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# Cropping Systems as Water Harvesting Techniques for Barley Production in Arid and Semi-arid Areas in Jordan

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## Abstract

**Purpose:**
The application of water harvesting techniques as a sustainability measure of the cropping system for barley production in the Fa'a farming area located in the northern part of Jordan, was investigated.

**Design/methodology/approach:**
Usually, the farmers plant barley to feed their animals. The climate of the area is semi-arid to arid. Annual average rainfall in the area is not enough for the survival of barley and farmers are usually grassing barley instead of harvesting. Overgrazing and mismanagement contributes to land degradation in the area, which affected the production system in the area.

**Findings:**
The research investigated the runoff collection system which is framed with two different sizes in three different land uses: cultivated with barley; fallow, and rangeland. Data was collected in all of five stormy events. The total soil sediment was measured for these land uses. The amount of water collected from runoff was also measured for the same areas. The ploughing against the slope with planting barley can reduce the runoff and soil sediment increasing soil moisture and reducing soil erosion. The barley production as biomass was highest using strip cropping as opposed to zero ratio control site or conventional cultivation. The plants' lengths were also higher in strip cropping ranging between 26-28 cm in the different strip cropping ratios compared to 23 cm in the conventional cropping system.

**Originality**:
By using the results from this new research to such an area, surface runoff from the uncultivated land can be used to supplement the rainfall to the cultivated land. This increases the share of runoff on the cultivated land to the degree where Barley can be harvested.

Key words: Water Harvesting, Strip Cropping, Rainfall, Runoff, Soil Erosion

## 1- Introduction

Water is the most important environmental factor that determins plant growth and fruit yield in Jordan, where rainfall is the main source of irrigation water. Agricultural production in Jordan depends on rainfall which is highly variable spatially and temporally. Jordan's availability of water for irrigation is expected to decrease in the future especially due to increased demands from other sectors. In Jordan about 70% of fresh-water is devoted to irrigation. Irrigation demand is expected to increase in the next decades due to enhanced food demands by the increasing population In Jordan population growth, coupled with economic growth and increased awareness of environmental needs, are now subjecting existing freshwater resources to considerable pressures (Lorite et al., 2004). The amount of fresh water available for irrigation is decreasing, and the decrease is greater in semi-arid zones, where drinking water resources are limited. Therefore, there is a constant need to improve water use efficiency. Water shortage is a worldwide problem and the only solution is to make efficient use of water in agriculture and to increase productivity of limited water resources. Shangguan et al. (2002)'s research indicates that 50% of potential water saving comes from water management practices. Due to water resource scarcity, water-saving in agriculture is an urgent need, particularly in the Mediterranean region. Governmental water agencies of the countries facing water scarcity encourage the farmers to shift from traditional to localized irrigation methods to save water (Luquet et al., 2005). The limited water availability in the Mediterranean ecosystems and the predicted decrease of water resources are leading to the urgent need to reduce water use for irrigation in the arid and semi-arid regions (Wahbi et al., 2005). Nevertheless, water scarcity and increased demand for water are causing pressure on reducing freshwater usage share in irrigation. Taking into consideration the degree of scarcity of water resources in many areas of the Mediterranean basin, if irrigation water usage is reduced, it could become a major water source, thus releasing resources for alternative use (Castiel et al., 2004). Jordan faces the same problem as it is classified among other countries of the world with limited water resources where demand exceeds supply (Shatanawi et al., 2006). In Jordan irrigation in agriculture consumes about 62% of the available water resources (Shatanawi et al., 2006). As stated in the Executive Programme 2007-2009 prepared by the Ministry of Planning and International Cooperation in Jordan, scarcity of water resources, low percentages of rainfall in addition to the inefficient use of existing water resources affect agriculture sector adversely. This in turn reveals the need for research on increasing the efficiency of water usage in agriculture. For this reason, this research has been conducted to investigate the suitability of water harvesting techniques as a method for sustainability of cropping system for barley production in Fa’a area in Jordan.

## 2-Literature review:

### 2-1 Water Resources in Jordan

The Middle East region is considered to be an arid or semi-arid area where water in most of the parts of the area is scarce. Jordan is not an exemption. Quoting from Project rainkeep website, Nydahl (2002) stated that Jordan has approximately 250 $m^3$ per capita per year compared to the 1000 $m^3$ per capita per year of replenishable water supply needed to support the average needs of a country’s population and civilization. Rainfall average varies from less then 50 mm in the eastern deserts to 600 mm in the high plateau areas of North Jordan (Al-Qudah, 2004). The average rainfall over Jordan’s agro-climatic zones is presented in Table 1. As reported by Namrouqa (2007), the Minister of Water and Irrigation in Jordan stated that Water demand in Jordan stands at 1,250 million cubic metres (mcm), while available resources don't exceed 830mcm annually. Namrouque (2007) further reported that the Deputy Prime Minister and Minister of Finance emphasized the means of addressing these challenges as: using advanced irrigation techniques; increasing the volume of investments in the field of water treatment and improving water infrastructure.

**Table 1:** The average rainfall over Jordan's agro-climatic zones

| Area | Rainfall (mm) | Area (km sq) | Percent of total | Rainfall Volume (mcm) |
|---|---|---|---|---|
| Desert | <100 | 633849 | 71.5 | 3414 |
| Arid | 100-200 | 19914 | 22.3 | 2947 |
| Marginal | 200-300 | 1965 | 2.2 | 513 |
| Semi Arid | 300-500 | 2947 | 3.3 | 1160 |
| Humid | >500 | 625 | 0.7 | 390 |
| Total | | 89300 | 100% | 8424 |

The average annual volume of rainfall in Jordan has been estimated to be 8.5 billion cubic meters. However, with high evaporation losses, the average net annual yield is only about 112 mcm (1.3%), with 875 mcm (10%) in the form of surface water and 242 mcm (3%) in ground water. About two-thirds of Jordan's potential usable water resources is surface water. About 400 MCM per year of the surface flow, which is 46% of the total runoff, forms the discharge in the Yarmouk River. Sustained yield and/or renewable groundwater resources are preliminary estimated at 3% of the annual rainfall; their recharge is mostly dependent on rainfall in the western highlands. In addition, it is estimated that over 11 mcm of stored fresh groundwater exists within the state, but this is mostly non-renewable groundwater which may offer opportunities for short-term and emergency uses (Masahiro, 1995). Jordan depends on a variety of water resources in an attempt to meet the increasing demands. These resources can be mainly classified into two categories conventional and non-conventional. The conventional resources include surface and ground water and the non-conventional include water from treated wastewater and desalinated sources. Water harvesting is considered as another water source in Jordan. It is common in the rural areas of Jordan where rainwater is collected from the roofs of houses and stored in concrete-lined wells. Building larger reservoirs to collect the water can expand this, and it is estimated that water harvesting reached about 6 mcm by year 2000 (Faruqui and Raschid-Sally, 2002).

### 2-2 Agriculture in Jordan

Cultivated lands comprise about five percent of the total land area, and are classified into two categories irrigated and rain fed. Irrigated lands are primarily located in the

Jordan Valley, and account for a relatively small area, comprising about 16% of the total cultivated lands in the country (Shatanawi, et al., 2003). Rain fed lands is primarily located in the hilly areas, and account for the remainder of the cultivated lands (Shatanawi, et al., 2003). In fact less than 8% of the land area of Jordan is arable, agriculture was the occupation of the majority of the population until 1946. Since that time socioeconomic and demographic changes in the country have dictated a decline in the status of agriculture in the economy. The agricultural sector's contribution to the gross domestic product (GDP) during the period 1980 to 1985 was 7.9%, down from 9% during the 1972 to 1975 period (Ministry of Planning, 1986). According to WTO Trade Policy Review (2008), agriculture's contribution to GDP was low, at 3% in 2008. However, as stated in the Executive Programme 2007-2009 of the Ministry of Planning and International Cooperation, the percentage of agricultural sector's contribution to GDP is planned to increase to 4% by 2017.

In terms of employment, agriculture's share had declined to 33.5% by 1961, and to about 12% by 1987 (Ministry of Agriculture, 1989). According to the Human Development Report (2007/2008), employment in agriculture's share in total employment is 4% for the period of 1996-2005. The apparent current trend towards a dry climate, (which prevails at the present time) with frequent droughts, together with misuse of land resources, is considered to be a primary cause of the development of unfavourable soil properties, and degradation of vegetative cover. More than 90% of Jordan suffers from dry climate and fragile ecological systems and undergoes various degree of desertification (UNEP, 2006). The misuse of land resources comprises overgrazing in the steppe and desert zones, as well as in the forestland of the Highlands. Overstocking of grazing animals has led to either destruction or severe cutting of plant cover, with subsequent exposure of the soil to the erosion effects of rainfall and runoff. Generation of dust storms by ploughing practices in the steppe zone is an additional factor in estimating soil loss by deflation.

### 2-3 Water Harvesting Techniques

A water-harvesting system is the complete facility for collecting and storing the runoff water (Frasier and Renner,1995). Water harvesting encompasses all those techniques, methods and innovations which induce collection and storage of water from various sources for its beneficial use including conservation practices in water deficient areas (Mengistie, 1997; 53). Boers (1994) defined water harvesting as: *"the collection and storage of any farm water, either runoff or creek flow, for irrigation use"*". In arid regions rain-fed agriculture is not feasible without the use of water harvesting (Critchley and Siegert, 1991). A fair amount of research have been conducted on water harvesting to solve the problem of irrigation water shortages. Examples of this research include, Arnon (1972), Boers and Ben-Asher (1982), Boers et al., (1986), Brunis et al., (1986), Akasheh and Abu-Awwad (1997) and Schiettecatte et al., (2005).

On the (UNEP) United Nations Environment Programme website, it is stated that water harvesting is often practiced in arid and semi-arid regions and that the basic technology requirements are: availability of at least 80 mm annual rainfall, and extended land areas, and absence of sharp topographical variations. Furthermore, according to the UNEP website, the reasons why water harvesting is considered as an effective tool for creating a sustainable, and productive farming system, are as follows:

> *"Water harvesting is a good way to transform lands under direct threat of desertification into agriculturally-productive lands thus, it is considered a practical means of resisting soil desertification in dry regions; it allows existence of a farming system suitable for the prevailing environment conditions, and with a minimum limit of needed investment; water harvesting is considered a successful approach for improving vegetative cover, by selection of suitable local plant species; water harvesting reduces rainwater losses, and allows the existing rainfall to be utilized in useful ways, including agricultural and other activities."*

Water harvesting occurs naturally or by intervention (Oweis, et al. 2003): Natural water harvesting can be observed after heavy storms, when water flows to depressions, increasing areas for farmers to cultivate whereas water harvesting by intervention involves including runoff and either collecting or directing it, or both, to a target area for use. Besides being applied to agriculture, water harvesting may be developed to provide drinking water for humans and animals as well as for domestic and environmental purposes (Oweis, et al. 2003). Each water harvesting system consists of a catchment (collection) area and a cultivated (concentration) area (Critchley and Siegert, 1991). The relation between the two, in terms of size, determines by what factor the rainfall will be multiplied (Critchley and Siegert, 1991). Nevertheless, it should be noted that calculations are always based on parameters with high variability. Rainfall and runoff are characteristically erratic in regions where water harvesting is practiced therefore, it is necessary to modify the original design in the light of experience, and often it will be useful to incorporate safety measures, such as cutoff drains, to avoid damage in years when rainfall exceeds the design rainfall (Shatanawi, 1995).

There are two main types of water harvesting techniques, namely: micro and macro catchment systems. Micro catchment systems include farm (contour bunds; semi-circular and trapezoidal; small pits; diamond shape; strip cropping) and rooftop systems. Macro catchment systems on the other hand have wadi-bed (small farm reservoirs; wadi bed cultivation; jessour) and off wadi (water spreading systems, large bunds, tanks and cisterns) systems. As strip cropping is focused upon in this study as a water harvesting technique, it is briefly explained in the following paragraphs.

Strip cropping is based on the principle of depriving part of the land of its share of rain, which is usually small and non-productive, and adding it to the share of another part. This brings the amount of water available to the area closer to crop water requirements and thereby permits economic agricultural production. Strip cropping involves planting row crops in strips across the slope, with alternate strips of grain and/or forage crops. The technique of runoff strips is suitable for gentle slopes. Carman (2005) stated that the reasons for introducing strip cropping are to, reduce soil erosion from water, reduce the transport of sediment and other waterborne contaminants, reduce soil erosion from wind, protect growing crops from damage by windborne soil particles and improve water quality. Strip cropping is a multi-purpose practice that has one or more of the following effects: reduce sheet and rill erosion; reduce wind erosion; increase infiltration and available soil moisture; reduce dust emissions into the air; improve visual quality of the landscape; improve wildlife habitat; improve crop growth, and improve soil quality (Chepil and Woodruff, 1963).

The points to be taken into account while strip cropping are as follows as stated by Carman (2005), *"the crops are arranged so that a strip of grass or close-growing crop is alternated with a clean-tilled strip or a strip with less protective cover; Generally, the strip widths are equal across the field; where sheet and rill erosion is a concern on sloping land, the strips are laid out on the contour or across the general slope; where wind erosion is a concern, the strips are laid out as closely perpendicular to the prevailing erosive wind direction as possible."* The strips are used to support field crops in the drier area (such as barley in the Badia), where production is risky yields are low. Strip cropping combines the soil and moisture conservation properties of cross slope farming with the soil building advantages of a crop rotation and is more effective in reducing soil losses. This technique is highly recommended for barley cultivation and other field crops in large steppe areas, where it can reduce risk and substantially improve production.

## 3-Materials and methods

The study area is on Faa Village. Faa is marginal land between agricultural and desert areas. Faa area is located in the northern part of Jordan, at 32.15 N and 26.5 E, with an altitude of about 750-800 m. The climate in Faa is dominated by a Mediterranean arid type of climate; it is characterized by a long, dry, hot summer, a cold, rainy winter and a short spring and autumn. The area has following characteristics: (1) the land is fragmented between farmers (2 to 5 ha per farmer), (2) most of the inhabitants have animals such as goats and/or sheep. The main problems in the study area are the shortage of water, and degradation of vegetation cover. For these reasons, research for sustainability of the cropping system has been conducted as a water harvesting technique for barley production in this area. Farmers usually plant barley to feed their animals. The average rainfall in the study area is about 160 mm/year; this amount of water is not enough for the survival of barley (ACSAD and MOA, 1990). Barley is the main crop which is commonly used in the study area. It is an important winter crop in the drier, predominantly rain-fed areas of West Asia and Africa (Tawaha, et al, 2002). Barley is sowed in October and November, harvested in May, but usually the farmers in arid and semiarid areas graze the barley crop instead of harvesting it. The Badia region, comprising more than 80 % (2.27 million ha) of the total land area of Jordan, receives less than 200 mm of rainfall annually (Department of Agriculture Statistics, 1994). Under stresses such as drought and cold, the yield of barley is much higher than that of oats, wheat or rye. The average harvested area of barley in Jordan is around 45000 ha. The grain yield of barley is low (average 770 kg/ha), far below the international average of 2606 kg/ha (Department of Agriculture Statistics, 1996). Barley grain is used as feed and food, and for malting purposes, while straw provides an important source of roughage. Many factors are responsible for yield reduction, including erratic and poor distribution of rainfall, low soil fertility levels, minimal use of fertilizers, an absence of high yielding varieties, a lack of effective weed control measures and a lack of basic knowledge of weed management in barley production. In 1998, Jordan's production of barley was 44880 tonnes and the area planted was 52740 hectares.

The data was collected from the study area. The study was related to runoff and soil loss measurement with a Sediment Sampler. The study was conducted at the Fa'a area in 2004/2005, on clay loam soil with 150 mm of precipitation per year. Strip cropping water harvesting technique was used as it was suitable for gentle slopes and barley production. A strip cropping was accomplished based on the Conservation Practice Standard Strip cropping Code 585. The experiment was designed according to the land use, where there were three different land use types: an area cultivated with barley; uncultivated (fallow); and rangeland. In each field there are 4 frames in two different sizes. Two frames were 2 m in width and 4 m in length. The other two frames were 2 m in width and 8 m in length. Frame methods for collection of runoff and sediments are shown in Figure 1. The slope in the entire field was 2-4%. Runoff samples were extracted after each storm events throughout the year by diverting runoff into a collection container. There were in total five storm events on the following dates: 24.12.2004; 15.12.2004; 24.1.2005; 1.2.2005; 3.3.2005.

**Figure 1** Frame methods for collection of runoff and sediments

A representative sample was taken at the end of each replication from the collection container and measured. Samples were shacked and 100 ml of each sample was dried in the oven at 100°C for 24 hours and weighed to determine the average sediment yield. Both fields were planted in November 2004 with barley seed (ACSAD cultivar) with 100 kg of seeds per hectare, and Di-Amino Phosphate (DAP) fertilizer was used at a rate of 100 kg per hectare. A planting machine was used to sow the seed sin rows which were spaced 20 cm apart from each other. Three treatments were used: 1:1, 1:2, and 1:3 metre ratios of cultivated to catchment area, which each had a strip width of 4 metres. Soil profile description is given in Table 2.

**Table 2** Soil profile

| | |
|---|---|
| Location: | One km from main road of Balama. |
| Physiography | Valley bottom. |
| Elevation: | 725 m over sea level. |
| Microrelief: | Gully, sheet erosion. |
| Precipitation: | 200 mm. |
| Drainage: | Well water. |
| General description: | Soil formed by calcareous material, colluviated from the higher neighbouring. |
| Horizontal: | There are three different horizontal, including the parent rock |
| Ap | 0-35 cm depth, colour: dark brown 7.5 YR 4/4, gravelly silty clay loam, weak very fine to fine sub angular blocky, friable sticky and plastic, very few gravels, many fine to very fine root, common pores.<br>Strongly effervescent, Clear smooth boundary.<br>Sand 23.3%, 31.6% silt, 45.1% clay. |

| | |
|---|---|
| | PH 8.0. EC 0.4 mm.hos. CEC 26.1. O.M 2.3%. $CaCO_3$ 33.2% |
| Bca | 35-105 cm depth, colour: strong brown 7.5 YR 5/6, clay loam, medium to coarse sub angular blocky, firm, sticky and plastic, very few soft concentrations of $CaCO_3$ nodules through the horizon, common pores, coarse fragment 5-10%.<br>Sand 24.3%, 37.3% silt, 48.4% clay.<br>PH 7.8. EC 0.94 mm.hos. CEC 24. O.M 0%. CaCO3 40.5% |
| C1Ca | 105 + cm depth, soft limestone loamy skeletal. |

## 4- RESULTS AND DISCUSSION

Technical assistance for laying out a strip cropping system was needed. The farm is divided into strips along the contour. An upstream strip was used as a catchment, while a downstream strip supports crops. Attention has been paid such that the downstream strip's width did not exceed 1-3 m, while the catchment width was determined in accordance with the amount of runoff water required (see Figure 2). Runoff strip-cropping was fully mechanized needing only a relatively low input of labour.

**Figure 2** Strip cropping system - planted by barley

### 4.1 Surface Runoff

Quantity of surface runoff was dependent on many factors such as: land topography and slope; nature of soil surface; surface and subsurface of soil profile; land cover and their type; period and intervals of rainfall; density of rainfall, and other climatic factors (evapotranspiration, temperature, moisture, wind, *etc*). Surface runoff occurred and reached to 0.5 mm when the rainfall was more than 1.5 mm. However, if the rainfall was less than 5 mm surface runoff would not be recognized. When the rainfall was more than 5 mm, the surface runoff increase would be clearly recognised with increasing rainfall (ACSAD and MOA, 1990). Runoff accumulation during season 2004/2005 is presented in Figure 3. Table 3 shows that there is a significant difference in the runoff according to the land use in the study area, at Fa'a. Runoff was highest on uncultivated land, less in range land, and lowest in cultivated land with measurements of 96.93, 36.74, and 12.86 $m^3$/ha respectively. This means that the ploughing and cultivating of the marginal land in Fa'a can sharply decrease the runoff. The surface runoff from the uncultivated land was 96.93 $m^3$/ha. This can be used to supplement rainfall to the cultivated land. This increases the share of the runnoff through the cultivated land, to the degree where barley can be cultivated.

**Table 3** Surface water runoff for three different land use systems, during the 2004/2005.

| Rain Storm | 1st 24/12/2004 | 2nd 15/12/2004 | 3rd 24/1/2005 | 4th 1/2/2005 | 5th 3/3/2005 | Total |
|---|---|---|---|---|---|---|
| Rain mm | 6.1 | 3.03 | 3.8 | 4.9 | 2.6 | |
| Runoff ($m^3$/ha) | | | | | | |
| Cultivated | 0.600 | 0.360 | 2.940 | 3.600 | 5.360 | 12.86 |
| Uncultivated | 17.220 | 19.420 | 21.410 | 27.10 | 11.780 | 96.93 |
| Range land | 3.320 | 2.250 | 10.260 | 11.30 | 9.610 | 36.74 |

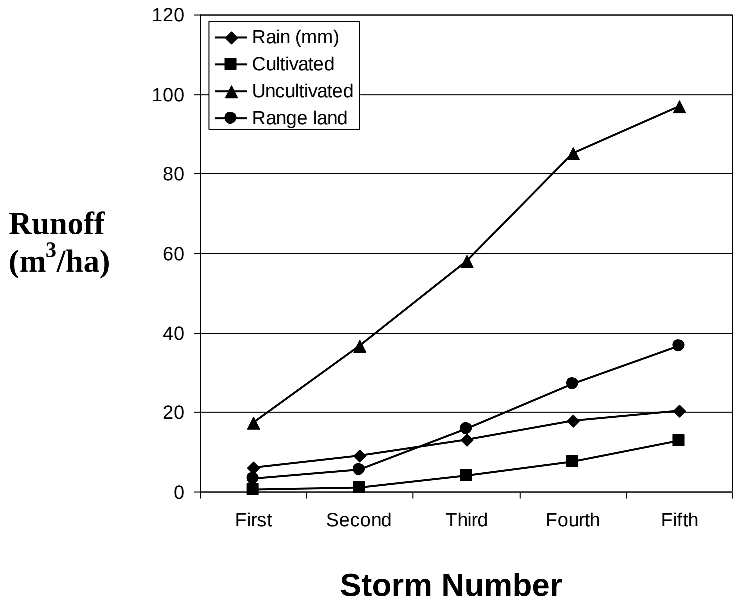


**Figure 3:** Runoff accumulation during season 2004/2005

### 4.2 Soil Loss Measurement with a Sediment Sampler

There are many factors that have an effect on the soil losses including, surface runoff quantities, surface runoff coefficient and the quantity and density of rainfall. The sediment loss is clearly affected by the same factors. In natural soil condition, when the rainfall is about 12 mm per day, with a density between 2-3 mm/hr, and a surface runoff coefficient between 5-10%, the sediment reaches between 0.2 to 0.6 kg/ha. The sediment loss reaches up to 10 kg/ha when the rainfall is about 24 mm per day (ACSAD and MOA, 1990). In the study area (Fa'a) for 2004/2005, the sediment/soil loss is less in cultivated and range land compared to uncultivated land. The lowest sediment/soil loss was on the cultivated and range land, whereas the highest was on the uncultivated land. Soil losses (sediments) during the season are presented in Figure 4. The average value of sediment loss was 8.28, 8.41, and 21.49 kg/m$^3$ for cultivated, range land and uncultivated land respectively as shown in Table 4. These results show that soil erosion can be controlled or reduced by using simple methods of water harvesting techniques (strip cropping) for the purpose of improving and developing the agricultural environments as vegetation land cover, organic matter, and biodiversity.

**Table 4:** Sediment from three different land use systems, during the 2004/2005

| Rain Storm | 1st<br>24/12/2004 | 2nd<br>15/12/2004 | 3rd<br>24/1/2005 | 4th<br>1/2/2005 | 5th<br>3/3/2005 | Total |
|---|---|---|---|---|---|---|
| Sediment (kg/ $m^3$) | | | | | | |
| Cultivated | 3.02 | 2.61 | 2.01 | 0.00 | 0.64 | 8.28 |
| Uncultivated | 4.00 | 3.34 | 4.75 | 5.06 | 4.34 | 21.49 |
| Range land | 4.06 | 0.51 | 2.34 | 0.17 | 1.33 | 8.41 |

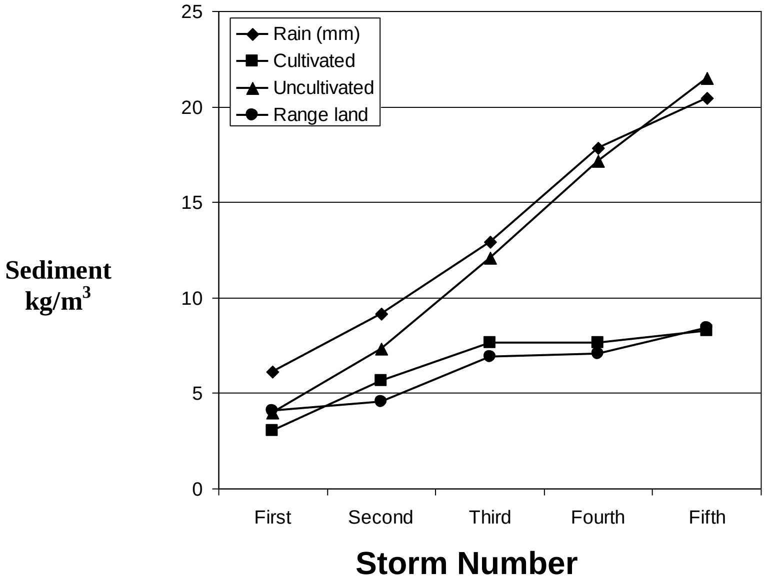


**Figure 4:** Soil losses (sediments) during season 2004/2005

For the strip cropping system the results are presented in Table 5, which shows that the barley production as biomass was highest using strip cropping ratios of 1:1, 1:2, and 1:3 as opposed to a conventional farm system. The products for these methods were; 160.3,150.7, 152.5, and 116.3 grams per one row meter length respectively. The plants length was also higher in strip cropping ranging between 26-32 cm in the different strip cropping ratios compared with 23 cm in the conventional cropping system. A strip cropping system with a 1:1 ratio was the best for biomass and crop productions, with maximum rate of land use meaning that the rate of land use is 50% in a 1:1 ratio, compared to 33% and 25% land use in the 1:2 and 1:3 ratios respectively.

**Table 5:** Agronomic information for dry land cropping systems at Fa'a, during the 2004 growing seasons.

| Treatment | Green wt. (gm) | Dry wt. (gm) | Seed number | Seed wt. (gm) | Plant length (cm) | Plant # |
|---|---|---|---|---|---|---|
| | One meter row length | | | | | |
| **Traditional** | 116.3 | 78.3 | 740 | 8.4 | 23.2 | 57 |
| 1:1 | 160.3 | 106.3 | 1272 | 11.6 | 26.2 | 46 |
| 1:2 | 150.7 | 82.7 | 1215 | 8.9 | 32.2 | 53 |
| 1:3 | 152.5 | 99.6 | 1091 | 12.9 | 28.9 | 47 |

## 5- CONCLUSION

Cropping systems are considered to be a valuable technique, especially in arid and semiarid regions to increase productivity of barley crops, and to decrease costs of production by saving machinery cost, seed, and fertilizer. It makes efficient use of available water and natural resources. Under good management, continuous cultivation of the cropped strip, soil fertility can be built up and soil structure can be improved, making the land more productive. It has the potential to increase the productivity of arable and grazing land by increasing the yields and by reducing the risk of crop failure and soil losses. Additionally, cropping systems help in combating desertification. The findings confirmed that the strip cropping technique is a good method for barley production for seed production, green biomass and/or pastured for sheep and goat and that strip cropping helps preventing or reducing the surface runoff, and soil erosion. Strip cropping can increase the surface and subsurface soil moisture. By using this technique, surface runoff from the uncultivated land can be used to supplement the rainfall to the cultivated land. This increases the share of runnoff on the cultivated land to the degree where Barley can be harvested. In dry land, farmers by using strip cropping techniques can obtain a good return through harvest barley crops and/or grazing, whereas in conventional cultivation systems farmers use their land only for grazing. However, the farmers may encounter the problem due to the un-uniform distribution of water across the strip. To overcome this problem, the cropped strip should not exceed 2 m in width, and that water distribution should be helped by good preparation of the strip surface.

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