinosum*. This is might be related to the seed bank since the seeds have more chance to germinate and grow and increase the cover percent due to reduced the competition between the *S. spinosum* and grasses. In addition, it might be related to the type of seed production and the number of these seeds. These results agree with Strenberg et al (1999) who found that *Avena sterilis* become dominant after clearing the perennial vegetation (mainly dwarf shrubs).

After removing of *S. spinosum* new forbs cover become dominant. The results in table (6) show that *Lactuca virosa*, *lotus corniculatus* and *Uropermum picroides* have the highest percent forbs cover in treatment with *S. spinosum*. While *Trifolium stellatum*, *Crupina crupinastrum* and *Trifolium scabrum* have the highest percent cover after removing the *S. spinosum*, which might be related to the fact that the forbs in treatment with *S. spinosum* have more ability to compete with *S. spinosum* for the nutrient, water and light more than the forbs which occur after removing the *S. spinosum*.

4.3.2 Plant biomass

Competition can reduce plant biomass and growth rate and decrease its ability to survive and reproduce (Gurevitch et al 2002).

After removing the *S. spinosum* the grasses and forbs biomass increased significantly during the two seasons 2005 and 2006 (table 8). This result was due to the removal of *S. spinosum* which give more chance for other plants (grasses and forbs) to increase in number and size, as a result of less competition for water, nutrient and light between the grasses and forbs from one side and *S. spinosum* on the other side. In addition, forbs biomass increased much more than grasses biomass, which might be related to larger number of seeds that produced by forbs that lead to higher forbs density than grasses, and it have much ability to compete for water, light, and nutrients. Also, the sizes of most forbs are much larger than grasses size, and the leaves of forbs are larger than leaves of grasses which mean producing more biomass. This result agree with Facelli et al (2002) who mentioned that presence of shrub canopy inhibits the growth of annual species probably through reduce the light availability. In addition Pervolotsky (2001) found that after the removing of *S. spinosum* the annual plant biomass was increased. Generally when the plant grown without neighbors they are generally much larger than similar individuals surrounded closely by others and often have very different morphology or form.

4.3.3 Plant density

The results in table (12) show a significant increase in plant density when *S. spinosum* was removed during the two seasons of 2005 and 2006. This result can be explained by the fact that removing of *S. spinosum* increases the availability of the resource such as nutrient, water and light. However, despite of high soil moisture content in treatment with *S. spinosum* the plant density less than after removing the *S. spinosum,* which indicate that the competition between plant mainly for space and nutrients. Also, after removing the *S. spinosum* some annual species may be replenished there seed bank and grow as a result of less competition between annual species and *S. spinosum*. These results agree with Strenberg et al (1999) and Liat et al (1999) they mentioned that after the clearing of the shrub, herbaceous plants increased in their density, frequency, richness and diversity. However no significant differences of plant density was found between cultivated and with *S. spinosum* treatments; this mean that cultivation did not give the seeds of the plants more chance for germination.

4.4 Surface runoff

Rainfall intensity, slop gradient, vegetation cover and type, soil type, slop length and root systems are factors affect the amount of surface water runoff. Several studies demonstrated the positive effect of vegetation cover in reducing water runoff and soil conservation (Chirino et al., 2006, Dunjo et al., 2004, Abu hammad 2004, Chaplot et al., 2003, Reid et al 1999, Kothyari et al 2004 and Merzer 2007). There are a close relationship between each rainfall event and amount of runoff, which depend directly on the type of vegetation cover. Also, the presence of spares dead vegetation from the previous season is sufficient to decrease runoff generation during the early stages of the rainy season (Merzer 2007). The results in figures (7 and 8) show that close relationships between types of vegetation cover and the amount of runoff in each rainfall event. Deforestation had the highest surface runoff in each rainfall event, while in afforestation and with *S. spinosum* treatments had the lowest runoff during 2004/2005 and 2005/2006.

Removing the *S. spinosum* increase the surface runoff in 2005/2006. These results can be explained by the fact that there are differences between treatment in percent of plant cover, bare soil, rock cover, type of vegetation cover, and organic matter, which affect directly on the amount of runoff.

Data from figure (5) show that deforestation treatment had significantly the highest total amount of runoff compared with other treatments during the two years 2004/2005 and 2005/2006 except in without *S. spinosum* treatment in 2006. These might be related to the disturbance of the land when the forest was removed and decrease the impact of canopy interception from rain drops on soil. In addition, it was exposed to overgrazing for a long period of time after clearing the trees. Also, the significantly high rock cover in deforestation treatment compared with other treatments explains the high runoff in deforestation treatment. Figures (5 and 6) showed that forest and with *S. spinosum* treatments had significantly lower amount of total runoff (Mm) compared with other treatments during the two seasons 2004/ 2005 and 2005/2006. These results might be due to the phenomena of interception which decrease the velocity of rain drop and prevent the rain drop to impact directly to soil surface and splash the soil particles. In addition, the rain drop that intercepted by plant might be evaporated and go again directly to the atmosphere. Also, the good vegetation cover slowing down the overland flow and the root system of trees and shrubs play an important role in decreasing the runoff by improving the soil characteristics such as soil porosity, organic matter and increase the infiltration rate and so decrease the runoff. Furthermore, our result show that afforestation and with *S. spinosum* treatments have a higher organic matter compared with other treatments and this contributed to better soil properties such as porosity and aggregate stability, which increase the infiltration rate and decrease the water runoff and sedimentation, which finally lead to higher soil moisture in these treatments. These results agree with Chirino et al (2006) who mentioned that affortestation with Allpino pine (*Pinus halepensis*) and natural vegetation without trees are the same (not significant difference) in the amount of runoff. Also, Merzer (2007), reported that the interaction between trees and annual understory reduce the runoff close to nil. In addition, Al-seikh (2006) conclude that reforestation (shrub land) had significantly lower amount of runoff due to the high amount of organic matter and clay particles which improve the soil structure and increase the infiltration rate. Also Casermoero (2004) mentioned that runoff and soil erosion are significantly lower under shrub land as a result of high infiltration rate by adding the organic matter to the soil.

After removing the *S. spinosum* (without *S. spinosum* and cultivated treatment) the amount of runoff is significantly higher compared with other treatments (figures 5 and 6). These probably due to low interception of the rain drop, which mean that the rainfall drops fall with high speed and with high kinetic energy which increase the amount of runoff. Also, after removing *S. spinosum* the plant density increase significantly, but the percentage of plant cover does not change significantly, despite that the amount of runoff was higher after removing the *S. spinosum*, which might be related to the root system of the *S. spinosum;* which effect directly to the soil properties as well as the porosity of the soil, and so to the amount of runoff and infiltration rate. In addition, after removing the *S. spinosum* the annual plant (grasses and forbs) become dominant species, which do not have extensive root system similar to the shrub roots. These results agree with Gyssels et al (2005) who reported that plant roots penetrating the soil layer macrospores that improve the soil infiltration capacity which reduce the volume of surface runoff. Also, the disturbances of the land by removing of the *S. spinosum* and cultivation the land increase the amount of runoff.

4.5 Soil Erosion

Generally, there is close relationship between the amount of runoff and soil erosion (sedimentation).

The results in figures (9 and 10) show that there are significant differences in the total amount of accumulative sedimentation were found between treatments during the two seasons 2004 and 2005. From figures (9 and 10) we concluded that the forest and natural vegetation dominated with *S. spinosum* treatments had significantly lowest amount of sediments compared with other treatments during 2005 and 2006. The result can be related to the low amount of water runoff. On the other hand these might be related to high root system and to high organic matter content which improve the soil structure (Al-seikh 2006).

From figures (11 and 12) the data show that a close relationship between the amount of sedimentation and runoff, when the runoff increase the sedimentation increases. However, the significantly highest soil losses generated from cultivated treatment were equal to 0.58g/m^2 and 0.9g/m^2 in 2005 and 2006, respectively, compared with other treatments, except in deforestation treatment. In cultivated treatment despite of low amount of runoff compared with other treatments, the soil loss is high. These results may related to the fact that cultivating the land lead to break down the aggregate stability, loss of vegetation cover, expose the soil particles to direct impact of rain drops and detachment of the soil particles, as a result of these factors the soil particles become easy to movement by overland flow. Also, most of the prevailing erosion events were transport-limited or detachment-limited; in the case of cultivation the erosion occur by transport-limited factors (Abu-Hammad, 2004). In addition, Al-seikh (2006) reported that the amount of sedimentation is higher in cultivated land compared with natural vegetation as a result of loss of vegetation cover and detachment of the soil particles. In the condition under which the research was carried out the afforestation with *P. halepensis*; does not significantly reduce the runoff and sedimentation in comparison to the natural vegetation dominated with *S. spinosum*. Therefore, to reduce the risk of runoff and soil erosion after removing of *S. Spinosum* it can be achieved by increase the number of plant to maintain a stable and suitable plant cover.

4.6 Soil moisture

Many factors affect on soil water content such as topography, type of the soil, elevation, climatic factors and type of vegetation cover (Fu et al 2003 and Al-seikh 2006).

Evaluating the variation in the soil moisture is important because it determines the distribution of the vegetation cover and it is important to land – use planning. The results in tables (16,17,18 and 19) show that significant differences of soil water content were found between treatments at the two depths (15 and 30 cm) during the rainy season (winter) and summer season of years 2005 and 2006. These variations of soil moisture might be related to the differences in the characteristics of the ground cover (plant type, percent of plant cover, biomass and density). There is a decrease in soil moisture during the summer season in all treatments but at different rates. These might be explained by the fact that during the summer season the temperature increase which increase the evapotranspiration rate, and vegetation cover (mainly herbaceous plant cover) were decrease, then the shading effect decrease, and so the soil water content decrease, and with different plant cover percentage lead to different evapotranspiration rates. Merzer (2007) mentioned that twoards the end of the summer all the rainfall reaching the soil has been either entirely used by vegetation or evaporated directly from the ground.

Significantly highest soil moisture was found in treatment with *S. spinosum* in most of the reading at the two depths (tables 16, 17, 18 and 19). This is related to high infiltration rate under the shrub that collects the overland flow from the upslope. In addition, the shading effects which prevent the radiation of the sun to penetrate inside the shrub and so decrease the evaporation rate. In addition, under the shrub microenvironment the soil structure is very well developed and contain high amount of organic matter, which increase the efficiency of the soil to capture the water in the soil for long time. These agree with others (Parienteh 2002, Al – seikh 2006, and Fu et al 2004), whom mentioned that in the shrub area the soil water content is relatively higher than in cultivated and grass site.

Removing of *S. spinosum* (without *S. spinosum* and cultiuvated treatments) affect directly on the soil moisture at the two depths (15 and 30 cm). When *S. spinosum* was removed, soil water content decreased at the two depths compared with treatment with *S. spinosum*, this is related to the high runoff and less infiltration rate in treatment where the *S. spinosum* was removed. Also, the removing of *S. spinosum* decrease the shading effects which lead to increase the evapotranspiration and decrease the soil moisture.

Afforestation with *Pinus halepensis* had positive effect on soil moisture. There is a significant increase in soil moisture at the two depths under the forest compared with other treatments. These might be related to lower evaporation rate of water from the soil, high organic matter under the forest and the accumulation of leaves residue.

Recommendation

After two years of investigation the following recommendation can be suggested:

Human activity such as: deforestation, cultivation the land and removing the *S. spinosum* significantly increase the runoff generation and sedimentation production; which might be increase the possibility of land degradation. Also, these activities affect directly on the amount of soil water content. Therefore, for soil and water conservation in forest and rangeland keeping a suitable vegetation cover should be considered.

Removing the *S. spinosum* increase the herbaceous plant density, biomass and percent cover. It is important to beer in mind that such an activity must be considered in integrated grazing management plans.

However, two years of investigation is not sufficient to understand dynamic of vegetation cover after removing the *S. spinposum*. Therefore, many researches about the effects of vegetation cover on runoff and sedimentation must be taking place, due to the complex relationship between different variables.

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Appendix (A)

Table (20) Plant species recorded at the study site.

Scientific Name	Arabic Name
Adonis sp	شقائق النعمان
Aegilops binuncialis	
Aegilops genculita	شعير بليس
Ajuga chamaepitys	رجل الأرنب
Ajuga orientalis	عشبة الدم
Alcea setosa	ختمية
Allium neapolitanum	ثوم
Anagallis arvensis	عين جمل
Anchusa aegyptica	حمحم ابض الزهور
Anchusa sp	حمحم
Anchusa strigosa	
Andropogon distachyos	سنام شعبتين
Anthemis sp	إقحوان
Arnebia tinctoria	شجرة الأرنب
Asparagus stipularis	عجرم
Asphodelus aestivus	غيصلان
Astomaea seselifolium	بلبوس
Atractylis cancellata	ام خرس
Atractylis comosa	شوكة الغزال
Avena sterilis	شوفان
Ballota undulata	رسا
Bellevali flexuosa	ثوم ابيض
Bellevalia warburgii	بصيل جبل
Biscutella didyma	رغيف الراعي
Brachypodium distachym	دنبان
Bromus diandrus	
Bromus fasciculatus	ثرغول حزمي
Bromus lanceolatus	ثرغول سناني
Bromus tectorum	
Cardus argentatus	شوك عنتر
Carlina curetum	شوكة حمار
Carlina hispanica	ساق العروس
Carlina libanotica	حمرة
Carthamus tenuis	قوس
Ceratophyllum demersum	حامول
Chaetosciadium trichospermum	لزيقة
Cicer judaicum	حمص بري

Cichorium intybus	مدك
Cichorium pumilum	علك
Cistus creticus	لباد احمر
Coronilla scorpiodes	برجية الحمام
Crepis aspera	صفيرة
Crucianella macrostachya	صليبية كبيرة السنابل
Cruciata articulata	حلبلوب كاذب
Crupina crupinastrum	كروبينيا
Cyclamen persicum	قرن غزال
Cynosurus echinatus	ذيل الكلب الشائك
Daucus carota	جزر بري
Erodium gruinum	مسلة عجوز
Eryngium sp	قرصعنة
Evax contracta	قطينة
Gynandriris sisyrinchium	عقال
Hedypnois cretica	رويس الجبل
Helianthemum lippii	ورد الشمس
Helianthemum salicifolium	عدسية
Helianthemum vesicarium	ورد الشمس
Heliotropium arbainense	غبيرة
Hippocrepis unisiliquosa	
Hordeum spontaneum	شعير بري
Iris postii	سوسن
Lactuca virosa	خس بري
Lagoecia cuminoides	ريشة كروية
Lagousia falcata	
Lathyrus cicera	سعيسعة
Leontodon tuberosus	ربيان جبلي
Linum corymbulosum	كتانية عذقي
Linum strictum	كتان قائم
Lolium sp	زوان
Lomelosia palaestina	ركيبة
Lotus corniculatus	لوتس
Medicago sativa	قرط بنفسجي
Medicago scutellata	دحريجة
Melilotus indicus	حندقوق
Mercurialis annue	عصا هرمس
Micromeria sinaica	صليصلة
Nonea phillistaea	
Onobrychis caput-galli	جريس
Ononis orthopodiodes	

Ononis sicula	
Pallenis spinosa	بخور مريم
Phalaris sp	فلارس
Phangnalon rupestre	صوفان
Piptatherum holciforme	سنام عصافير
Piptatherum miliaceum	سنام
Plantago afra	قطونة
Plantago lanceolata	لسان الحمل
Poa bulbosa	نزعة
Rhagadiolus stellatus	رويس
Rubia tenuifolia	دبيقة
Salvia palaestina	
Sarcopoterium spinosum	نتش
Scandix pecten-veneris	ابرة الراعي
Scorpiurus muricatus	عنجد
Senecio vulgars	صفيرة
Silene aegyptiaca	عوينة
Silene aegyptiaca	احلوان
Sinapis alba	خردل
Sinapis arvensis	لفيتة
Smilax aspera	عليق
Stipa capensis	بهمة
Telmissea microcarpa	
Teucrium capitatum	جعدة
Teucrium divaicatum	كماندرة
Theligonum cynocrambe	
Tordylium officinal	دريهمة
Tragopogon coelesyriacus	ذيل الفرس
Tragopogon porrifolius	لحية التيس
Trifolium campestre	قرط اصفر
Trifolium purpureum	بيكا
Trifolium scabrum	برسيم خشن
Trifolium stellatum	برسيم نجمي
Trigonella berythea	حلبة برية
Trigonella stellata	حواجة
Urosperm picroides	قضيد
Valantia hispida	
Varthemia iphionoides	كتيلة
Verbascum sinaticum	عورور

Abstract (Arabic)
الخلاصة

تاثير نوع الغطاء النباتي على الجريان السطحي للماء و انجراف التربة

في هذه الدراسة تم دراسة تاثير نوع الغطاء النباتي على الجريان السطحي للماء و انجراف التربة. تم تنفيذ هذا البحث في منطقة صوريف الواقعة على بعد 10 كم شمال غرب مدينة الخليل. ولفهم العلاقة بين تاثير نوع الغطاء النباتي على الجريان السطحي للماء و انجراف التربة تم اختيار خمسة مواقع تختلف بخصائص الغطاء النباتي وتشمل غابة مزروعة باشجار الصنوبر (صنوبر حلبي) و منطقة ازيلت منها ألأشجار من اكثر من 20 سنة و منطقة نباتات طبيعية يسود فيها النتش و منطقة تم ازالة النتش منها و منطقة تم حراثتها.

القياسات التي تم جمعها تشمل: الجريان السطحي للماء بعد كل عاصفة مطرية و انجراف التربة في نهاية موسم المطر و الخصائص الفيزيائية والكيميائية للتربة و رطوبة التربة بالأضافة الى نسبة الغطاء النباتي وكثافة النباتات وكمية المادة الجافة للنبات.

دلت النتائج على ان هناك فروقات في كمية الجريان السطحي وانجراف التربة بين المعاملات المختلفة. حيث وجد ان المنطقة المزروعة بالصنوبريات والمنطقة التي يسود فيها النتش هي اقل المناطق للجريان السطحي وانجراف للتربة بالمقارنة بالمعاملات الأخرى. اعلى كمية انجراف للتربة سجلت في المناطق المحروثة والمناطق التي تم ازالة الأشجار منها. من ناحية اخرى وجد ان المنطقة المزروعة بالصنوبريات والمنطقة التي يسود فيها النتش تحتوي على اعلى نسبة من المادة العضوية و العناصر الأخرى ورطوبة التربة على عمقين (15 و 30 سم) بالمقارنة مع المعاملات الأخرى.

دلت النتائج ايضا على ان ازالة النتش ادت الى زيادة نسبة الغطاء النباتي للنباتات الرعوية وكذلك كثافتها و كمية المادة الجافة بالمقارنة مع المناطق التي يسود فيها النتش. بالأضافة الى ان الحراثة ادت الى زيادة المادة الجافة للنباتات الرعوية.

مع ذلك كله فان سنتين من البحث غير كافية لاعطاء الفهم و الصورة الكاملة عن تاثير نوع الغطاء النباتي على الجريان السطحي وانجراف التربة نتيجة للاختلاف الكبير في العوامل الجوية من امطار و رياح و درجة حرارة و غيرها.