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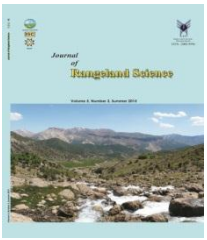

Research and Full Length Article:

Effects of Rangeland Restoration (Contour Furrows, and Mortar Stone Dam) on Soil Fertilization (Case Study: Silvana Region, West Azerbaijan Province, Iran)

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Abstract. The overgrazing and excessive utilization of rangelands has caused vegetation and soil degradation in many rangelands. In the rangeland management, the soil and vegetation elements, environmental factors and livestock should be considered as decision making agents. Various methods are applicable for the rangeland restoration as contour furrows and mortar stone dam. In order to evaluate the effects of restoration treatment on soil fertility parameters, this research was carried out in Rangelands of Silvana region, West Azerbaijan Province, Iran. Soil samples were taken based on a random method using six 100-m long transects in both treated and control sites. Soil samples were taken from the beginning, middle and end of each transect in both 0-30 cm and 30-60 cm depths. Nitrogen (N), Phosphorus (P) and Potassium (K) contents of soil samples were determined using Kjeldal, P-Olsen and flame photometer method, respectively. Differences between means of soil properties in the restoration and control treatments were compared by applying one-way ANOVA and SNK ($P<0.05$) test using $SPSS_{18}$ software. The results showed significant differences between restoration and control for soil properties. N, P and K contents in mortar stone dam treatment in both depth soils were increased as compared to contour furrows and control. According to the results, there are significant differences among P, N and K concentrations in both mortar stone dam and contour furrow treatments between upper and lower soil layers. But, amount of K in the upper soil layer of contour furrow and mortar stone dam treatments was less than lower layer. It was concluded that the constriction of mortar stone dam in the studied area had led to positive impacts on soil fertilization**.** Overall, the results show that in Silvana region, rangeland improving is possible through applying the mechanical operation of mortar stone dam.

Key words: Rangeland restoration, Mortar stone dam, Contour furrow, Soil fertilization

Introduction

The vegetation cover of most of Iranian rangelands has been overgrazed from many years and has become a threat for the animal production and its byproducts as well as soil stability (Azarnivand and Zare chahooki, 2008). Reduction of canopy cover, the destruction of structure of soil surface, and soil compaction as a result of overgrazing by livestock are some of the most significant factors degrading grassland (Manzano and Na´var, 2000, Mwangi & Swallow, 2008).

Altering plant community and soil properties by severe overgrazing leads to rangeland degradation and desertification (Steffens *et al*., 2008). To prevent this continuing degradation on these rangelands, it is essential to conduct the mechanical and biological restoration operations including shrubing, seeding associated with furrow, pit seed sowing and rangeland restoration treatments such as contour furrows and mortar stone dam in order to improve the vegetation and stabilize the soil surface to reduce wind and water erosions and improve the ecosystem function (Chen *et al*., 2012). Rangeland restoration treatments have positive effects on biodiversity (Abebe *et al*., 2006) and soil fertility (Mekuria *et al*., 2007).

It reduces soil erosion (Descheemaecker *et al*., 2006) and increases water availability (Hongo *et al*., 1995). Contour furrowing consists of plowing the soil to a depth of about 30 cm. Plowing breaks up the restrictive clay pan and may improve the soil productivity depending on the depth of water table and the amount of soluble salts beneath the surface (Sandoval and Reichman, 1971; Sandoval, 1978; Seelig and Richardson, 1991). It is performed in the areas with slopes less than 20%, medium depth and soil texture. This method is recommended in the areas with annual rainfall ranged from 100 to 300 mm (Azarnivand and Zare Chahooki, 2008). Usually to prevent the erosion and restore the eroded surfaces into waterways, cement small dams had been built that are called mortar stone dam. The opening in these dams built outside collected water using filter that is located between dam and weir. Researchers studied the effects of restoration operation on soil properties. Mofidi *et al*. (2011) evaluated the effects of Pit seeding on the soil and vegetation properties in Imam Kandi rangelands, Iran. They expressed that due to pit seeding, soil Electrical Conductivity (EC), organic matter and N, P and K contents in first depth were significantly increased as compared to control while pH and Carbonate Calcium Equivalent (CCE) decreased. In the second depth, EC, CCE, organic matter and N and P contents increased as compared to control while pH and K decreased by conducting pit seeding. Vegetation properties (canopy cover, yield, density and litter) in pit seeding treatment significantly increased as compared to control**.**

Jafari *et al*. (2009) studied the effects of rangeland restoration treatments on some aspects of soil and vegetation parameters in Sirjan rangelands. They noted that the improvement practices had significant effects on increasing the canopy percent, yield, vegetation density of I and II classes and decreasing III class vegetation. The investigation of studied soil specification with t test showed that nutritive elements of N, P, K and organic matter had significant differences between every treatment site and control sit.

Rich (2005) studied the effects of contour furrow on soil, vegetation, and grassland breeding birds in North Dakota, USA. His results showed that breeding bird densities did not differ between the treated and untreated sites during three years and the chemical makeup of soil on two sites was similar for 20 years following the treatment but vegetation cover was different. The treated site had

greater cover and unidentified lichen than the untreated site. Chamani *et al.* (2011) investigated the effects of three operation systems of contour furrow, pitting and enclosure on rangeland improvement in Golestan Province, Iran. Their results showed that contour furrow had more efficiency for plant characteristics as compared with the other operation systems. Habibzadeh *et al.* (2007) in the study of reform operations for the storage of moisture and increased vegetation in Khajeh station, West Azerbaijan, Iran had concluded that in the lands with heavy texture, contour furrow and pitting led to the precipitation storage, soil conservation and vegetation improvement. Jahantigh & Pesarakli (2009) investigated the effects of pitting and contour furrow of rangelands in Sistan and Baluchestan province, Iran. Their results showed that the effects of contour furrow and pitting techniques on the increases of runoff, infiltration and soil moisture statistically were significant. They stated that with the increased water infiltration, soil moisture and soil erosion control, soil conditions were improved. Based on literature, we hypothesize that the restoration treatment improved soil properties. The aim of present study is to investigate and compare soil fertilization parameters (N.P.K) in two restoration treatments and control site in Silvana rangelands, Urmia, Iran.

Materials and Methods

Study area

Silvana is located in West Azerbaijan province at 32.5 km of Urmia town, Iran between 44˚46' 55.9" W to 44˚51'58.5" E and 37˚21'45.8" S to 37˚23' 57.5" N. The mean altitude is 2100 m ranging from 3139 to 1702 m above sea level. Region area is 1579 ha. This region has a cold semi-arid climate with mean annual rainfall of 398 mm and mean annual temperature of 12.8 ºC (Fig. 1).

Mortar stone dam was constructed in 2000 in Khalilrajan Mountain with the area of 538 ha. Contour furrow treatments were also established in 2000 in the area of 625ha at Sarshiv region (local name) and finally, control area is located at Barandooz area which is next to Mortar stone dam and Contour furrow treatments. None of them were located in the enclosure.

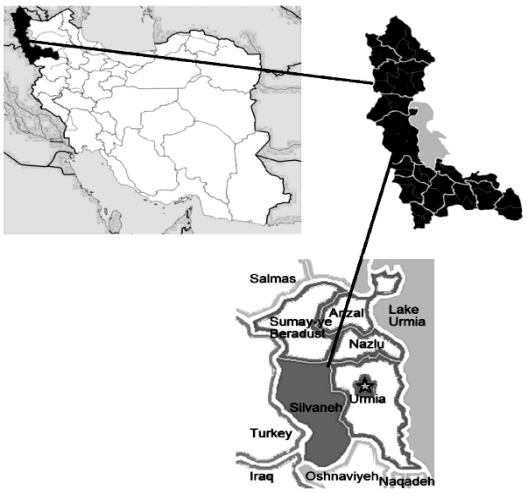

Fig. 1. Geographical location of studied sites, Silvana rangeland, Urmia, West Azerbaijan, Iran

Sampling method

Sampling was conducted using a randomized method in six 100-m long transects in each area. Soil samples were collected from the depth of 0–30 cm and 30-60 cm. These are the depths of rangeland species root system (Jafari *et al.*, 2009). In each transect, soil samples were taken in the beginning, middle and end of each transect and then, they were mixed together to make one sample for each transect. Totally, 36 soil samples were collected. The soil samples were air dried, crushed by hand, passed through a 2-mm sieve, mixed and analyzed for different determinations. Total N content using Kjeldal (Bremmer & Mulvaney, 1982), the amount of available P by P-Olsen (Olsen & Sommers, 1982) and K using flame photometer were calculated (Boltz & Howel, 1978).

Statistical analysis

Data were tested for normality before conducting a statistical analysis using the Kolmogorov Smirnove test (Bihamta and Zare chahouki, 2010). For means comparison of soil properties in the restoration and control treatments, ANOVA and SNK tests ($P<0.01$) with $SPSS_{18}$ software were used. Then, means comparison of N.P.K values between treatments at two different depths was done by Excel software graphs. Finally, to compare the N P K factors in two depths of soil, Paired-Samples T-Test was used.

Results

Results of one-way ANOVA between three treatments (contour furrow, mortar stone dam and control) are presented in Table 1. According to the results, there were significant differences among treatments for N, P and K in upper soil layer (0-30cm). But there were no significant differences between treatments for P and K in lower soil layer. Results showed that in depth of 0-30cm, N% in mortar stone dam (0.18%) was higher than control (0.09%) and contour furrow as 0.14% (Fig. 2). Soil P in mortar stone dam (17.25 ppm) and contour furrow (12.75 ppm) treatment at upper layers (0-30) was higher than control (8.24 ppm). However, there were no significant differences between mortar stone dam and contour furrow and also between control and contour furrow treatments (Fig. 3). There was a significant difference among three treatments for K (Fig. 4).

In lower depth (30-60 cm), higher values of N% were obtained in contour furrow as 13% (Fig.2), but there were no significant differences for P and K in three treatments (Figs. 3 and 4).

Table 1. Variance analysis of N.P.K amount among three treatments in 0-30cm and 30-60cm depths

Source of variation	df	MS					
		Nitrogen (N)		Phosphorus (P)		Potassium (K)	
		0-30cm	30-60cm	0-30cm	30-60 cm	0-30cm	30-60cm
Treatment	2	2.364**	1.211**	243.91**	110.29 ^{ns}	77278.58**	8023.86^{ns}
Error	33	0.26	0.173	29.49	37.01	2105.19	3632.38

**, ns= Significant at 1% probability level and non significant, respectively

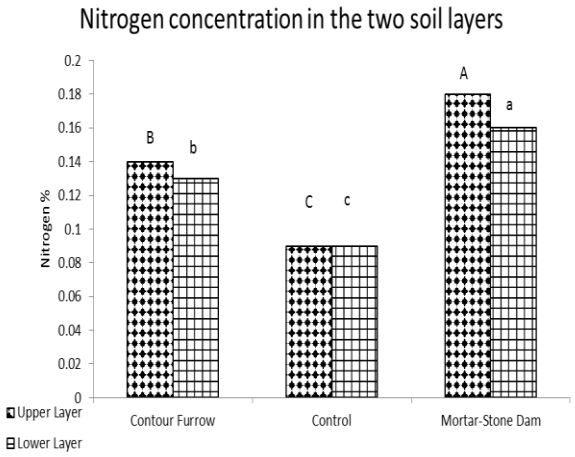

Fig. 2. The effects of rangeland restoration on N (%) concentration in two soil layers
Means with the same upper case and lower case letters are not significantly different ($\rho<0.01$)

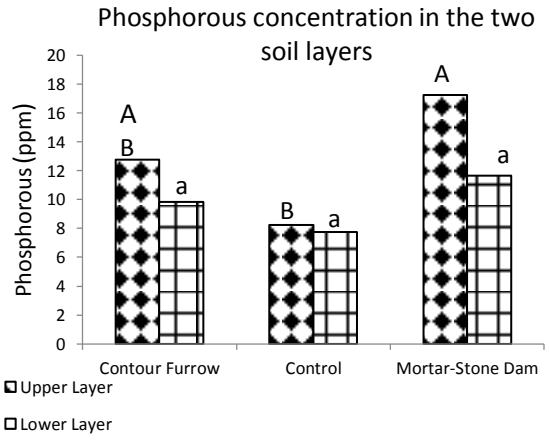

Fig. 3. The effects of rangeland restoration on Phosphorous concentration in two soil layers
Means with the same upper case and lower case letters are not significantly different ($\rho<0.01$)

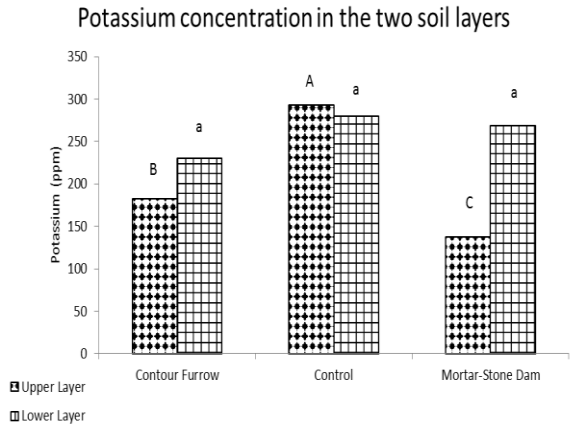

Fig. 4. The effects of rangeland restoration on Potassium concentration in two soil layers
Means with the same upper case and lower case letters are not significantly different ($\rho<0.01$)

As the final step, the N, P and K values were compared in two depths of soil using Paired-Samples T-Test (Table 2). According to the results, there were significant differences between two depths for P and K concentrations in mortar stone dam. In control, there was a significant difference between two depths and only for Phosphorous (Table 2). As explained in figures, higher values of N and P were obtained in upper soil layer and lower values of K were obtained in upper layer in both contour furrow and mortar stone dam (Table 2).

Table 2. Comparing N P K factors in two depths of soil using Paired-Samples T-Test

Restoration Treatment	Soil Fertility	0-30cm	30-60cm	T value
Contour furrow	Nitrogen (%)	0.14	0.13	0.85 ^{ns}
	Phosphorous (ppm)	12.75	9.85	2.39 *
	Potassium (ppm)	182.83	230.25	2.15 *
Mortar stone dam	Nitrogen (%)	0.18	0.16	2.42 ^{ns}
	Phosphorous (ppm)	17.25	11.64	3.22 *
	Potassium (ppm)	137.17	268.16	4.21 **
Control	Nitrogen (%)	0.09	0.09	0.79 ^{ns}
	Phosphorous (ppm)	8.24	7.73	0.25 ^{ns}
	Potassium (ppm)	293.25	279.66	4.17 **

**,*, ns= Significant at 1% & 5% probability level and non significant, respectively

Discussion

Based on the results of means comparison and soil parameters in the improvement treatments, soil parameters in the mortar stone dam were higher than the other treatments. So, we can conclude that in Silvana region, improving the situation of soil parameters through applying the mechanical operation of mortar stone dam is possible in rangelands. It can be stated that despite the primary aim of construction mortar stone dams, they tried to control the sediments carried by the flow of water and water supply for the agriculture, livestock, forestry and range management. But this issue should be noted that construction structures as transverse along the rivers and channels balance the slope of the floor in addition to prevent the sediment transport. The slope balancing reduces the flow rate and the reduction of peak flow in watershed will increase the time of concentration. The overall structures that were constructed across the channel created a delay in runoff time. As a result, a greater amount of water penetrates into the soil and at that time, it reduces the soil erosion and runoff. On the other hand, it increases the soil moisture, period of plant growth and plant production. Chamani *et al.* (2011) believe that the purpose of improvement treatments such as creating contour furrow is to control the surface runoffs and increase the vegetation. Jahantigh (2007) concluded that some operations for storing the precipitation can help to increase the soil permeability and supplying the aquifers for groundwater increases the vegetation density leading to the increased production and capacity of rangelands.

With increasing the coverage, the plant roots increase the number of

bacteria that solubilize calcium phosphate. These bacteria are able to secrete organic acids such as lactic acid which makes dissolve calcium phosphate and thereby will increase the soil phosphorus. Zakeri *et al.* (2013) pointed out that the reclamation and improvement practices influenced soil phosphorus levels. Thereby, comparing the mean values of K between contour furrow and mortar stone dam treatments with control treatment showed that the amount of K decreases due to the restoration treatments. Mut and Ayan (2011) found that due to restoration treatment, mean of organic matter, P and Ca was increased while pH, EC, K and Mg were decreased. On the other hand, nitrogen-washing that was one of the most important factors of N losses and the function of factors such as soil and vegetation was reduced. This, in turn, led to the creation and improvement of vegetation, the return of litter to the soil and the improvement of soil parameters in the area. Saffariha *et al.* (2014) indicated that vegetation cover strongly influences soil N content. Jafari *et al.* (2009) found that increasing vegetation cover resulted in improving soil chemical properties and increasing water infiltration; thus, more dense vegetation and appropriate aeration and litter enhancement were caused and its decomposing increased soil organic matter in the restoration treatments such as seeding and also increased N and P contents. Naderi *et al.* (2000) reviewed the effects of construction on the mortar stone dam and concluded that the soil of regional mortar stone dam had more dense vegetation than the control. Also, the soil of mortar stone dam had more dense plant roots and organic matter and more available water and proper ventilation than the control soil. Kholfi *et al.* (2006) in their study on the construction contour furrow concluded that performing this operation would cause the stabilization of structure and stability of soil aggregates and improve soil nutrients that corresponded with the results of this study. They also stated that if operation water that penetrates with biological operation due to changes in soil structure increases the improvement of soil structure. Regeneration of vegetation had positive effects on biodiversity (Abebe *et al.*, 2006) and soil fertility (Mekuria *et al.*, 2007); it reduces soil erosion (Descheemaecker *et al.*, 2006).

According to the results, there are significant differences between P and K concentrations in both mortar stone dam and contour furrow treatments between upper and lower soil layers. Plants absorbed more P from both lower soil layers, formed litters and returned them to the upper layer after the plant death. So, P concentration in the upper soil layer is more than the other layers. Amount of K in the upper soil layer of contour furrow and mortar stone dam treatments was less than lower layer because more moisture content in upper layer of mentioned treatments causes to transfer K to lower layers (Salardini, 2008).

Conclusions

Therefore, it is essential to apply appropriate management for the preservation and proper utilization of valuable resources of rangelands. In the management of rangelands, the soil and vegetation elements, environmental factors and livestock should be considered as decision making agents. In general, to investigate the effects of improvement practices of contour furrow and mortar stone dam on soil parameters in Silvana, it can be concluded that in this area, mechanical performance operations of mortar stone dam regarding the corrective actions have a greater impact on improving soil parameters. Unfortunately, in the field of evaluation, effects and performance operations of constructing contour furrow and mortar stone dam, research had not been done on soil parameters. Most researches were

done in the field of projects of enclosure and flood spreading. Therefore, it is suggested that the effects of corrective actions must be evaluated on factors of soil in different climate zones.

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چکیده. چرای بیش از حد و بهره‌برداری شدید از مراتع منجر به تخریب خاک و پوشش گیاهی در بسیاری از مراتع می‌شود. در برنامه‌ریزی و مدیریت مراتع بایستی تمامی پارامترهای خاکی، گیاهی و اقلیمی در نظر گرفته شود. روش‌های مدیریتی گوناگونی از جمله کنتور فارو و سد سنگی ملاتی برای اصلاح مرتع به کار برده می‌شود. در این تحقیق، به منظور ارزیابی اثرات عملیات اصلاحی کنتور فارو و سد سنگی ملاتی بر روی خصوصیات خاک در مناطق معرف مراتع منطقه سیلوانا در ارومیه، نمونه‌برداری به روش تصادفی با استفاده از ۶ ترانسکت ۱۰۰ متری در هر تیمار و همچنین منطقه شاهد انجام شد. نمونه‌برداری از خاک در ابتدا، وسط و انتهای هر ترانسکت از دو عمق ۳۰-۰ و ۶۰-۳۰ سانتی‌متری صورت گرفت. میزان نیتروژن (به روش کجدال)، میزان فسفر قابل دسترس (به روش اولسون) و میزان پتاسیم (به روش فلوم فتومتری) تعیین گردید. تجزیه آماری داده‌ها با استفاده از روش تجزیه واریانس یک طرفه (ANOVA) و مقایسه میانگین فاکتورها به روش آزمون SNK در محیط نرم افزار $SPSS_{18}$ انجام شد. مقایسه میانگین پارامترهای پوشش خاکی در تیمارهای اصلاحی نشان داد که میزان پارامترهای خاکی نیتروژن و پتاسیم در لایه‌های سطحی خاک تیمار ها نسبت به لایه‌های زیرین بیشتر است. اما میزان پتاسیم در لایه‌های سطحی خاک تیمارها نسبت به لایه‌های زیرین کمتر است. همچنین، نتایج نشان داد که از نظر فاکتورهای نیتروژن، پتاسیم و فسفر تفاوت بین تیمارها معنی‌دار بود. درصد نیتروژن، پتاسیم و فسفر در تیمار سد سنگی ملاتی در هر دو عمق در مقایسه با تیمارهای شاهد و کنتور فارو بیشتر بود. بنابراین، می‌توان چنین نتیجه گرفت که در منطقه سیلوانا بهبود وضعیت پارامترهای خاک از طریق اعمال عملیات مکانیکی احداث سدسنگی ملاتی در مرتع امکان‌پذیر است.

کلمات کلیدی: عملیات اصلاح مرتع، سد سنگی ملاتی، کنتور فارو، حاصلخیزی خاک