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**Full Length Article:**

## **Investigation of the Effect of Biological Stabilization Practice on Some Soil Parameters (North East of Iran)**

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**Abstract.** One of the ordinary methods to protect, rehabilitate, and enhance an ecosystem function in arid and semi-arid areas of the world is sand dune stabilization using biological practices. Plantation of species on the soil plays a great role in sustainable management of the ecosystem. This research studies the effects of cultivation of *Haloxylon ammodendron* and *Atriplex canescens* on physical-chemical characteristics of soil. The study area was Yousef Abad, Neyshabour, located in the northeastern part of Iran in which these two plants species were cultivated 20 years ago. The study area was then compared with a control area near the investigated area. Two different sites within the cultivated area as well as a site in control area were selected for soil sampling. Six samples were taken at each site from depths of 0-20 cm and 20-80 cm, in the sites of *H. ammodendron* and *A. canescens* three profiles were randomly digging from under the shrubs canopy and 3 of them were sampled from between the shrubs totaled 36 soil samples. The percentage of clay, silt, sand, electrical conductivity, soil acidity, organic matter content, nitrogen, phosphorus, potassium, calcium, sodium, and calcium carbonate of each sample were measured. The collected data were analyzed and means comparisons were made using LSD by SAS software. The results showed that the three sites had different soil characteristics. *H. ammodendron* led to increasing soil nutrient factors and soil fertility after 20 years of cultivation but silt particles transportation and wind erosion was reduced in site of *A. canescens* in this period.

**Key words:** Biological stabilization, Soil nutrients, Semi-arid areas, Neyshabour.

## Introduction

Iran is one of the world's arid and semi-arid areas so that the average annual rainfall in more than 80 percent of its area is about 50 to 250 mm. About 472000 km<sup>2</sup> (29/12 %) of the country is covered by the dry climate (Jafari, 2009). Using methods of rangeland reclamation and development, including cultivation suitable plants is one of the most important ways that stabilize the soil and creating a new microclimate that leads to changes in the soil physical and chemical properties gradually. Since the establishment of vegetation in this condition is not easy, so, for improving the rangelands the plants are needed which have adapted to arid and semiarid areas and environmental conditions. Some of plants that have adapted to arid and semiarid areas are Chenopodiaceae family plants such as *Haloxylon ammodendron* and *Atriplex canescens* that are widely cultivated in Iran. Despite numerous studies concerning the influence of these plants on their habitat has been done, different results have been reported from positive and negative effects of this species on the environment and this point highlights the importance of profound research and evaluate the effects of planted them after a few years that by accurate information with regard to its impact on other factors in the ecosystem in the long term, is decided to continue, stop and replace the culture of this species. The sand stabilization in Iran had began from 1960 in about 18 ha of surrounding areas of Ahvaz (Rahbar, 1988).

*Haloxylon* species inhabit arid environments on the continents of Africa and Asia. *H. aphyllum* and *H. persicum* are dominant components of the vegetation of the sandy and clay deserts across central Asia, from western China and Mongolia to the Caspian Sea. They cover a total area of 1 million km<sup>2</sup> across the Turanian deserts as well as appearing in the thermal deserts of the Middle East.

In the desert areas of Central Asia, the forests of both species play an enormous role in combating land degradation (Orlovsky and Birnbaum, 2002). This plant belongs to early stages of sequences in sandy soils (Javanshir *et al.*, 1998). Previous researches showed in areas and *H. ammodendron* was planted, the organic carbon was increased so that causes to improve of the soil structure in the long time. The elements of N, P, K, which are the essential needs by plants, has also increased in the soil and creating an appropriate environment for microorganisms activity and accelerates the processes of pedogenesis and have increased clay and silt in the dunes where this suitable condition led to return native species and the fauna of the region (Azarnivand *et al.*, 2004). In the area that *H. ammodendron* has been cultivated, with increasing depth, pH and EC levels are increased and this trend is opposite to organic carbon (Farzaneh, 2004), and the amount of nitrogen, potassium, electrical conductivity, acidity, increase significantly and phosphorus is also reduced (Jafari *et al.*, 2006). The physiochemical analysis results show that the soil porosity, total organic carbon, total nitrogen and phosphorus levels increased during time and its value is high under its canopy cover (Miyoko *et al.*, 2008)

*Atriplex canescens* is a native shrub of South America arid regions that has been planted in different parts of Iran-Turan (Asadi, 2002). Among the species imported to Iran, this plant has been planted at the highest area of country (Moghimi, 2006). Some of researches show that the positive influence of planting *Atriplex* sp. on the soil structure is more specific than negative impacts (Khalkhali, 1997). In a study on the ecological effects of cultivation *A. canescens* on the environment results show that the EC and Na solution in the soil increase at the *Atriplex* site compare with control area, but phosphorus does

not follow a clear trend. Moreover this plant led to the saltier the surface soil (Arzani *et al.*, 2001). Nevertheless, some researcher pointed out that cultivation *Atriplex* increase the amount of nitrogen, phosphorus, potassium, organic matter significantly and soil acidity is reduced (Henteh and Jafari, 2006). In another study was expressed *Atriplex* along with these positive characteristics, such as soil stabilization, high forage in undesirable environmental conditions, fuel production and carbon storage, may has negative effects on ecosystems (Azarnivand and Zare chahooki, 2009). In a desert area near Monument Valley, Arizona, which established a uranium factory led to pollution of soil with ammonium nitrate, planting *A. canescens* cause rapid uptake of nitrate from the desert soil (McKeon, 2005). The aim of this study was to investigation of the effect of 20 years of plant cultivation of *H. ammodendron* and *A. canescens* on soil physical-chemical characteristics in North East of Iran.

## Materials and Methods

### Study area

Field experiments were conducted in Yousefabad ranges (25 km southeast of Neyshabour, Iran). The range has 500 ha of area where is located between 59° 00' and 59° 05' geographical lengths and 36°

00' up 36° 05' altitude. The altitude is 1200 m above sea level, the average of long-term rainfall based on the nearest climatology stations (Eshgh Abad) is 213 mm and the annual average of temperature is 14.8°C. The average of maximum monthly temperature is 27.6° C in July and average minimum temperature is 2° C in January. The soil of the area is sandy and clay, alkali with relatively good drainage. The soil structure also is amorphous and is poor in organic matter compounds. The minerals composition is constituted of gypsum and claic. Soil depth is 20-50cm and the lower class, in foothills areas are gypsum and claic. The study site is flat having numerous foothills. The maximum slope is 10% which mostly has east-west direction. The area has seasonal winds starting to blast at second half of spring and continue up to summer, the winds direction is usually East-West with intensity of about 24 km per hour. The wind causes erosion in the area therefore the aim of stabilization was to prevent erosion and sand transport to the villages by planting of *Atriplex canescens* and *Haloxylon ammodendron*. These rangelands are winter pastures which are grazed by the village livestock (Behzad Nia and Bagheri, 1996; Naseri, 2010) (Fig. 1).

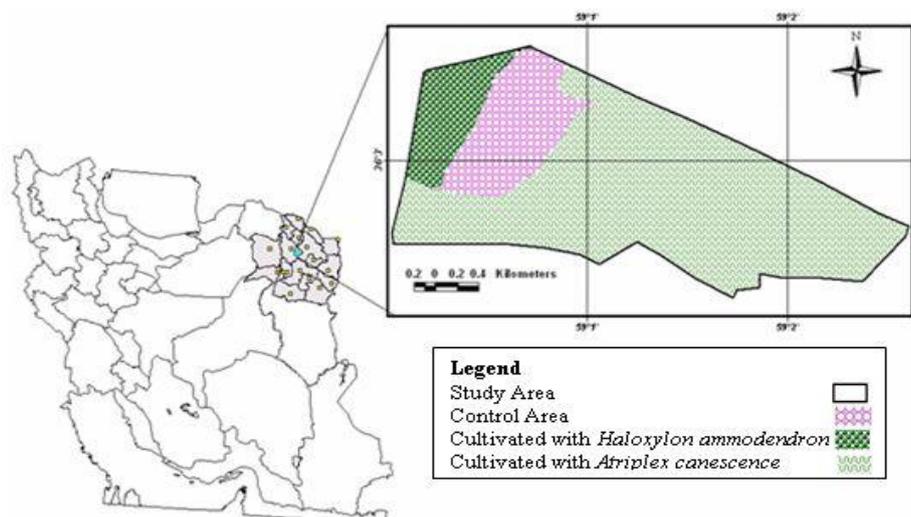


Fig. 1. Position of study area in Iran

Field measurements and methods of experiment

The area under cultivation of *Haloxylon ammodendron* (Fig. 2), *Atriplex canescens* (Fig. 3), plus with control region (Fig. 4), was identified by field operations. These sites are similar in terms of climate conditions and topography. To compare soil elements of each area, six samples were taken at each site from depths of 0-20 cm and 20-80 cm (Fig. 5). In the sites of *H. ammodendron* and *A. canescens* three profiles were randomly digging from beneath the shrubs canopy and 3 of them were sampled from between the shrubs

(totalled 36 soil samples). The percentage of clay, silt, sand, Electrical Conductivity (EC), soil acidity (pH), organic matter content, nitrogen, phosphorus, potassium, calcium, sodium, and calcium carbonate of samples were analyzed using standard methods (Jafari Haghighi, 2004). Then the normality of data was tested using kolmogorov – smirnov (k-s) test. The collected data were analyzed in a one-way completely randomized design. The mean values of soil properties between under the canopies and open canopies areas were tested by LSD using SAS 9.1 software.

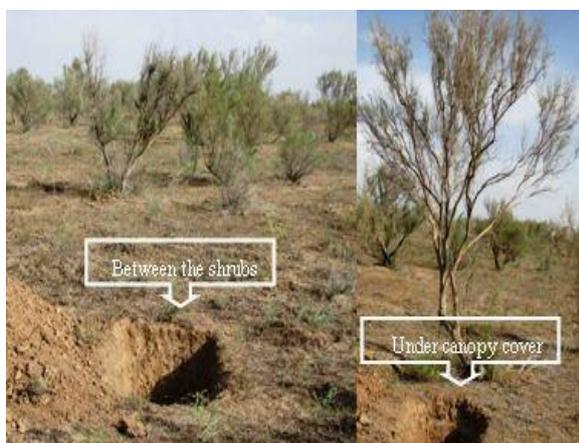


Fig. 2. Soil sampling from *Haloxylon ammodendron* site



Fig. 3. Soil sampling from *Atriplex canescens* site



Fig. 4. Soil sampling from control area



Fig. 5. Soil sampling from depth of 0-20 cm

## Results

There were significant differences for the most of soil physicochemical properties among five treatments and two depths that are presented in (Tables 1 and 2). Compared with control site, some soil parameters measured in open areas that planted with *H. ammodendron* (between canopy cover of *H. ammodendron*) had significant differences for pH, EC, nitrogen, phosphorus, calcium and sodium. According to the results, the amount of potassium was higher in the cultivated area especially in site of *H. ammodendron* and under the canopy cover of *H. ammodendron*, this indicates that revegetation had remarkable effects on this parameter (it is especially effects on soil chemical properties). Twenty years after plantation of *A. canescens* led to establishment of sand dunes and silt particles were 44% in control area compare to 63% and 59% for between and under canopy cover of *A. canescens* respectively (Table 1). In the site of *A. canescens* proportion of sand-size particles was 22.3% and 30.3% in the topsoil layer (0-20 cm) under and between the canopy cover and 21.7% and 22.3% in the depth of 20-80 cm (under and between the canopy cover respectively). In the comparison between depths of 0-20 cm and 20-80 cm, it shows that cultivating *A. canescens* causes to decrease the sand dunes movement by reducing the amount of sand size and increase in silt content after twenty years (by modification of soil texture, Tables 1 & 2 & Fig. 6). In other words *A. canescens* plantations has led to improved soil texture during this period. In addition, there were significant differences for EC, clay, nitrogen, phosphorus, potassium and sodium between two depths. The amount of organic matter, nitrogen, phosphorus, potassium content, T. N. V, sand and silt was higher in the top soil layer (0-20 cm) (Table 2). This shows the nutrient

material and its fertility has increased in surface soils.

The amount of organic matter has increased in the top soil layer (0-20 cm) of *H. ammodendron* site, especially between the shrubs (Fig. 6).

Like wise, the nitrogen content in the surface layer of control area was less than the 0-20 cm layer of other treatments. It indicates that cultivation of *H. ammodendron* and *A. canescens* leads to increase nitrogen in the topsoil layer particularly in site of *H. ammodendron* especially under the canopy cover compare with control area.

The results showed that interaction effects of treatments and depths were significant in for pH and phosphorus. pH values was high in the top layer of soil (0-20 cm depth), under canopy cover of *H. ammodendron*. In contrast, the EC values were high in subsurface layer (20-80 cm) at the site of *H. ammodendron* compare with other treatments (Fig. 6).

There were no significant differences in T. N. V content of revegetation in various treatments and depths in this duration.

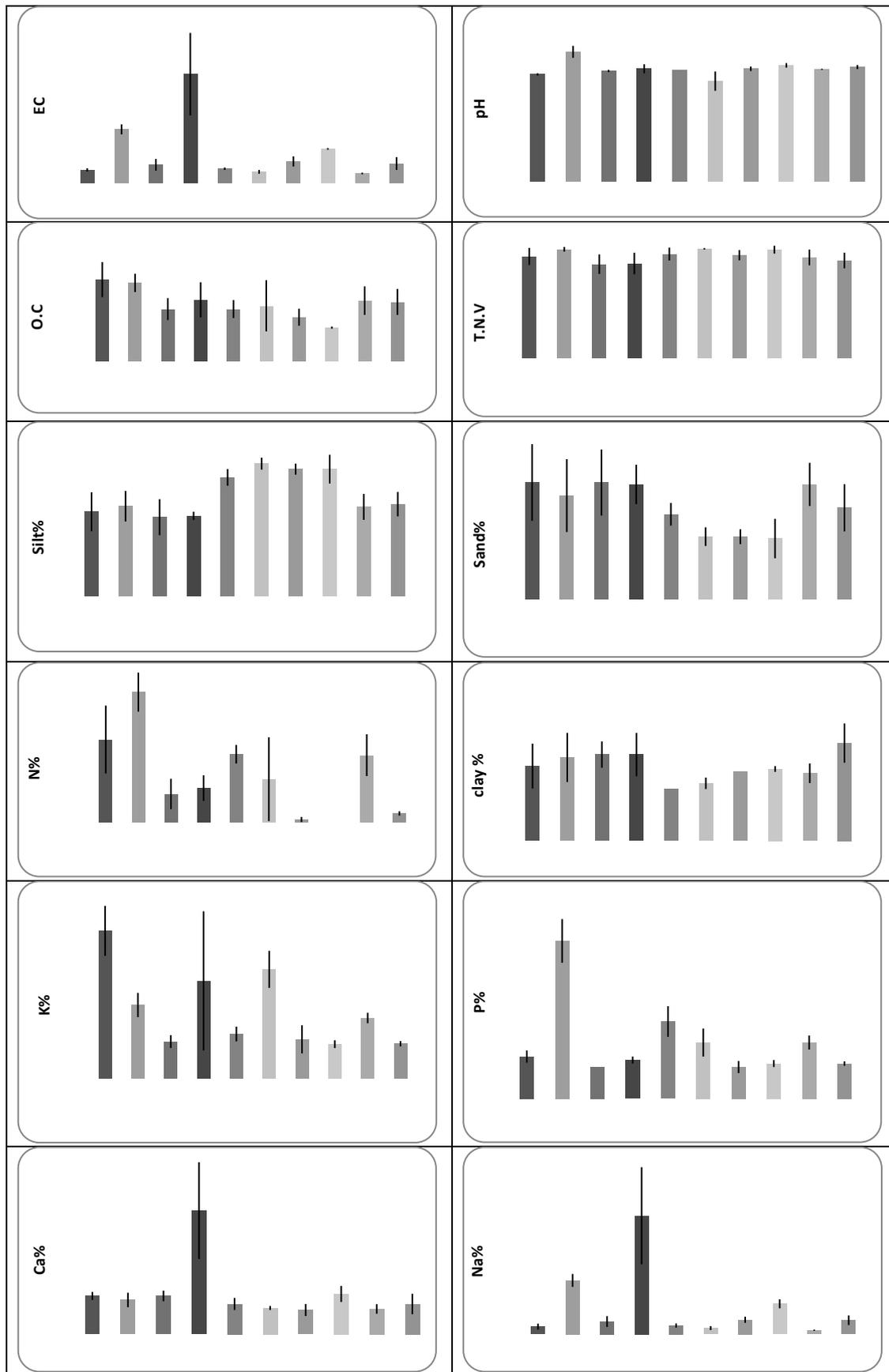


Fig. 6. Interaction effects of soil properties between the treatments and two depths (Ha= *Haloxylon ammodendron* site, At= *Atriplex canescens*, b= between the shrubs, u= under the shrubs, 1= first depth [0-20 cm], 2= second depth [20-80 cm] discussion

## Conclusions

The establishment of planted sand-binding vegetation in the Yousef Abad ranges promoted the improvement and restoration of this ecosystem. Ha-lin *et al.* (2007) studied the multiple effects of shrub on soil properties and undestroyed vegetation in Mongolia. Their results suggested that shrub had significant “fertile island” effects and important “keep species” roles in shifting sand dunes. Similarity in our research revegetation has remarkable effects on soil chemical properties in the *H. ammodendron* site and soil texture in the *A. canescens* site. Cultivated *H. ammodendron* has increased the organic matter and N, P, K which leads to higher fertility in this region compared with control area and *A. canescens* site. Azarnivand *et al.* (2004) and Jafari *et al.* (2006) also reported that planting *H. ammodendron* causes to increase these parameters in the soil (except phosphorus in the research of Jafari *et al.* (2006)) that they cause to improve soil structure in the long time and with providing a suitable environment for micro organisms activities. Also, there is the relationship between clay content and soil organic matter and it is because of food and water stored in these types of soils thus production and accumulation of organic matter is more in fine texture soils. By increasing amounts of organic matter in soil, nitrogen and phosphorus that are important components constituting increase (Mahmoodi and Hakimiyan, 2008). According to the observations, native range species and amount of litter are increased between shrubs in the *Haloxylon* site comparing other treatments. Therefore, it was concluded that the cultivated *H. ammodendron* cause to improve soil fertility and vegetation condition especially inter space the shrubs.

*H. ammodendron* has an important role in salinity and alkalinity of soil especially

surrounding the canopy cover. Also in site of *A. canescens*, amount of salinity is more than control area. Zandi Esfahan *et al.* (2007) in the same research stated that it is because of high level of groundwater and repulsing salt from leaves in halophytes. Likewise Jafari (2005) showed that in addition to positive effects of *A. canescens* such as modify soil structure, increase soil fertility and Improved soil moisture conditions, it has some negative effects such as increased salinity. He reported that salinity is leaching by rain and transferred to the below depth of soil. Also in the present study EC was much higher in sub surface layer of soil in these two site than that of control area. The present investigation demonstrates that *A. canescens* has positive effects on sand stabilization too. According to the results, in *H. ammodendron* treatment the amount of sand was more than other sites and this is because of the reason that in Yousef Abad rangelands *H. ammodendron* have been cultivated on soils with more sand at first. As some researchers stated, *H. ammodendron* belonging to the early stages of sequence is in sandy soil (Azarnivand and Zare chahooki (2009); Henteh (2004); Orlovsky & Birnbaum (2002); Jafari *et al.* (2006) and Javanshir *et al.* (1998).

Nitrogen content in *Atriplex* site was less than other treatments. As McKeon *et al.* (2005) are mentioned in their research planting *A. canescens* cause to rapid absorb nitrates from contaminated soil with ammonium nitrate in a desert area, Arizona thus the amount of nitrogen reduced in soil. *A. canescens* further improves soil structure. Active sand dunes usually have not much silt and clay. Because these particles leap into the air during saltation transport of fine grains and go out of the area as the suspended solids. When sand dunes are stabilized, the amount of clay and silt increase rapidly that it is due to the accumulation of suspended particles and

fine particulates that are produced by the weathering of sand in the place. On the other side type, height, density and growth stage of plants are effective in controlling wind erosion, those plants which produce more cover (when ground is susceptible to wind erosion) have most effect on control wind erosion (Rafahi, 2006). According to high amount of silt in *A. canescens* site, we can conclude that *A. canescens* is more effect on control wind erosion and it is prevented from moving silt particles. It seems to be related to different morphology of two species. *A. canescens* has a more compact vegetative form but there is more free space between leaves in *H. ammodendron*. The stem of *H. ammodendron* is above the ground surface, branches and leaves are at the top of the plant unlike *A. canescens* that growth begins almost near the ground (Javadi et al., 2011). Li et al. (2007) said that the variations between soil physicochemical parameters are attributed to the difference in morphology of the two studied species: the Y-shaped crowns of *H. ammodendron* and hemispheroidal crowns of *Tamarix* spp., which leads to the less well developed fertile islands surrounding *H. ammodendron* shrubs.

Anthropogenic changes in environment have positive or negative effects on the ecosystems and can impress the succession. After making changes, including cultivated species in order to reclaim and improve rangelands or for purpose of biological stabilization practices in arid and semiarid regions, the required time for improvement in soils will be long due to the ecological conditions. In other word, changes may appear after many years in these ecosystems. Therefore, in order to assess the effects of cultivating various species in these types of areas should consider a gradual process of change. In this study, changes in chemical parameters of soil is very slow in site of *A. canescens* so that

after 20 years of cultivation, differences in soil nutrient contents is not considerable. But it controls wind erosion more and transportation of silt particles is reduced in this site. On the other hand *H. ammodendron* has increased soil nutrient factors and soil fertility. Therefore according to similarity of the ecological condition in these sites can say cultivating different plant species have different effect on the soil and duration of their impact on ecosystems are vary. Finally, it is recommended to research the planting of other species that are adaptable to the ecological and edaphic conditions in addition to sand dune stabilization, to improve soil physicochemical properties in such areas.

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**Table 1. Comparison of soil properties in different treatments**

Species	Treatments	pH	EC	T.N.V (%)	Organic Matter (%)	Sand (%)	Silt (%)	Clay (%)	Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)	Calcium (meq/lit)	Sodium (meq/lit)
<i>H. ammodendron</i>	Under canopy	8.22±0.03 <sup>b</sup>	0.92±0.17 <sup>b</sup>	23.0±1.43 <sup>a</sup>	0.41±0.07 <sup>a</sup>	41.6±8.08 <sup>a</sup>	39.6±5.79 <sup>b</sup>	18.6±2.76 <sup>a</sup>	0.03±0.01 <sup>ab</sup>	1.40±0.14 <sup>b</sup>	221.1±65.5 <sup>a</sup>	2.53±0.2 <sup>b</sup>	4.43±1.32 <sup>b</sup>
	Between canopy	8.58±0.15 <sup>a</sup>	4.76±1.31 <sup>a</sup>	24.0±1.39 <sup>a</sup>	0.43±0.06 <sup>a</sup>	39.0±6.67 <sup>a</sup>	41.3±3.59 <sup>b</sup>	19.6±3.4 <sup>a</sup>	0.04±0.01 <sup>a</sup>	3.73±1.08 <sup>a</sup>	205.0±76.9 <sup>ab</sup>	5.23±1.97 <sup>a</sup>	38.1±11.62 <sup>a</sup>
<i>A. Canescens</i>	Under canopy	8.32±0.03 <sup>b</sup>	1.05±0.17 <sup>b</sup>	24.4±0.88 <sup>a</sup>	0.29±0.04 <sup>a</sup>	26.3±2.81 <sup>b</sup>	59.6±2.35 <sup>a</sup>	14.0±0.89 <sup>b</sup>	0.02±0.01 <sup>b</sup>	2.07±0.48 <sup>b</sup>	100.0±17.2 <sup>b</sup>	1.80±0.27 <sup>b</sup>	5.07±0.92 <sup>b</sup>
	Between canopy	8.20±0.17 <sup>b</sup>	1.33±0.31 <sup>b</sup>	25.7±0.43 <sup>a</sup>	0.27±0.08 <sup>a</sup>	22.0±3.49 <sup>b</sup>	63.0±3.43 <sup>a</sup>	15.0±1.00 <sup>b</sup>	0.01±0.01 <sup>b</sup>	1.73±0.3 <sup>b</sup>	171.8±45.02 <sup>ab</sup>	2.20±0.32 <sup>b</sup>	8.03±2.59 <sup>b</sup>
	Control area	8.35±0.03 <sup>b</sup>	0.85±0.2 <sup>b</sup>	23.4±1.25 <sup>a</sup>	0.36±0.06 <sup>a</sup>	36.8±5.59 <sup>a</sup>	44.0±4.13 <sup>b</sup>	19.1±2.65 <sup>a</sup>	0.02±0.01 <sup>b</sup>	1.73±0.18 <sup>b</sup>	113.9±11.5 <sup>b</sup>	1.83±0.36 <sup>b</sup>	3.92±1.22 <sup>b</sup>
P value		0.027 <sup>*</sup>	0.0002 <sup>**</sup>	0.64 <sup>ns</sup>	0.51 <sup>ns</sup>	0.004 <sup>**</sup>	<0.0001 <sup>**</sup>	0.002 <sup>**</sup>	0.034 <sup>*</sup>	<0.0001 <sup>**</sup>	0.21 <sup>ns</sup>	0.035 <sup>*</sup>	0.0001 <sup>**</sup>

Mean ± standard error, Means with the same letters has no significant based on LSD test

\*, \*\* and ns = significant differences at levels 5% and 1%, and no significant

**Table 2. Comparison of soil properties in two depths**

Depth (cm)	pH	EC	T.N.V (%)	Organic Matter (%)	Sand (%)	Silt (%)	Clay (%)	Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)	Calcium (meq/lit)	Sodium (meq/lit)
0-20	8.33±0.08 <sup>a</sup>	1.1±0.23 <sup>a</sup>	23.5±0.72 <sup>a</sup>	0.39±0.04 <sup>a</sup>	44.47±4.04 <sup>a</sup>	45.47±3.43 <sup>a</sup>	10.07±1.4 <sup>b</sup>	0.04±0.01 <sup>a</sup>	3.07±0.4 <sup>a</sup>	198.1±23.8 <sup>a</sup>	2.03±0.16 <sup>a</sup>	5.99±1.90 <sup>b</sup>
20-80	8.36±0.03 <sup>a</sup>	2.2±0.59 <sup>b</sup>	22.3±0.83 <sup>a</sup>	0.29±0.03 <sup>a</sup>	41.87±3.93 <sup>a</sup>	44.53±3.42 <sup>a</sup>	13.6±1.77 <sup>a</sup>	0.004±0 <sup>b</sup>	1.41±0.05 <sup>b</sup>	105.7±27.6 <sup>b</sup>	3.37±0.75 <sup>a</sup>	15.7±5.16 <sup>a</sup>
P value	0.64 <sup>ns</sup>	0.017 <sup>*</sup>	0.23 <sup>ns</sup>	0.15 <sup>ns</sup>	0.44 <sup>ns</sup>	0.74 <sup>ns</sup>	0.04 <sup>*</sup>	<0.0001 <sup>**</sup>	<0.0001 <sup>**</sup>	0.0134 <sup>*</sup>	0.06 <sup>ns</sup>	0.019 <sup>*</sup>

Mean ± standard error, Means with the same letters has no significant based on LSD test

\*, \*\* and ns = significant differences at levels 5% and 1%, and no significant