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Utilization of contour furrow and pitting techniques on desert rangelands: Evaluation of runoff, sediment, soil water content and vegetation cover

Mansour Jahantigh [1] and Mohammad Pessarakli [2*]

[1]*Department of Soil Conservation and Water Management, Research Center for Natural Resources and Agriculture, Sistan, Iran, 98616-44534.* [2]*Department of Plant Sciences, The University of Arizona, Tucson, AZ 85721, USA.*
**e-mail: pessarak@email.arizona.edu, pessarak@ag.arizona.edu*

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Abstract

This investigation was conducted to study the effects of pitting and contour furrowing techniques on rangelands evaluation in the Sistan Baluchistan province of Iran. This region consists of 17,0431 km^2 of arid to semi-arid rangeland, located in the southeastern section of Iran. It is one of the driest regions of the country, which is home to 11.4% of the population. With the annual rainfall of the region ranging between 50-120 mm, methods of decreasing run-off, controlling soil erosion and water conservation through the utilization of pitting and contour furrowing are critical to restoring the delicate ecological balance of the rangelands in this region. In this study, twelve 20 m × 40 m plots with a slope of 3-5% were designed to compare two treatments, pitting and contour furrowing with control fields. The data indicated that the effects of runoff, water penetration and increased soil moisture in those plots utilizing contour furrowing and pitting were statistically significant. In the control fields, the amount of runoff and sedimentation increased compared to that in the plots utilizing pitting and contour furrowing. Utilization of these constructions in harvesting rain water has been effective in controlling soil erosion. Successfully increasing water penetration and soil moisture content, deterioration of plant cover was reversed and forage production was improved. Furthermore, contour furrowing promoted propagation of *Hammada saliconica* species, a desirable plant species for both soil conservation and livestock grazing in the region.

Key words: Pitting, contour furrow, water conservation, range improvement practices.

Introduction

The rangelands in Sistan Baluchistan province of Iran are critical not only in maintaining an ecological balance but also in providing forage for livestock and wildlife, meat products for consumption and medicinal herbs. Importance of protecting this region from soil erosion and sedimentation is clear, especially in light of its extremely harsh climatic conditions. Effendi [4] in his IRAN-UNEP-FAO Conference initiative lecture stated that it takes 100-800 years for only 1 cm layer of soil to form. Since rainfall is sparse, irrigation is problematic, and poor land use practices (a common problem), the soil is characterized as deterioration under range condition [2, 4, 12].

Soil erosion in arid and semi-arid regions remains a major problem exacerbated in the rangeland in Sistan Baluchistan by constant seasonal winds blowing and the absence of effective measures to stem water runoff. Erosion is greater in some select soil types and in areas with steep slopes and lack of vegetation. These conditions result in erosion occurring at an accelerated rate. Management techniques that control soil erosion will enable us toward improved water quality goals [12].

Soil conservation is dependent on water conservation. Arid and semi-arid regions receive such sparse rainfall that agricultural activities or vegetation cover cannot survive on rainfall alone [9]. Consequently, it necessitates developing other means of conserving soil and water.

Furthermore, rainfall in the area is unstable, typically presenting in a few torrential rain storms with much of the water running off the surface causing flooding and soil erosion. As the rangeland conditions deteriorate, rainwater infiltration decreases and runoff increases [12].

Water conservation in the Sistan Baluchistan Province relies on trapping as much water as possible in either surface storage tanks or reservoirs. Another method of water conservation commonly practiced in the area is to allow the water to be absorbed into the soil in order to raise the water table and increase the soil moisture content. Therefore, water conservation efforts focus on decreasing the flow of running water through the utilization of pits and dams [5]. Water is distributed over a large area through the use of contour ditches and pitting. Pitting has been effective in increasing plant production. Moreover, the increased productivity of vegetation facilitates plant succession. Development of plant communities increases water percolation and retention as well as soil permeability.

Busscher and Bauer [3] reported that in southern Arizona desert, furrowing produced 2.5 times more grass than the adjacent untreated land. According to these investigators, soil moisture storage was 66 mm in the furrowed area compared to 30 mm in untreated soil. Furthermore, these investigators reported that the ridging or basin tillage practices increased soil water storage more than simply breaking the soil surface crust. Soil moisture storage increased by applying contour furrows at 1 to 1.5 m intervals and the yield of perennial grasses reached approximately 560 kg/ha. Li and Gong [8] reported that ridge and furrow rainfall harvesting systems with mulches increased water availability for crops for higher and more stable agricultural production in many areas of the loose plateau in northwest China. Furrowing the soil surface was found essential for maximizing rainwater storage and minimizing surface runoff [1]. Li *et al*. [7] reported that combination of contour furrows and plastic-covered ridges as rainwater harvesting system may have a great potential for development of the small rainfall dominated arid regions. The results of previous research have shown that the depth of tillage was the most important factor controlling soil moisture contents. Hudson [6] reported that deep tillage increased soil porosity, reduced surface sealing of the soil and permitted root proliferation to exploit soil water and nutrients deeper in the profile.

Water resources issues are increasingly becoming a major factor in soil conservation. The lack of comprehensive studies in managing water resources continues to be one of the most serious problems facing Iran. Water scarcity is a significant problem, especially through the use of new technologies [10]. This paper presents the field results of experiments conducted in 1998 through 2001.

The objectives of this investigation were to compare the effects of soil modification practices, such as contour furrow and pitting, on changes in runoff, sediment, soil water content and vegetation cover of desert rangelands in Sistan Baluchistan province of Iran, a typical desert rangeland.

Materials and Methods

The experimental plots were located on 3-5% slope (attitude 27°14'15"N, longitude 60°28'40"E, altitude 591 m) in the Sistan Baluchistan province of southeastern Iran. The area is an arid region with an average temperature of 25°C and an average rainfall of 100 mm having 38.2, 30.7, 18.2 and 12.9 mm in winter, autumn, summer and spring, respectively. The plots were established and used for these experiments during 1998-2001 by the Center of Livestock Research and Natural Resource of Sistan Baluchistan province. The experiments were conducted in a completely randomized design, consisting of 12 plots with four replications of three treatments. The treatments were (1) contour furrow, (2) pitting, (3) control field. Twelve 20 m x 40 m (800 m^2) plots were constructed on the 3-5% slope with concrete collection tanks 3000 litres in capacity at the down slope end (Fig. 1). Plots were prepared in 1998. Each contour furrow was 20-25 cm deep and 5-6 m wide on the level lines. Each pitting was 30-50 cm wide and 25-30 cm deep. The pittings were 80 cm apart from each other. In order to avoid transportation effects, soil sampling and field measurements were done on sediments collected from the ponds. Windbreaks and shade constructions were made using tin to fit the size of the ponds and were placed on top of them.

Runoff containing sediments from each plot was first collected into 3000 L sedimentation tank in order to trap the coarse sediments and store the runoff water. Depth of runoff containing sediments in each tank was measured and then thoroughly mixed with an agitator. A 300 ml portion of the soil suspension (runoff containing sediments) sample was taken from each sedimentation tank and evaporated in order to calculate sediment loss per litre of runoff and thereby calculating total sediments. Soil water content was measured by gypsum block up and down the soil profile down to depth 25, 50, 75 and 100 cm after calibration. Runoff containing sedimentation and water was measured after each rain and runoff collected in each plot was first transferred into a pond to trap mixed runoff (runoff containing sediments).

The vegetative cover was analyzed at the beginning and the end of each year of the study. For the soil moisture measurements, the gypsum block was placed at depths of 25, 50 and 75 cm after calibration. The soil moisture measurements were taken after each precipitation. The amount of runoff that entered each pond was measured. After complete transfer of runoff water from the plots to the ponds, the sediments in the ponds were collected and measured.

Statistical analysis: The data were subjected to Analysis of Variance (ANOVA), using SAS statistical package [11]. The means were separated using Duncan Multiple Range test.

Results and Discussion

Physicochemical characteristics of the soil samples are presented in Table 1. Carbon and organic matter contents of the soil were found very low in study area. This is mainly because during the experimental period (1998-2001) there was drought in the region (Table 2). Contour furrowing resulted in the lowest runoff and the least soil erosion (Table 3). The furrow-planting method consistently resulted in more soil moisture content compared with pitting and control treatments. The higher soil water contents in the furrow compared with pitting and control treatments were probably because of the furrow positions.

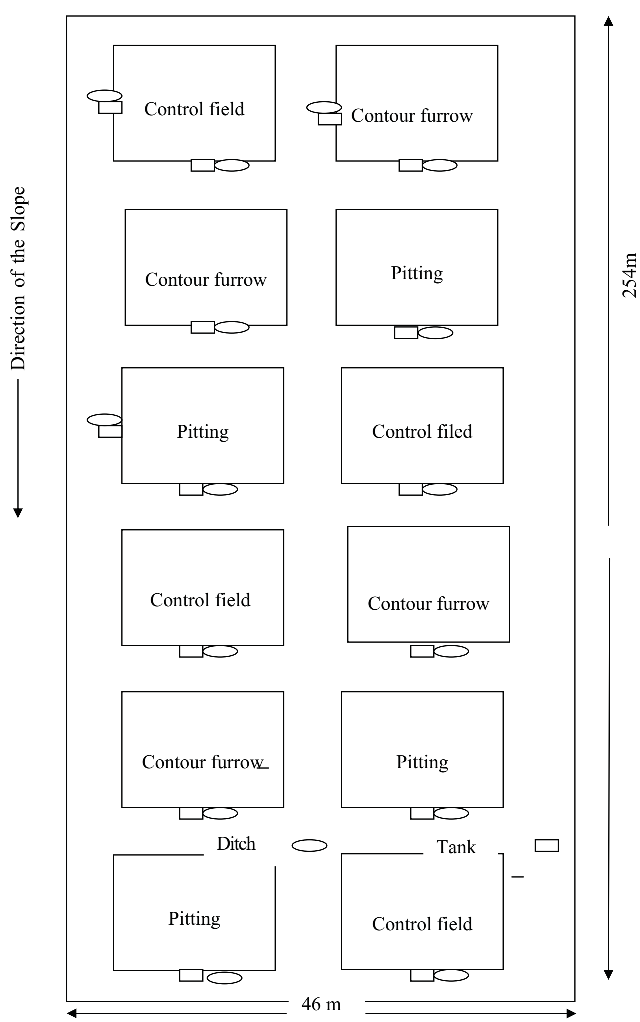

Figure 1. Plan of the study site.

Table 1. Mean soil chemical properties of the study area.

Sample No.	pH	EC dS/m	%OM	Ca (meq/l)	Mg (meq/l)	Na (mg/l)	K (mg/l)	P (mg/l)
D_1a-1	8.5	0.9	0.2	8.5	22.3	14.0	1.5	14.3

Table 2. Rainfall data of the study area (1998-2001).*

1998-1999	1999-2000	2000-2001	Year / Month
2	-		Oct
-	-	-	Nov
2	-	2	Des
19.7	8	-	Jan
-	26.8	-	Feb
-	-	-	March
1	3	-	April
-	0.8	-	May
3	-	-	June
-	-	-	July
-	-	-	Aug
	-	-	Sep
25.7	41.6	2	Total

*Data collection (rainfall, mm) from October 1998 to December 2001

Table 3. Data collection from the study area.

Treatment	Run off (l)	Sediment (kg)	Moisture (%)
Furrow	1000	0.5	11
Pitting	2000	1.0	10
Control	8000	10	7

Table 4. The number of *Hammada saliconica* plant species grown in the study area.

Treatment	Furrow	Pitting	Control
		Number of plants	
Before treatments	2c	2c	2c
After treatments	10a	8b	2c

The values followed by different letters are significantly different at the 0.05 probability level.

Soil water-holding capacity improved significantly by using furrow and pitting compared with the control treatment. The advantage of furrows is that water infiltration inside the furrows occurs in two-dimensions: vertical and horizontal. This was why the furrow soil surface treatments produced significantly better than pitting.

The numbers of the *Hammada saliconica* species populations were significantly different among the three treatments (Table 4).

Although there were no significant differences in yields between the fields utilizing contour furrowing and pitting, there was a significant difference in yields between the contour furrowing and pitting fields compared with the control fields. Also, the control fields had maximum runoff values.

Water storage within the soil profile to a 1.5 m depth was affected by soil modification practices. The soil profile of contour furrow and pitting was filled with rainwater to its maximum holding capacity during rainfall. Contour furrow had the most stored soil water compared with the other treatments.

Overall, the work done with contour furrow and pitting indicated their mutual potential in controlling both soil erosion and increase moisture availability in arid and semi-arid land in the study region of Iran. Furthermore, by controlling soil erosion and increasing soil moisture content, an increase in plant growth was resulted with further beneficial impacts on the environmental conditions.

Conclusions

This study was conducted in a section of an arid zone of Iran that experiences harsh climatic conditions which include warm to very hot weather throughout both the winter and summer months. The scarcity of groundwater resources of this region is a major concern, as is the rare phenomenon of locating new sources of groundwater due to the adverse geo-environmental conditions. The study area is characterized by a high evaporative demand region in the desert. This area, in fact, is a place of deposition of sediment load, both soluble and insoluble carried in the Kaskin and other major rivers and streams. The main source of water in this area is rainfall, which explains the critical importance of harvesting rain water. The results of this study showed that furrowing technique was most effective on the heavier textured soil. It produced miniature furrows and ridges across the slope that trapped more rainwater and provided it more time to infiltrate. Water storage was the highest when furrows were located exactly on the contour because water could move across the slope when there was even a slight gradient. More water was conserved by contouring on gradual than on steep slopes. This is because the effective capacity of channels decreased as the slopes became progressively steeper.

Generally, the soil in the study area had poor water retention capacities. This could be due to poor structure and low organic matter content of the soil in the region. Contour furrow technique had statistically significantly better residual moisture retention capacities than the pitting and control fields. The vegetation cover under contour furrow technique was significantly higher compared to vegetation cover under pitting and control fields.

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References

[1]Abu-Awwad, A. M. and Kharabshed, A. 2000. Influence of supplemental irrigation and soil surface furrow on barley yield in arid areas affected by surface crust. Journal of Arid Environments **46**:227-237.

[2]Brunist, H. J., Evenari, M. and Nessler, U. 1986. Rain water harvesting for Agriculture food production in arid zone: The challenge of African famine. Applied Geography **6**:13-36.

[3]Busscher, W. J. and Bauer, P.J. 2003. Soil strength, cotton root growth and lint yield in a Southeastern USA coastal loamy sand. Soil and Tillage **74**:151-159.

[4]Effendi, A. 1999. Specific needs and requirements of developing countries with low forest cover and unique types of forest. IRAN-UNEP-FAO Initiative, Low Forest Cover Country (LFCC) Meeting October 4 - 8, 1999, Tehran.

[5]Gilbertson, D. 1986. Runoff (floodwater) farming and rural water supply in arid lands. Applied Geography **6**:5-11.

[6]Hudson, N. 1987. Soil and Water Conservation in Semi-Arid Areas. FAO Soil Bulletin No. 57. FAO, pp. 172.

[7]Li, X.Y., Zhao, W.W., Song, Y.X., Wang, W. and Zhang, X.Y. 2008. Rainfall harvesting on slopes using contour furrows with plastic-covered transverse ridges for growing *Caragoa korshinshir* in the semi-arid region of China. Agricultural Water Management **95**:539-544.
[8]Li, X.Y. and Gong, J.D. 2002. Effects of different ridge-furrow ratios and supplemental irrigation on crop production in ridge and furrow rainfall harvesting system with mulches. Agricultural Water Management **54**:243-254.
[9]Prinz, D. and Wolfer, S. 1998. Opportunities to ease water scarcity (water conservation techniques and approaches; added values and limits). Proceedings, International Conference on World Water Resources at the Beginning of the 21st Century, June 3-6, 1998, Paris,UNESCO-IHP, Paris.
[10]Saleh, W. 2008. Running Dry: The Humanitarian Impact of the Global Water Crisis. IRIN, The United Nations, August, 2008, No. 8.
[11]SAS Institute, Inc. 1991. SAS/STAT User's guide. SAS Inst., Inc., Cary, NC.
[12]Sedivec, K. 1992. Water Quality: The Rangeland Component. NDSU Extension Publication R-1028, North Dakota State University.