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Vegetation and Soil Properties of a Sandy Desert Affected by Shrub (*Haloxylon aphyllum*) Plantation and Oil Mulching

J. Gholami Tabasi[1], M. Jafary[2], H. Azarnivand[2], M. Sarparast[3]
[1] M.Sc Student, Tehran University
[2] Professor, Tehran University
[3] PhD Candidate, Gorgan University of Agricultural Sciences and Natural Resources

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Abstract

Planting shrub seedlings under oil mulches has frequently been used for stabilizing mobile sands in Iran over the last three decades. Sandy desert of Samad Abad, Sarakhs, northeast Iran, has been fixed by cultivating seedling of *Haloxylon aphyllum* under oil mulches. This study was designed to investigate the effects of the sand fixation project on soil and vegetation properties. Vegetation samples were taken in a randomized-systematic method from representative areas of the rehabilitated and control sites. At each site, nine transects, 50 meters long, were established. Canopy cover and density of two dominant shrub species (*Astragalus squarrosus* and *Convolvolus hamadae*) as well as the total canopy cover of understory plants were measured, along the line transects. In each area, 220 individuals of the two shrub species mentioned above were selected and their total and living aerial foliage volumes were measured. Moreover, in each area, four soil samples were taken from 0-20 and 20-80 cm depths. The percentage of organic matter was measured in soil samples. Data analysis was implemented using independent T-test. According to the results, oil mulch and *Haloxylon* plantation caused a significant reduction in the percentage of total canopy cover of *A. squarrosus* and density of *A. squarrosus* and *C. hamadae* but these practices increased the living aerial foliage volume of *A. squarrosus* and *C. hamadae*.

Keywords: Oil mulch, *Haloxylon aphyllum*, Vegetation *rehabilitation*, Organic matter, Sarakhs.

*Corresponding author; javad.tabassi@gmail.com

1. Introduction

Soil erosion (water and wind) is known as one of the major land degradation types in different regions of the world. Although this destructive phenomenon is as old as the earth but fast human population growth has increased the use of natural resources and hence intensive soil erosion (Ahmadi, 2008). Iran is located on the dry belt of the world, with 64/5% of its area being affected by the dry climate receiving annual rainfall less than 250 mm (Ekhtesasi, 2010). In addition to water erosion, wind erosion is also considered an important destructive factor. Wind erosion is stronger in dryer regions mainly because of the dry surface of the ground and low vegetation cover (Refahi, 2009). More than 95% of the sandy deposits of Iran are located in arid and hyper-arid climates. Vegetation is fundamental for terrestrial ecosystems and plays important roles in life on earth. When the climatic, edaphic and geographical factors of the ecosystems are affected by the dry climate, the role of vegetation increases even more to keep life in balance (Jafary *et al.,* 2011). The best, cheapest and the most effective method for controlling wind erosion is protecting the ground surface by vegetation cover. The protective effects of vegetation increases by increasing the total canopy cover (Refahi, 2009).

Therefore, conservation and restoration of the vegetation has a high priority in dry areas and deserts. Besides, every management plan of these areas should lead to the appropriate establishment and regeneration of plants that are adapted to the ecological characteristics of the landscape. Combination of oil mulching- *Haloxylon* plantation serves as a preventing measure to control wind erosion, and paving the way for restoration of native vegetation. Enforcing an integrated plan on seeding and seedling plantation along with oil mulching, gives the ecosystem enough time for plant growth in case of suitable climatic and environmental conditions as long as the mulch layer has not lost its special quality. So basically, the objective of permanent stabilization of the mobile sands will be fulfilled by creating protection cover (Kholdbarin, 2009). Nonetheless, the landscape natural restoration potential of vegetation should not be ignored, which recovers native plants in the absence of seeding and plantations (Sadeghinia and Hakimi, 2009). Despite the long history of oil mulch usage and planting *Haloxylon,* to the best of our knowledge, there is no comprehensive and scientific research on effects of planting *Haloxylon aphyllum* as well as mulching on ecological resources. In this regard, the following brief literature review is presented.

Ruhipoor (1987) while evaluating interactions among sand dunes morphology, mulch mode (strip and uniform) and plant species (*Tamarix* spp*, Prosopis* spp), reported strip mulch spraying as the best option to absorb rainfall humidity and establish vegetation species. Through examining the effects of mulch spraying on the common species involved in biological operations in deserts and evaluating operation method (seeding and planting), Loqman (2000) showed that planting would be more successful than the control in case of application of water ponds.

Regarding the planting method, planting success in the study area was three times more than seeding. Akbarian and Biniaz (2011) comparing plantation of *Acacia tortilis, Acacia nubica, Prosopis cineraria* and *Asclepias* spp in mulched areas in Hormozgan Province, found that the percentage of survived seedlings for most species except *mesquite* was more than 90%. This could be attributed to physical protective action of mulch layer against wind erosion and temporary dunes stabilization. Hashemimanesh and Matinfar (2012) while assessing deserts management and rehabilitation by means of oil mulching, conducted a temporal analysis and field study in Ahvaz and found that afforested areas had increased from 2.1% in 1991 to 7.3% in 2002. Moreover, their observations confirmed a positive and significant positive change in mulch-sprayed area in terms of vegetation cover. Most of the desert restoration plans have failed because of careless designs and implementation. Hence, it is essential to check viability and efficiency of such plans in the desert areas of the country. For this, the present study was designed to assess vegetation restoration through planting *Haloxylon aphyllum* in mulching areas located in the critical wind erosion center in Samad Abad County along with control sites to shed lights on their effects on the vegetation and soil.

2. Materials and methods

2-1-The study area

The study was conducted in arid rangelands of Samad Abad located in the southern Sarakhs (eastern Iran) characterized by coordinates 35°58' to 36° 18' N and 61° 3'to °12 E along Tajan river and Turkmenistan.

The area's average elevation, mean annual temperature and average rainfall is 235 m, 18.3° and 187.6 mm, respectively. Rainfall is distributed in different seasons as spring 54.8, summer 1.1, fall 31.6 and winter 100.1 (mm). The prevailing wind direction is northwest which is known as Black wind. Among other well-known winds in this region blowing during cold seasons is Kiblah (qebleh) whose direction is from south to north. The area's climate was determined based on De Marten method as arid cold desert (Ramezani, 1995). Given available data and expert opinions, the study area is located at the beginning of the windborne sediment particles. After uniform total mulching in this area, the *Haloxylon aphyllum* seedlings were planted with a density of 400 seedling per hectare (Figure 1).

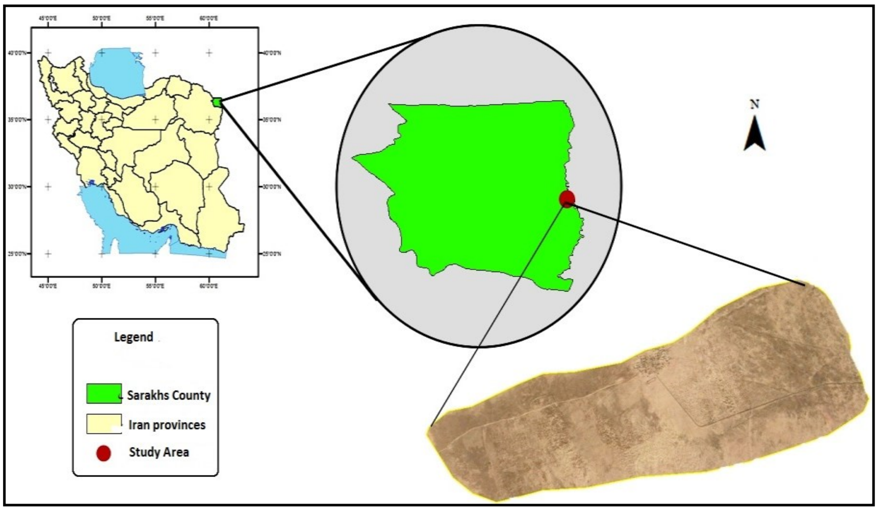

Figure 1. Location of the study area on Iran map

To evaluate oil mulching-*Haloxylon* plantation impact on vegetation and soil properties, *Haloxylon* planted spots were distinguished and after field reconnaissance, two representative areas (*Haloxylon* planted in mulching spots) and control site (no mulch and *Haloxylon*) were selected characterized by similar environmental conditions and topography (low and highlands). The vegetation samples were taken both in oil mulching-*Haloxylon* plantation area and that of the control one using a randomized- systematically method. Sampling was done according to area of the vegetation, homogeneity and environmental factors along nine transects each 50 meters long within selected areas. In order to measure the total crown cover and percentage of canopy cover for two dominant species (*Astragalus squarrosus* and *Convolvolus hamadae*), line interception method was used separately. This method is suitable since the area is dominated by shrubs. This method has also been found to be the most accurate and effective approach for sites with sparse vegetation such as shrubs where plants are characterized by dense canopy in regular distance to each other (Coulloudou *et al.,* 1996). To measure the density of the two species (*As sq* & *Co ha*) the belt transect method was applied. After transects were established in the spots and canopy cover was measured, densities of both species were measured. Each transect was 50 m in length. T-ruler was moved along the transects and those vegetation collided with the ruler were counted. For plants whose canopies was outside the transects, a rule of thumb was considered; in case up to 50% of the canopy is found in transect and the strikes to ruler were counted.

Thus for each transect, the considered species were counted in an area of 50 m^2 within a total area of 450 m^2. In addition, along 3 belts each 300 m long and 100 m far from each other, 220 stands of the two species were chosen and their total volume along with their biomass of their live shoots were evaluated. To study soil organic matter, four profiles were excavated in each region and soil sampling was done in 0-20 and 20-80 cm depths and the percentage of the organic matter was measured. Data analysis was implemented in SPSS 16 software using independent T-test.

3. Results and discussion

The results of the independent T-test on vegetation and soil parameters on mulching area are summarized in 4 tables. As it can be seen in Table 1, total canopy cover has more proportion in control and differed significantly for *Haloxylon* plantation in mulching areas.

Table 1. Comparing the percentage of average total canopy cover in oil mulching-*Haloxylon* plantation and control area

Property	Mean		df	t	Result
	Treatment	Control			
Total Canopy Cover %	2.6644 ±0.7141[a]	8.9311 ±0.6117[b]	16	-6.664	**

** represents significant difference in probability level of 1%

Table 2 comparing the percentage of canopy cover, density, and total biomass for live shoots related to *As sq* species. Results show a drastic reduction of the canopy cover and density of this species in the study area is compared to the control in probability level of 1%. Although the total volume of this species does not differ significantly from its control but, it's live volume shows significant difference at significance level of 1% compared to the control.

Table 2. Comparing vegetative traits of *As sq* in oil mulching-*Haloxylon* plantation area and the control

Property	Mean		df	t	Result
	Treatment	Control			
Canopy Cover %	1.075 ± .3827[a]	5.724 ± .6040[b]	16	-6.501	**
Density (N/ha)	600 ± 120[a]	3711 ± 354[b]	16	-8.311	**
Total Volume (m^3)	0.0252 ± .0050[a]	0.0235 ± .0021[a]	438	- .338	N.S
Alive Volume (m^3)	0.0252 ± .0050[a]	0.008 ± .001[b]	438	5.151	**

n.s: non-significant difference
** represents significant difference in probability level of 1%

Table 3 compares the percentage of canopy cover, density, total biomass and current biomass of shoots related to *Co ha*. These results imply considerable losses in density and significant increase in total and current year biomass compared to control at probability level of 1% but the canopy cover percentage did not differed significantly.

Table 3. Comparing vegetative traits of *Co ha* in oil mulching-*Haloxylon* plantation area and the control

Property	Mean		df	t	Result
	Treatment	Control			
Canopy Cover %	1.5244 ± .5404[a]	1.8911±.3260[a]	16	- 0.581	N.S
Density (N/ha)	1089 ± 254[a]	2311 ± 235[b]	16	- 3.525	**
Total Volume (m^3)	.016 ± .0032[a]	.0058 ± .0005[b]	438	- 4.513	**
Alive Volume (m^3)	.016 ± .0032[a]	.0058 ± .0005[b]	438	- 4.513	**

n.s: non-significant difference
** represents significant difference in probability level of 1%

Table 4 comparing the percentage of organic matter in 0-20 and 20-80 cm depth indicating no significant difference in the first depth but a significant difference at probability level of 1% in the second depth compared to control.

Table 4. Comparing average percentage of the organic matter in the deep and surface soil depth in the oil mulch sprayed and control area

Property	Mean		df	t	Result
	Treatment	Control			
OM % (0-20 cm)	0.195 ± .002[a]	0.24 ± 0.082[a]	6	- 0.545	N.S
OM % (20-80 cm)	0.3725 ± .0209[a]	0.13 ± 0.028[b]	6	6.842	**

n.s: non-significant difference
** represents significant difference in probability level of 1%

Overall, results of the present research suggest the negative effect of implementation of mulching-*Haloxylon* planting on *Haloxylon* understory vegetation. Measuring the total canopy cover indicated that mulching-*Haloxylon* planting causes a dramatic and significant reduction in this parameter. Distribution and significant reduction in the *Astragalus squarrosus* density decreased the canopy cover percent of this species significantly. Counting 600 stands of *As sq* in one hectare was reached that accounts for 17% of the control site. However, a decrease in canopy cover of about 80% was found in the area. Despite a 50% reduction of *Co ha* the percentage of canopy cover of this species did not show significant differences in comparison with the control one. It is clear that any increase in the canopy cover of the *Co ha* compensate the density losses. The average *Co ha* biomass is three times as much as its average in the control group. Mulch, *Haloxylon* trees and improved humidity condition exert positive effects on the *Co ha* stands growth by stabilizing soil effectively. Tabasi (2013) pointed out that oil mulch did not affect plants negatively but also increased vigor and biomass in the plants stands. The volume measurement in *As sq* showed that there is no significant difference in its total volume between the two areas. All the *As sq* stands and their shoots were alive in the mulching- *Haloxylon* planted area but this was not true for the control area; that is, they had no volume growth. On the one hand this lack of difference is because of the growth stop in the control area and on the other this is due to slow growth among *Haloxylon* species. Higher density of *As sq* in the mulch-sprayed area where *Haloxylon* were not planted proved that despite presence of mulch this plant could not grow well in mulching-*Haloxylon* plantation area. So, contrary to the control area, all the *As sq* stands are alive and their live volume equals total volume. Measuring current biomass in *As sq* showed that there is a significant difference between this parameter relative to the control area. Although in the control area *As sq* stands are alive, but on the average just 30% of the live shoots did not undergo dehydration. Wind erosion and soil disturbance and displacement adjacent to plants are negative factors that cause dehydration and slowing of plant growth. However, there are some plants that can overcome such shortcomings (Jafary and Tavili, 2010).

Efficient dune stabilization through oil mulching removes this negative factor during operation. Under such conditions, plants expand their root system to withstand harsh situation as well as utilize their total energy for development (Ekhtesasi, 2010). Besides vegetation parameters, percent of soil organic matter has been measured in soil depth and surface. Results of the soil experiments showed that the soil organic matter did not varied significantly in 0-20 cm depth in both areas (study and control). One reason for this lack of difference can perhaps be attributed to not mixing of mulch humus or to humus carrying by the wind. Nevertheless, in the 20-80 cm depth, organic matters differed significantly and on average this was three times more than that in the control site. The underground shoots density follows *Haloxylon* trees and to provide proper place for soil microorganism may be another reason for this (at probability level of 1%). Tabasi (2013) in his investigation deduced that oil mulching impose positive effects in restoration process and one expects that integrating mulching with *Haloxylon* plantation may provide better condition for plants growth. However, field survey and measurements showed the negative effects of *Haloxylon* plantation on vegetation. Based on the different researches, contradictory results have been reported on the effect of *Haloxylon* on vegetation rehabilitation. Afkhamoshoara (1995) reported that *Haloxylon* planting increased the vegetation diversity after 8-10 years and recovered vegetation in long term. Niknahad (2002) and Zareei, *et al.* (2011) confirmed the positive effects of *Haloxylon* plantation on vegetation. However, Zandi, *et al.* (2011) in Sajzi area (Isfahan Province) concluded that *Haloxylon* plantation causes the soil to become saline, degrading vegetation. It seems that these results are in line with *Haloxylon* density. Results proved that where the density of *Haloxylon* trees are low, the grass and shrubs dominate and most of the vegetation is found where there is no trees. On the other hand, as the density of *Haloxylon* increases, the density of *As sq* and *Co ha* species decrease so that in a 10 meter distance there may be no vegetation. Yajuan and Zing (2011) claimed that as the *Haloxylon* aged, it required more water and it exploited the humidity in the upper horizons to meet its water demands. Therefore, the plant's population grows more than usual, decreases soil humidity, lowers water table and makes humidity as a limiting factor for plants.

4.Conclusion

Referring to the results of our study and the literature cited, we can claim that there are evidences that planting *Haloxylon* separately and paying no attention to the nature's potential in providing proper conditions for its growth is the worst decision for sandy deserts stabilization and vegetation restoration. Hence, this issue merits more consideration in future studies and applications.

References

Afkhamoshoara, M.R. 1995. Effect of *Haloxylon* plantation on understory plants, south of Khorasan. Journal of Research and Development. 29(1):1-10.

Ahmadi, H. 2008. Applied Geomorphology. Desert- Wind Erosion. University of Tehran press. 100p.

Akbarian, M., and Biniyaz, M. 2011. Comparing plantation of some vegetative species planted in sandy desert fixation project, Hormozgan province. Journal of Forest and Range. 89 (1):1-18.

Coulloudou, B. 1996. Sampling Vegetation Attributes. U.S. Department of Agriculture-Forest services. Natural Resource Conservation Service. Grazing Land Technology Institute. 100p.

Ekhtesasi, M.R. 2010. Suitable plants for sand dunes and sandy sheets stabilization. University of Yazd Press. 100p.

Hashemimanesh, M., and Matinfar, H.R. 2012. Evaluation of desert management and rehabilitation by petroleum mulch base on temporal spectral analysis and field study. (Case study: Ahvaz, Iran). Journal of Ecological Engineering.46 (1): 1-20.

Jafary, M., and Tavili, A. 2010. Reclamation of Arid lands. University of Tehran press.

Jafary, M., Tahmouresm, M., and Ghoddosi, J. 2011. Biological soil erosion control. University of Tehran press. 100p.

Kholdbarin, A. 2009. Guidelines for Petroleum Mulching. Pooneh Press. 80p.

Luqman, H. 2000. Comparison of sand fixation methods using gravel mulch and without mulch. Research Institute of Forests and Rangelands. 100p.

Niknahad, H. 2002. Study of Haloxylon plantation on some vegetation and soil characteristics, Qum province. Thesis of range management. University of Tehran. 100p.

Ramezani, M. 1995. Vegetation types of Sarakhs Area. Research Institute of Forests and Rangelands Press. 80p.

Refahi, H.Gh. 2009. Wind erosion & Conservation. University of Tehran press. 100p.

Roohipoor, H. 1987. The best and most economical way to stabilize sand dunes for vegetation establishment. Research Institute of Forests and rangelands. 100p.

Sadeqinia, M., and Hakimi, M.H. 2009. Study on *Haloxylonaphyllum* changes in oil-mulched area. Proceedings of the Fourth National Conference on pasture and rangeland. Research Institute of Forests and Rangelands publication. 110p.

Tabasi, J. 2014. Sandy deserts vegetation and soil changes due to some wind erosion control steps (Samadabad, Sarakhs). Thesis of range management. University of Tehran. 100p.

Zandi Esfahan, E., Jafari, M., Khajjedin, S.J., and Azarnivand, H. 2011. Study on soil salinization and its amplitude due to the planting of *Haloxylonammodendron* in Segzi plain of Isfahan. Iranian journal of Range and Desert Research.18 (2):1-13.

Zarei, A., Zarechahouki, M.A., Jafary, M., Bagheri, H., and Ebrahimi, M.A. 2011. Plantation and enclosure effects on vegetation characteristics (Case study: QohNamak Rangelands of Qom Province). Watershed Management Research (Pajouhesh and Sazandegi). 90 (1):20-28.

Yajuan, Z., and Zhiqing, J. 2011. Soil water utilization characteristics of *Haloxylonammodendron* plantation with different age during summer. Journal of Acta Ecologica Sinica. 31 (1):23-33.