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The Effect of Planted Saltbush (*Atriplex lentiformis*) on Edaphic Factors in Grazed and Ungrazed Area

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ABSTRACT Re-vegetation of bare soil is believed to increase, or at least maintain the organic matter levels of soil. The aim of this study was to investigate the soil characteristics changes, nutrient pool sizes and their availability under mid canopy, and canopy gap positions of saltbush in an area re-vegetated with *Atriplex lentiformis*. Some of the physical and chemical soil characteristics (the particle size distribution, soil bulk density, EC, pH, Na, K, organic C, N, P, C/N ratio and C/P ratio) were measured in two different soil depths at both planted shrublands and control area. The results from samples analysis showed that the soil of the control area is significantly different from the Atriplex shrublands area. Maximum of K and Na proportion were measured in 0 to 20 cm under mid canopy in the planted sites. K and Na in different soil layer showed a significant difference between ungrazed area, grazing area and control area ($P<0.05$). Maximum of Na was measured in 20 cm top soil of mid canopy in the ungrazed area and minimum Na was observed in 20cm top soil of mid canopy in the grazing area. Organic C and total N were maximum in 0 to 20 cm soil layer under all canopy positions and declined with the increasing depth of soil ($P< 0.05$). Total P did not differed significantly between Atriplex shrub land and control area ($P<0.05$).

Key words: *Atriplex lentiformis, Re-vegetation, Saltbush, Soil characteristics and Soil nutrient*

1 INTRODUCTION

Chenopod shrub-lands cover 8% of the arid zone. Chenopods are salt tolerant xenomorphic (plant characteristics determined by ability to resist drought) shrubs, sub-shrubs or forbs. The leaves are frequently covered with soft hairs; some are leafless with fleshy jointed stems. Many have pores, which excrete salt. Saltbush (*Atriplex* sp.) is an extremely important plant as it provides perennial shrub-lands with a large distribution (Graetz, 1978).

Saltbush (*Atriplex* sp.) occurs in many communities, including riparian zones, desert scrubs, and coastal areas. This species can occur in mixed woody scrub, Joshua tree woodland, and creosote bush scrub (Thorne and Robert, 1976; Thorne and Robert, 1982).

Improvement of soil fertility in arid area is mainly a consequence of increased above-and below-ground organic matter inputs, nutrient cycling, and protection of soil from erosion and N2 fixation, depending on plant species (Nair,

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1993; Palm, 1995; James *et al.,* 2005; Ghazavi *et al.*, 2010). Re-vegetation of bare soil is believed to increase, or at least maintain the organic matter levels of soils (Young, 1989). Consistent increase of organic matter promotes soil aggregation which in turn provides stability to soil against erosion (Pandey *et al.,* 1995) and improves soil texture, structure and microbial biomass (Singh and Singh, 1995). The immobilized nutrients in microbial biomass constitute a reservoir of mineralizable N, and other nutrients, which upon biological transformation become available to plants (Singh *et al.,* 1989). However, the concentration and availability of nutrients and moisture under plant crown vary with depth of soil and distance from plants (Mazzarino *et al.*, 1991; Ghazavi *et al.,* 2008). Most species of Atriplex are able to accumulate a high level of sodium and other ions under salt stress conditions (Bajji *et al.,* 1998). The ability of some *Atriplex* sp. to accumulate ions within their tissues may make them useful in remediating high levels of soluble salts and exchangeable sodium present in saline soils (Glenn *et al.,* 1996). Like other dry-land shrubs, saltbush may added a lot of leaf and flower in the vicinity of them and could be thought of as significant 'point-sources' for organic litter (Browaldh, 1995) and salinity accumulation (Helalia *et al.,* 1990), consequently, the soils of the canopy and the mid canopy areas have different properties (Wilson *et al.,* 2000). Increasing of organic litter improve physicochemical soil properties while salinity accumulation increase soil deterioration. High sodium concentrations in soil generally cause soil dispersion as a result of break down of soil aggregates, which, subsequently, settle into soil pores. Soil dispersion causes soil pore blockage resulting in the reduction of soil permeability (Geddesand and Dunkerley, 1999; Pearson, 2004).Versus salinity, increase of organic matter promotes soil aggregation which in turn provides stability to soil against erosion (Pandey *et al.,* 1995) and improves soil texture, structure and microbial biomass (Singh and Singh, 1996). It is well recognized that relative growth rates of plants closely coupled with C: N: P rates (Elser *et al.,* 2000; Hessen *et al.*, 2008). Plant N capture depends not only on soil N concentration but also on plant growth rate and plant demand for N (Forde, 2002; Collier *et al.*, 2003). C: N: P rates should effected by *Atriplex* sp. in re- vegetated bare area with this species.

Also saltbush is an important plant in arid and semi arid area, especially in slain soil and wetlands; there is a general lack of information on spatial variation in soil characteristics, nutrient pool sizes and their availability to crops under its canopy. This study quantified soil textural changes, nutrient pool sizes and their availability under mid canopy, and canopy gap positions of saltbush in an area re-vegetated with *Atriplex lentiformis*.

2 MATERIALS AND METHODS

2.1 Study area

The study area (latitudes 28°38' 16" N, longitudes 54°14'12" E) located in a catchment 5 km South of Darab, Fars, Iran. Darab located in an arid and semi-arid zone with semi tropic climate.

According to the local meteorological data measured in the nearest climatological stations located at 2km south of the study area, the area has a mean annual rainfall of 270 mm of which 93% was occurred in the winter-spring period, 3.3% in the autumn and 3.7% in the summer . Class A pan evaporation is about 2524 mm in the study area and the mean annual air temperature is 22°C, ranging from 10°C in January to 34°C in July. The average elevation of the study area is approximately 1180m above sea level.

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The site is part of the simply folded belt of the Zagros Ranges (Stocklin and Setudehnia, 1977). Alluvial and colluvial sediments were deposited in the study area during the Late Quaternary. The soil surface is covered by fine grained with 2 to 7% slopes. The low precipitation rate of the area is insufficient to leach soluble salts and calcium carbonate into the sub-soil. Typically, the upper 30 cm is clay, calcareous, mildly alkaline and saline (Rahbar and Kowsar, 1996).

Atriplex lentiformis was planted in 60ha of the study area in 1980 with a density of 400 plants per hectare. 40 ha of planted Atriplex were protected from grazing while 20ha were under grazing since 1985 by sheep and goat.

2.2 Data monitoring

Three sites were selected for sampling; ungrazed-planted area, grazed-planted area, and grazed-control area. Dominant species in the grazing and ungrazed area is *Atriplex lentiformis*. The control area was selected in the vicinity of the Atriplex shrub land with the same geological and soil condition. The dominant plant in the control area is *Artemisia* sp. (a native shrub), with small numbers of *Convolvulus spinosus* (a native shrub) and annual forbs such as *Astragalus.* sp., *Medicago minima*, *Antemis* sp., and *Peganum harmala.* Control area was grazed with the same condition of the Atriplex grazed-planted area.

Two transects (with 200m length) were established randomly at each site. Along each transect ten 10 m^2 plot were established. Soil was sampled in May 2010 from 0 to 20 and 20 to 40 cm depths. In each plot, samples were collected from three random locations in mid canopy and canopy gap. Samples were prepared separately for each plot by mixing samples from same location (under canopy and mid canopy). These composite samples were used for determination of pH, EC, soil texture, bulk density, organic-C, total N, total P, Na and K contents. pH values, were determined potentiometrically in a 1:2.5 soil– water ratio. Electrical conductivity was measured in saturated pastes after a 4 h equilibration. Soil texture analysis was done by hydrometer method. Organic-C was determined by Walkley and Black rapid titration method. Phosphate-P was determined by an ammonium molybdatestannous chloride method (Sparling *et al.*, 1985). Total N was measured by microkjedhal digestion method. Sodium and potassium values were determined using Flam photometry method.

For statistical analysis of the data, the MINITAB statistical package (Minitab 14 Statistical Software) and Excel (Microsoft Office Excel 2009) were used. The soil properties of the ungrazed, grazing and control areas were compared using ANOVA (independent samples t- test analysis). In this study, we did not analyse the interaction between three groups (there are not interaction between them), but we compared them in paired (Grazing area with control area, Grazing with un-grazing area, un-grazing with control area). This test was carried out in MINITAB.

3 RESULTS

The results of particle size distribution are shown in Table 1. The results of analyses showed that the amount of silt in 20cm of topsoil was significantly different between Atriplex shrub land and control area, but not significant difference was observed between grazing and ungrazed area ($P<0.05$). The amount of silt was decreased with depth in all studied areas, but between top soil and down soil layer was significantly different only for mid canopy in Atriplex shrub land ($P<0.05$).

Maximum Proportion of sand particles was observed in 0 to20 cm top soil and declined with depth in all areas. However, the decline was significant (P <0.05) only between 0 to 20 and 20 to 40 cm depth of the soil under canopy gap in the ungrazed area. A significant difference was also observed between mid canopy and canopy gap in shrub land. This different should be due to increasing of leaf litter and dead roots. Variations in clay particles due to different positions of the three study area were not significant for 20cm of down soil (P< 0.05), but a significant difference was observed between top soil and down soil layer in ungrazed area and also in mid canopy in the grazing area (Table 1).

There were significant differences in some of the soil ions between ungrazed area, grazing area and control area (Table 2). Maximum of K and Na proportion were measured in 0 to20 cm under mid canopy in the ungrazed area. K ranging from 1.45 to 4.4, Na ranging from 33.4 to 15.6 in different soil layer show a significant difference between ungrazed area, grazing area and control area (P<0.05). Maximum of Na was measured in 20 cm top soil of mid canopy in the ungrazed area and minimum Na was observed in 20cm top soil of mid canopy in the grazing area. Proportion of Na in the mid canopy in shrub land and in the control area was significantly higher in the top soil layer than down soil layer (Table 2).

Values in a column for a parameter suffixed with different superscripts are significantly different at P<0.05. Values in a row for a parameter prefixed with different superscripts are significantly different at P<0.05.

In the protected area, bulk density for 0 to 20cm of top soil was 0.88 $gr.cm^{-3}$ and significantly increased with depth (1.12 between 20 to 40 cm depth). Not significant difference was observed between the top and down soil layer for other studied area. A significant different was observed between ungrazed and grazing area for 20 cm of top soil layer (P<0.05). This different was also observed between grazing and control area.

Table 1 Sand, silt and clay particles; bulk density and soil water content in different soil depths under mid canopy, canopy gap and in control area.

Soil properties	Soil depth (cm)	Ungrazed area		Grazing area		Control area
		Mid canopy	Canopy gap	Mid canopy	Canopy gap	
Silt (%)	0-20	$^{x}51.48^{a}$	$^{x}52.8^{a}$	$^{x}51.69^{a}$	$^{x}51.89^{a}$	$^{x}49.86^{b}$
	20-40	$^{y}48.48^{a}$	$^{x}51.48^{b}$	$^{y}48.56^{a}$	$^{x}51.5^{b}$	$^{x}48.01^{a}$
Clay (%)	0-20	$^{v}27.4^{a}$	$^{v}27.08^{a}$	$^{v}28.3^{a}$	$^{v}29.56^{b}$	$^{v}29.01^{b}$
	20-40	$^{w}30.4^{a}$	$^{w}30.4^{a}$	$^{w}30.34^{a}$	$^{v}29.54^{a}$	$^{v}29.87^{a}$
Sand (%)	0-20	$^{t}21.12^{a}$	$^{t}20.12^{b}$	$^{t}20.01^{b}$	$^{t}18.55^{c}$	$^{t}22.13^{a}$
	20-40	$^{t}21.12^{a}$	$^{u}18.12^{b}$	$^{t}21.1^{a}$	$^{t}18.96^{c}$	$^{t}21.12^{d}$
Bulk density (gr/cm^3)	0-20	$^{q}0.88^{a}$	$^{q}1.01^{b}$	$^{q}1.01^{b}$	$^{q}1.15^{c}$	$^{q}1.21^{d}$
	20-40	$^{r}1.12^{a}$	$^{q}1.11^{a}$	$^{q}1.14^{a}$	$^{q}1.16^{a}$	$^{q}1.28^{b}$
Soil water content (%)	0-20	$^{o}9.12^{a}$	$^{o}6.14^{b}$	$^{o}7.15^{c}$	$^{o}6.12^{d}$	$^{o}1.12^{e}$
	20-40	$^{p}10.6^{a}$	$^{p}8.62^{b}$	$^{p}9.89^{c}$	$^{p}7.99$d	$^{p}3.09^{e}$

Values in a column for a parameter suffixed with different superscripts are significantly different at P < 0.05. Values in a row for a parameter prefixed with different superscripts are significantly different at P < 0.05.

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Table 2 Soil properties in different soil depths under mid canopy, canopy gap and in control area.

soil properties	Soil depth (cm)	Ungrazed area		Grazing area		Control area
		Mid canopy	Canopy gap	Mid canopy	Canopy gap	
K(meq/lit)	0-20	$^x2.55^a$	$^x1.73^b$	$^x1.85^c$	$^x1.56^d$	$^x2.80^e$
	20-40	$^y1.97^a$	$^x1.65^b$	$^x1.45^c$	$^x1.48^c$	$^y4.40^d$
Na(meq/lit)	0-20	$^x33.4^a$	$^x18.4^b$	$^x19.45^c$	$^x14.24^d$	$^x63.40^e$
	20-40	$^y15.80^a$	$^y26.01^b$	$^y15.60^c$	$^y21.30^d$	$^y43.40^e$
EC (ds/m)	0-20	$^x1.43^a$	$^x1.01^b$	$^x1.14^c$	$^x1.01^d$	$^x1.96^e$
	20-40	$^y0.55^a$	$^y0.84^b$	$^y0.58^c$	$^y0.89^d$	$^y1.092^e$
pH	0-20	$^x7.75^a$	$^x7.61^a$	$^x7.45^a$	$^x7.64^a$	$^x8.19^b$
	20-40	$^x7.84^a$	$^x7.5^a$	$^x7.78^b$	$^x7.89^b$	$^x8.12^b$
Organic carbon (gr/100g)	0-20	$^x1.442^a$	$^x0.59^b$	$^x3.46^c$	$^x0.47^d$	$^x0.49^d$
	20-40	$^y0.32^a$	$^y0.18^b$	$^y0.83^c$	$^y0.24^d$	$^y0.26^d$
Total Nitrogen (gr/100gr)	0-20	$^x0.124^a$	$^x0.05^b$	$^x0.3^c$	$^x0.04^d$	$^x0.04^d$
	20-40	$^y0.03^a$	$^y0.02^b$	$^y0.07^a$	$^y0.02^d$	$^y0.02^d$
Total P (gr/100gr)	0-20	$^x0.02^a$	$^x0.02^a$	$^x0.03^a$	$^x0.02^a$	$^x0.02^a$
	20-40	$^y0.01^a$	$^y0.01^a$	$^x0.02^b$	$^x0.02^b$	$^y0.01^a$
C/N Ratio	0-20	$^x11.63^a$	$^x11.61^a$	$^x11.59^a$	$^x11.56^a$	$^x11.74^b$
	20-40	$^x11.71^a$	$^x11.8^a$	$^x11.68^b$	$^x11.85^a$	$^x11.64^a$
C/P Ratio	0-20	$^x65.55^a$	$^x34.83^b$	$^x132.92^c$	$^x26.31^d$	$^x22.41^e$
	20-40	$^y26.33^a$	$^y14.75^b$	$^y48.77^c$	$^y13.17^d$	$^x21.33^e$

Values in a row for a parameter suffixed with different superscripts are significantly different at P < 0.05. Values in a column for a parameter prefixed with different superscripts are significantly different at P < 0.05.

Values in a row for a parameter suffixed with different superscripts are significantly different at P<0.05. Values in a column for a parameter prefixed with different superscripts are significantly different at P<0.05.

Variations in soil water content due to different positions of the 3 studied areas were significant (P<0.05). Soil water content was increased with depth significantly for all positions. Average of soil water content in 0-20 cm depth was 7.63 and 6.64, respectively for protected and grazing area and increased to 9.61 and 8.94 for 20-40cm depth.

In the canopy position, a significant difference was observed between studied soil layer for C and N (P<0.05). Organic C was maximum in 0 to 20 cm soil layer under all canopy positions and declined with increasing depth (P<0.05).

Organic C and total N varied among the canopy positions (P<0.05) at each soil depth (Table 2). Organic C, averaged across the soil depth, was 0.88 under mid canopy and 0.36 at canopy gap in the ungrazed area, 2.14 under mid canopy and 0.36 at canopy gap in the grazing area, and 0.38 in the control area. For organic C, different was significant between Atriplex shrub land and control area (P<0.05).

Like organic C, total N was also maximum in 0 to 20 cm soil layer under all canopy positions and declined with the increasing depth of soil (P<0.05). Total P did not differ significantly among canopy positions and soil depths (Table 2). Different was not also significant between Atriplex shrub land and control area for total P.

C/N ratio varied among canopy positions, but different was not significant (P<0.05).

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Average of C/N ratio for 0-40 cm depth was 11.67, 11.7, 11.64, 11.71 and 11.69 for mid canopy and canopy gap in the ungrazed area, mid canopy and canopy gap in grazed area and in the control area respectively. It was minimum in the 0 to 20 cm soil layer under all canopy positions and increased with depth of the soil. C/N ratio was higher in 0-20 cm of top soil than down soil layer in the control are. Unlike C/N ratio, C/P ratio was highest ($P<0.05$) under mid canopy and lowest under canopy gap position at all depths ($P<0.05$). C/P ratio varied due to canopy position ($P<0.05$). In all canopy position, a significant difference was observed for two studied soil depth was also significant ($P<0.05$). C/P ratio was maximum in 0 to 20 cm soil layer under all canopy positions and declined with depth ($P<0.05$), but different between top soil layer and down soil layer was not significant in the control area(Table 2). Amount of EC differed among canopy positions ($P<0.05$) and soil depths ($P<0.05$). Soil EC was significantly higher in 0-20cm top soil than down soil layer (Table2).

Soil pH, ranging from 7.5 to 8.12 in different soil layers did not show any significant difference between the grazing and ungrazed area but a significant difference was observed between control area and Atriplex shrub land area ($P<0.05$).

4 DISCUSSION AND CONCLUSIONS

Change in sand and clay particles under the saltbush canopy could be due to protection of soil from the impact of rain drops which would otherwise increase the de floculation and erosion of clay particles. Greater organic C content under tree canopy also divert protection to soil structure. Soil organic substances stick soil particles together and protect them from erosion (Pandey *et al.*, 1995). Soil particle size distribution of the three studied area presented in Tables 1 indicate a significant difference for silt, clay and sand between control area and area re-vegetated with Atriplex lentiformis. The soils have silty-clay textures for both upper and lower layer in three studied area, but the amount of silt in 20cm of topsoil was significantly higher in the Atriplex shrub land than control area. By evaluating various soil physical and physico-chemical properties under and between the plants, Sharma (1973) studied spatial variability in two soils supporting 10-year old stands of Atriplex spp. The Results of this study showed that the differences in soil properties between these two positions were mostly significant for the surface layer (0-7.5cm) but only in a few cases for the 7.5-15 cm layer. No differences were observed below this depth.

The results from samples analysis for EC and the soluble soil cation data (Table2) for studied units showed that the soils of the control area is significantly different from the Atriplex shrub lands area. The relative distribution of the soluble soil cations (Table 2) in the grazing and ungrazed area can be related to *Atriplex* sp. The soils of both areas are dominated by soluble sodium throughout the majority of the profile. The largest concentrations of sodium and potassium were found in the top 20 cm under mid canopy in the ungrazed area.

Although soil salinity was reduced in the lower soil layer in both ungrazed and grazing area, reductions were much less in the ungrazed area than grazing area. There is a relatively slight increase in the concentration of sodium within the topsoil of the vegetated areas especially in the mid canopy. The increase of these soluble salts is because of the *Atriplex lentiformis* salt cycling. Holmes (2001) reports that content of sodium in the soil was decreased by 65% two years after planting with salt accumulating plants. Increasing of soil salinity in the top soil layer of grazing area is much less

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than ungrazed area, because a part of salt that accumulated in the leaf and branch was consumed by animal and transferred out of the study area.

Higher soil organic C and total N under mid canopy positions compared to canopy gap and control area should be related to accumulation of above land below-ground organic matter for 30 years (age of shrubs), through leaf litter and dead plants roots. The decrease in organic C and total N in down soil layer compared to up soil layer is due likely to root abstraction of this elements. Constant value of total P under mid canopy compared to that under canopy gap and under control area, observed in this study, may be due to amount of clay particles which are known to fix phosphorus (Lee *et al.,* 1990) and is approximately constant in top soil layer of three studied area.

The results of this study indicate that planted saltbush increase soil organic C under its canopy, probably through organic matter inputs via leaf litter and dead roots, which bind soil particles and reduce runoff. Increased soil C and clay contribute interactively to increased total and available forms of N. This increase most likely occurs gradually over a long period.

Saltbush should provides an important fodder reserve for animal, especially in arid and saline soil area, and protects the soil against erosion during drought periods due to its canopy cover. Management of these shrubs should aim towards reduction of soil salinity and maintaining a sufficient cover of perennial shrubs during drought periods.

Rangeland re-vegetation my not be economically feasible in all arid lands areas. However, there are also successful ones such as sand-dune stabilization projects, reclamation of saline and alkaline soils, and soil protection project. This project will be more prosperous where both introduced and native trees and shrubs are used.

Re-vegetation by native and artificial plant species is also a successfully methods to increase plant production and to protect soil and water in arid environments. However, under the arid environmental conditions, more research work is needed before considering re-vegetation as a tool for increasing plant production, soil and water conservation and increasing biodiversity.

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بررسی تأثیر کشت آتریپلکس (*Atriplex lentiformis*) بر فاکتورهای ادافیکی در دو منطقه چرا شده و چرا نشده

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چکیده احیای پوشش گیاهی اراضی بایر می‌تواند باعث افزایش مواد آلی و بهبود شرایط خاک شود. هدف از انجام این مطالعه بررسی تأثیر کاشت گیاه آتریپلکس (*Atriplex lentiformis*) بر برخی از خصوصیات فیزیکی و مواد مغذی خاک در دو منطقه آتریپلکس‌کاری شده (تحت چرا و قرق) نسبت به یک منطقه شاهد بوده است. برای انجام این تحقیق برخی از خصوصیات خاک (اندازه ذرات، تراکم، اسیدیته، هدایت الکتریکی، میزان سدیم، میزان کلسیم، کربن آلی، ازت، فسفر، نسبت ازت به نیتروژن و نسبت ازت به فسفر) در دو عمق ۲۰-۰ و ۴۰-۲۰ سانتی‌متری خاک در دو منطقه شاهد و بوته‌کاری شده اندازه‌گیری شد. نمونه‌برداری خاک در زیر تاج پوشش و بین بوته‌ها در منطقه آتریپلکس‌کاری شده و در منطقه شاهد انجام گرفت. نتایج حاصل از آنالیز داده‌ها نشان‌دهنده تأثیر معنی‌دار کشت آتریپلکس بر خصوصیات خاک منطقه بوته‌کاری شده است به طوری که حداکثر میزان سدیم و پتاسیم در زیر بوته‌ها و در منطقه آتریپلکس‌کاری شده مشاهده شد. میزان سدیم و پتاسیم در لایه‌های مختلف خاک تفاوت معنی‌داری ($P<0.05$)، بین منطقه شاهد و منطقه آتریپلکس‌کاری شده را نشان داد به طوری که حداکثر سدیم در لایه ۲۰-۰ سانتی‌متری خاک در زیر بوته‌ها و در منطقه چرا نشده و حداقل سدیم در همین عمق و در منطقه چرا شده مشاهده شد. حداکثر میزان کربن آلی و نیتروژن در عمق ۲۰-۰ سانتی‌متری زیر تاج پوشش در منطقه آتریپلکس‌کاری شده مشاهده شد و با افزایش عمق به طور معنی‌داری ($P<0.05$) کاهش یافته بود. تفاوت معنی‌داری در میزان فسفر منطقه شاهد و منطقه بوته‌کاری شده مشاهده نشد ($P>0.05$).

کلمات کلیدی: آتریپلکس لنتی فورمیس، بوته کاری، فاکتورهای ادافیکی، مواد مغذی خاک

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