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Effect of Water Harvesting with Runoff Strip Method on Lentil Yield in Şanlıurfa Province

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Abstract: Water harvesting is crucially important for arid regions where the deficits in rainfall are irregular and a great amount of this water is rapidly lost due to surface runoff. In the arid areas, water harvesting is directly related to process of plant growth and conservation of soil and water. Water harvesting is based on the principle of preventing a part of the land, which is usually small and non-productive, from getting the share of rain and adding it to the share of another part. This makes the amount of water available for the crop area and thereby contributes to economic and agricultural production. The most important land-based on micro catchments and farm water-harvesting systems in the arid areas are Contour ridges, Semi-circular and trapezoidal bunds, Small pits, Small runoff basins, Run-off strips, Inter-row systems, Meskat, and Contour-bench terraces. In this study, firstly, a detailed review on on-farm water-harvesting systems was performed. Secondly, a field experiment was carried out to determine the effect of water harvesting with run-off strip method on lentil yield. The experiment was conducted in Soil and Water Research Station, Şanlıurfa, Turkey. The area had low rainfall (370 mm year^{-1}) and high evaporation (2048 mm year^{-1}). Conventional and runoff strip method were applied with tree replication on plot of 12x2.8 m under the same condition. The straw and seed yields of control and Strip Plots application were 2663.7 and 4602 kg ha^{-1}, and 565.5 and 1160.1 kg ha^{-1} respectively. The results show that the runoff strips method increased straw and grain yield significantly. In addition, recent studies have proved that runoff strip method has the potential to hinder soil erosion by promoting water and crop productivity.

Keywords: Lentil, runoff strip, water harvesting

Şanlıurfa İlinde Akış Şerit Metodu ile Su Hasadının Mercimek Verimi Üzerine Etkisi

Özet: Kurak bölgelerde yağmur suları büyük miktarda düzensizdir ve bu sular hızla yüzey akış nedeniyle kaybolur. Su hasadı kurak bölgeler için son derece önemlidir. Kurak alanlarda, su hasadı doğrudan bitki büyüme ve toprak ve su korunması süreci ile ilgilidir. Su hasadı, arazinin bir bölümüne düşen genellikle az ve verimsiz yağmur suyu payını, bir başka bölüm arazisinin payına ekleyerek bu payı iki katına çıkarma ilkesine dayanmaktadır. Bu da ikinci bölge için gerekli sulama suyu miktarını karşılar duruma getirmekte ve böylece ekonomik tarımsal üretime katkıda bulunmaktadır. Kurak alanlarda uygulanan en önemli mikro havza ve çiftlik su toplama sistemleri; kontur sırtlar, yarı dairesel ve trapez setler, küçük çukurlar, küçük akış havzaları, yüzey akış şeritleri, inter-satır sistemleri, meskat ve kontur olan-tezgah teraslardır. Bu çalışmada, öncelikle çiftlik su toplama sistemlerinde ayrıntılı bir inceleme yapılmıştır. İkinci olarak, yüzey akış şeritleri yöntemi ile su hasadının mercimek verimi üzerine etkisini belirlemek amacıyla bir tarla denemesi yapılmıştır. Araştırma, Şanlıurfa Toprak ve Su Araştırma İstasyonu arazisinde yürütülmüştür. Alan, düşük yağış (370 mm yıl^{-1}) ve yüksek buharlaşmaya (2048 mm yıl^{-1}) sahiptir. Konvansiyonel ve yüzey akış şeritleri yöntemi aynı koşullar altında 12x2.8 m parsel üzerinde uygulanmıştır. Araştırma sonucuna göre, kontrol ve yüzey akış şeritleri için saman ve tohum verimi sırasıyla

2663.7 ve 4602 kg ha^{-1} ve 565.5 ve 1160.1 kg ha^{-1} bulunmuştur. Sonuçlar yüzey akış şeritler yönteminin önemli ölçüde mercimeğin saman ve tane verimini arttırdığını göstermektedir. Buna ek olarak, yüzey akış şerit yöntemi su ve ürün verimliliğini teşvik ederek toprak erozyonunu engellemek için önemli bir potansiyele sahip olduğunu kanıtlamıştır.

Anahtar Kelimeler: Mercimek, akış şerit, su hasadı

1. Introduction

Dry lands are known for their water scarcity, land degradation and declined livelihood. They constitute about 40% of the global area, 60% of which covers developing countries, spreading over 110 nations and sheltering more than a population of 700 million and their contribution to food security is well-acknowledged (Anonymous, 1994).

In the arid and semi-arid regions, water harvesting (WH) is vitally important due to the deficits in rainfall and irregular and rapid loss of water during the surface run-off. Water harvesting is based on the principle of preventing a part of the land, which is usually small and non-productive, from getting the share of rain and adding it to the share of another part. Run-off water is usually applied to an adjacent agricultural area, where it is both stored in the root zone and used directly by plants, or stored in a small reservoir for later use.

Rainwater harvesting is the process of capturing, diversion, and storage of rainwater for a number of different purposes including landscape irrigation, drinking and domestic use, aquifer recharge, and storm water abatement. The water balance is used as a tool to analyze the performance of the system, and to identify the problems during the water harvesting process. In addition to evaporation at the surface of the basin area, water is lost by deep percolation (Boers et al., 1986).

Macro catchment and floodwater-harvesting systems are characterized by having runoff water collected from a relatively large catchment. Micro catchment systems are those in which surface runoff is collected from a small catchment area with mainly sheet flow over a short distance. Contour ridges, Semi-circular and trapezoidal bunds, Small pits, Small runoff basins, Runoff strips, Contour-bench terraces and Inter-row systems are commonly used as micro-catchment water harvesting methods (Oweis et al., 2001).

Micro-catchment water harvesting (MCWH) can capture this local runoff and concentrate it into the plant basins before it is lost in the water conveyance network. Benefits of water harvesting are mentioned as speeding up of tree establishment and deep root development (Boers, 1994), an increase in crop productivity and diversity and a decrease in soil erosion (Gatot et al., 1999), and stable crop yield in poorly distributed rainfall areas (Oweis et al., 1999).

Vegetation can increase surface roughness and water infiltration rate, and decrease runoff volume that can reduce particles and sediment transport. Vegetative filter strips are defined as areas of vegetation designed to reduce transport of sediment and pollutants from surface runoff by deposition, infiltration, adsorption, and absorption (Dillaha et al., 1989). It has been recommended as a best management practice in controlling non-point source pollution from agricultural lands (Anonymous, 1976).

Li et al. (2000 and 2001) investigated the performance of grassed strips and mixed (grassed and treed) strips in terms of reducing agricultural non-point source pollution. The filtering effect of these buffer strips was compared with that of a control plot with no vegetative buffer. The grassed buffer filtered out 70% of the sediments contained in runoff water, whereas the mixed vegetation buffer trapped 90% of the sediment.

A number of studies were conducted to assess vegetative strips of varying size and composition for pollution. However strips farming and crops yield was not investigated adequately in this study. The runoff strips method can be applied with different crops. Lentils are grown in arid and semiarid region under different water management conditions. Lentils are slender, semi erect annuals, usually between 30 and 45 cm tall. Individual plants may vary from single stems to vigorous, bushy forms in dense or sparse stands. Lentils are grown in sandy loam soils, alluviums, black cotton soils, or in much heavier soils. They may be grown in moderately alkaline or saline soils where nutrient deficiencies are common (Summerfield, 1981).

Lentils can tolerate extreme environmental conditions of minimal rainfall and hot temperatures, although sensitivity to these stresses, particularly during flowering and fruit set, can have serious effects on yield. The crop is able to tolerate drought better than waterlogged soil. Worldwide, a large proportion of the lentil crop is grown in semiarid regions without the benefit of irrigation. India and Turkey are by far the world's largest producers. In most of those regions where lentils are important, agriculture depends on water conserved in the soil after fall and winter rains.

In this study, lentil was chosen because of mentioned properties as vegetative strip and conducted afield experiment with runoff strips method. The results were evaluated based on yield of straw, seed and biomass that depends on water use efficiency of lentil.

2. Material and Methods

2.1. Description of the study area

The study was conducted in the Tektek Soil and Water Conservation Research Station, located in approximately 45 km eastern of Şanlıurfa (Figure 1). The average altitude is 530 m and located between 37^{o} 07’ 30’’ North latitude and 39^{o} 15’ 00’’ east meridian. The research station is located in Tektek Mountains.

Local red lentil sowed 4 to 5 cm deep, inter rill with rows as 14 cm and 90 kg ha^{-1} seeds were used. The lentil crop has longer duration crops with duration of the total growing season of 150-170 days. Lentil plants were cut very close to the soil surface and land rolling was done before the plants reached the 5-7 node stage.

For the design of water harvesting systems, it is necessary to assess the water requirement of the crop intended to be grown. There have been various methods developed to determine the water requirement for specific plants. The lentil crops need 670 mm water per year in this region (Bilgel et al., 1997). In the absence of any measured climatic data, it is often adequate to use estimates of water requirements for common crops.

For the cultivation Lentil should be seeded as early as possible when the minimum average soil temperature reaches 5ºC. *Rhizobium* inoculants were used to increase the nitrogen fixing capacity of the plant. A well inoculated root system will be able to fix 60-80% of the nitrogen it requires from the atmosphere. The timetable for the cultivation was given in Table 1.

Table 1. The timetable for the cultivation for lentil

Timetable	
Time	Treatment
24.11.2006	Making treatment plots
27.11.2006	Planting lentil seeds
12.01.2007	Compacting the treatment plot
15.02.2007	Germination
15.04.2007	Flowering
18.05.2007	Harvesting

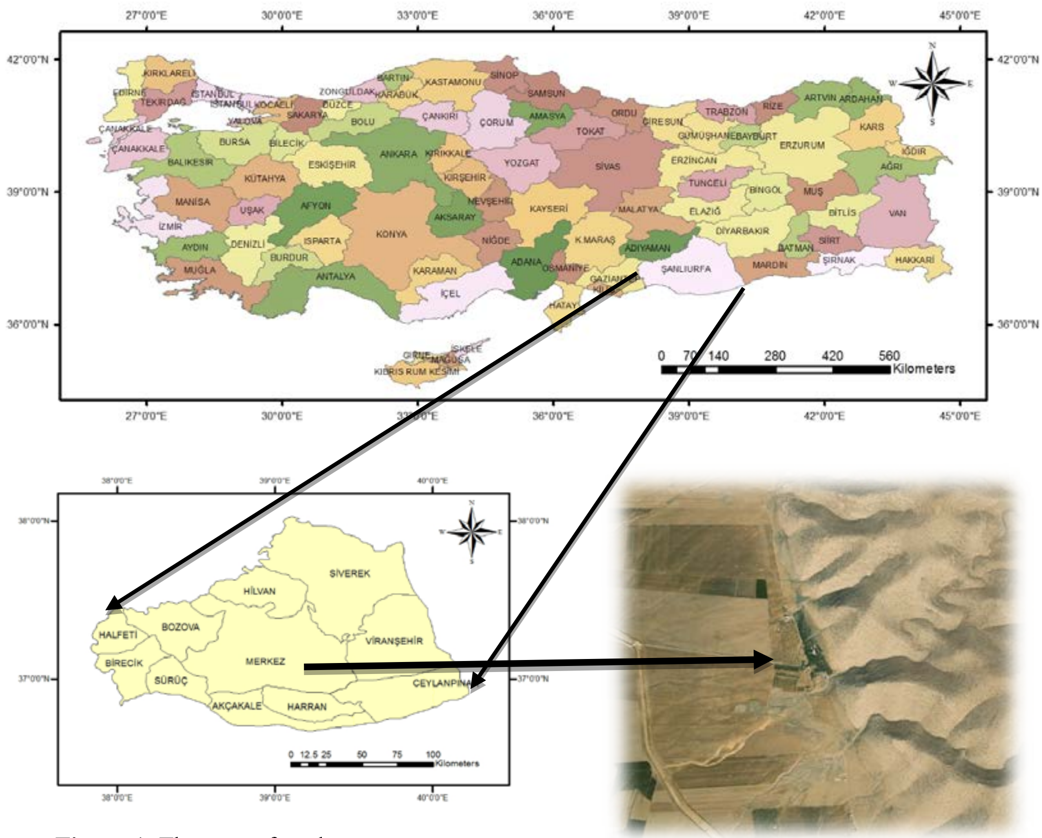

Figure 1. The map of study area

There have been a lot of systems for water harvesting. In this research runoff strips of Micro catchment Systems were used for water harvesting. Micro catchment systems are those in which surface runoff is collected from a small catchment area with mainly sheet flow over a short distance. For that reason, run-off strips are used to support lentil crops in these dry environments, where production is risky, and yield is low in Şanlıurfa province.

2.2. Soil characteristics of study area

The soil of the zone, Typical Torri fluvent had a clay silt soil texture, with 36% sand, 38% silt and 26% clay, 30% $CaCO_3$, 2.24% organic matter, 0.11% N (nitrogen), 21.2 kg ha^{-1} P_2O_5, and 1231 kg ha^{-1} available K_2O. pH of soil is 7.5. Salinity is 2.85 mmhos cm^{-1}, CEC (Cation Exchange Capacity) is 45 meq $100g^{-1}$, bulk density is 1.25 g cm^{-3}, field capacity is 29% and wilting point is 19% (Dinç et al., 1988).

The soils are stony, medium deeps, alkaline, non-saline, very lime, rich by phosphorus and potassium nutrients and very poor in terms of organic matter contents. Slope of area is between 5% to 12%. Soil of the study area has poor organic matter content due to the hot climatic conditions and rapid rates of decomposition. The infiltration rate of a soil depends primarily on its texture. The infiltration rate of the area is changeable between 7.5-25 mm h^{-1}.

The texture of a soil has an influence on several important soil characteristics including infiltration rate and available water capacity. Generally, the medium textured soils and the loams are best suited to WH system since these are ideally suited for plant growth in terms of nutrient supply, biological activity and nutrient and water holding capacities.

2.3. Climate of the study area

Climate of the research area is affected by Mediterranean climate although it is located in the region of Southeastern Anatolia climate. The annual precipitation of study area is approximately 370 mm. Distribution of rainfall are 56 %, 29%, 1% and 14% in the winter, spring, summer, autumn seasons, respectively. The average temperature is 18.1 ^{o}C, the maximum temperature is 46.5 °C and minimum temperature is -12.4 °C in the study area. The relative humidity is 48%, total evaporation is 2047 mm and daily sun shine duration is 8.73 hour.

2.4. Experimental setting and plant cover strips

The study area was divided into strips along the contour. An upstream strip was used as a catchment, while a downstream strip was used to grow crops. The experiment was designed with randomized complete block with three replications.

Conventional and runoff strip method were applied under the same condition. Each strip had 12.00 m x 2.80 m (Figure 2). But harvested area was 10.00 m x 2.24 m. The downstream strip should not be too wide (1–3 m), while the catchment width is determined in accordance with the amount of runoff water required. Runoff strip-cropping can be fully mechanized and needs only a relatively low input of labor. The lentil cropped strips are cultivated one year. Clearing and compaction can be needed to improve runoff. Agricultural inputs such as fertilizers and pesticides are applied to the cultivated area. Under good management, continuous cultivation of the cropped strip can promote soil fertility and improve soil structure, making the land more productive.

The plots were designed to slope as vertical. All of plots were fertilized with 30 kg ha^{-1} N and

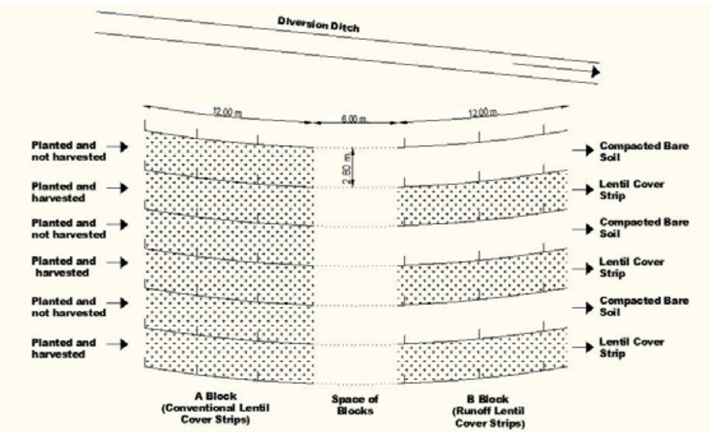

Figure 2. Runoff strips with lentil plant

90 kg ha^{-1} P_2O_5 as DAP, di ammonium phosphate, one times at the beginning of planted. The experimental design for the research was given in Figure 2.

3. Results and Discussion

The results of the straw, seed and biomass yield of lentil, and Independent Samples t test results were given Figure 3 and Table 2 for each yield.

The average straw yields were determined a 2663.7 and 4602 kg ha^{-1} for control and Strip Plots application, respectively. The average seed yields were 565.5 and 1160.1 kg ha^{-1} respectively. Biomass yield of strip plots application was given in Table 1. The average biomass yields of control plots and strip plots were determined 3229.2 kg ha^{-1} and 5762.4 kg ha^{-1} respectively. These results show that Strip plot application increased great amount of straw and seed yields. This differences were found significantly importance as statistically at P<0.001 level. But the important point is that half of field is used in strip plot application. That is why, it should be considered total area and its yield for the comparison.

When the yield of strip plots application was taken as half of yield is given in Table 1. There wasn't seen superiority of this application for one year production. But the using of half of field is decreased all expenses; soil tillage, cultivation, sowing, harvesting etc. According to experimental researches, total cost of lentil production is 1556.6 TL ha^{-1} in Şanlıurfa (Monis et al., 2011). At this situation it can be say that strip plot applications have advantages as economical. Also, compact plots are useful in the arid region. Water in this area is insufficient and evaporated easily. In this region, water can be collected with the compact areas in the strip plots and transferred to the near planted plots.

The fallow method is used for the conventional lentil production in study area due to water scarcity. But strip plot application is removed this requirement with the water harvesting and efficiently water using. When the two years are considered for this study, the advantages of strip plot application are seen clearly for sustainable and economical farming. Widespread adoption of water harvesting techniques by the local population is the only way that significant areas of

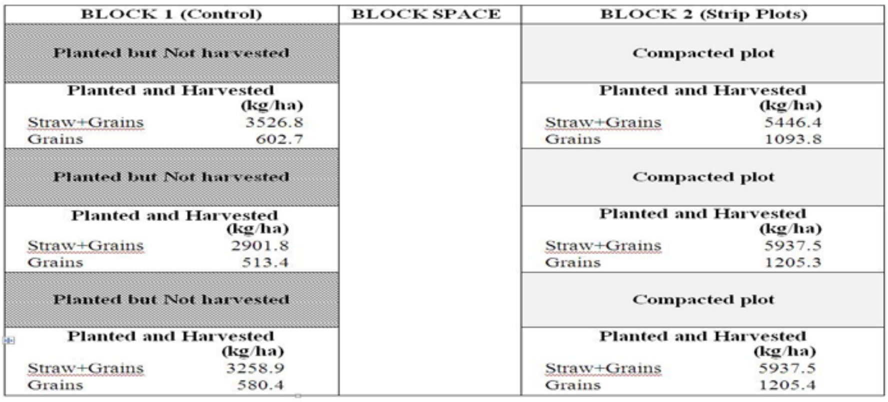

Figure 3. The experimental design of runoff strips with lentil plant

Table 2. Statistical data of treatments with yield of plants

Treatment	Replicates	Yields (kg ha^{-1}) Straw	Seed	Biomass
	1	2924.1	602.7	3526.8
Control	2	2388.4	513.4	2901.8
	3	2678.5	580.4	3258.9
Mean		2663.7***	565.5***	3229.2***
STD		268.2	46.5	313.6
	1	4352.6	1093.8	5446.4
Strip Plots	2	4732.2	1205.3	5937.5
	3	4722.1	1181.1	5903.2
Mean		4602.3***	1160.1***	5762.4***
STD		216.3	58.6	274.2

*** Significantly different at P <0.001 probability level land can be treated at a reasonable cost on a sustainable basis. It is therefore important that the systems proposed are simple enough for the people to implement and to maintain.

The results show that the runoff strip method increased straw and grain yields significantly. In addition recent studies have proved that runoff strip method has the potential to hinder soil erosion by promoting water and crop productivity. Furthermore, this kind of researches should be applied for different plant and different environmental conditions for dry land areas.

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