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Study of Non-Native Afforestation in Isfahan Province

(Case Study: Bakhtiar Dasht Forest Park Around Isfahan Refinery)

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Abstract

The drought of Pinus Eldarica and Cupressus Arizonica trees in the forestry around Isfahan refinery has been increasing in recent years. The purpose of this study was to investigate the quantitative and qualitative characteristics of two Cupressus arizonica and Pinus eldarica stands with an area of 93 hectares and soil analysis of the region. The area of the sample plot was 20 R (2000 square meters) and the shape of sample plots was rectangular. In the whole study area, 26 sample plots were implemented by random-systematic sampling method. The census network with dimensions of 290 × 160 meter and quantitative and qualitative information of trees in each sample plot included diameter equal to chest, total height, canopy surface, number of dried bases, species freshness and tree health. Twenty sex soil samples at depths of 0-30 and 30-60 cm in the center of each plot and four soil samples at depths of 0-30 and 30-60 cm from two control areas without any cultivation and afforestation around thestudy case area was harvested. The results showed that the soil salinity of afforested areas is higher than uncultivated areas and the soil of afforestation stands is alkaline, calcareous and weakin terms of nutrient. Drought of Pinus Eldarica trees is more than Cupressus Arizonica trees and vegetative parameters such as average diameter equal to the chest and canopy surface in Cupressus Arizonica stands are significantly different from Pinus Eldarica stands and only Pinus Eldarica standshas a significant differenceto the stand Cupressus Arizonicastands in terms of average total height.

Keywords: Bakhtiar Dasht Forest Park, Isfahan Refinery, Afforestation, Cupressus Arizonica, Pinus Eldarica

Introduction

Afforestation in arid and semi-arid regions is a good way to install green windbreaks, reduce pollution and increase landscape values (Honarjoo & Jalaliyan, 2016).In the central plateau of Iran, large parts of the lands around large cities are cultivated with native and non-native forest trees (Azedoo et al., 2003).These trees are irrigated continuously, but the depletion of water resources and recent long periods of drought have led to the gradual drying up of afforestation (Jazirehi, 2002).On the other hand, understanding the ecological characteristics of the afforested ecosystems for increase success, minimize damage, and optimize soil, water, and energy management is essential due to the pressure on natural resources is increasing

forthe population growth(Cuevas & Lugo, 1998). In climatic conditions such as Iran, the main reason for the failure of afforestation projects is water scarcity, but it has been found that other environmental factors can accelerate or delay this important issue.Two most important factors are the level of resistance of tree species and the physical and chemical conditions of the soil (Sheybani et al. 1997). Soil factors play a crucial role in the effect of salinity.In arid and saline areas, the problem of adaptation of tree species is important, because most of the energy received by the species is spent to deal with harsh conditions and lack of water absorption due to high salinity of water and soil.Therefore, the growth and production rate are not high in these areas (Ghazanshahi, 1997). Coarse-grained soils, for example, have low water holding capacity, but in saline irrigation conditions, sandy soils may be an advantage over drought (Feng, 1988). Also, nutritious soil nutrients may be the only obstacle to plants absorbing more water without sufficient levels of hydrolyzers (most importantly water and soil), (Antunes, 2008).Cupressus arizonica has been present in the population for a period of 10 to 10 days, and has been present every day since the beginning of the year.Cupressus arizonica has long been a non-native tree species resistant to dust and ash, a large part of Iran's urban afforestation (Zad & Koshnevice, 2001; Hassanpouraghdam, 2011). This species resists in terms of warm temperate climate, temperate cold, cold, semi-cold up to -30 ºC and is cold tolerant among cypress species (Fattahi, 1994).Therefore, it is widely used in arid and semi-arid regions of the world.In arid and semi-arid regions, irrigation speeds up its growth (Jazirehi, 2002). Despite the high resistance of this tree to long intervals of irrigation, the problem of drought has also plagued the afforestation of this species(Ahmadlooet al., 2011).Silver cypress forests in natural habitat, on brown silt-loam soils derived from limestone (Zare, 2001). Also, it grows in sandy, infertile, dry and acidic soils with good drainage except (clay), (Edward, 1993).In addition to Cupressus arizonica, Pinus eldarica Medw is a tree used in green space and urban afforestation.It is a tree that is up to 20 meters high and its trunk diameter is up to 50 centimeters;Its main habitat is located in a limited and separate geographical area (550 hectares and an altitude of 200-600 meters) in the south of the Caucasus Mountains and southeast of Tbilisi.In recent years, its seedlings have been planted, especially for urban green space in the central, eastern, western and other prone areas of the country due to some advantages (Sardabi, 1989). In recent years, Cupressus arizonica and Pinus eldarica trees in Bakhtiar Dasht Forest Park around the refinery in the north of Isfahan City have attracted much attention. In drought conditions where the need for water increases, regular irrigation is not enough and causes destructive biological effects on trees.According to Guideline 205 of the Soil and Water Research Institute, if the electrical conductivity of water (EC) is greater than 4 dS / m, the accumulation of salts and the high absorption of sodium and chlorine will lead to the development of alkaline soils.For this reason, the use of such water creates limitations. Soils that have an average moisture content of saturated mud (SP) of 2%-10% are also known as calcareous and very sensitive soils.If the soil is in the range of 7.5 to 8.5, the soil is wet every day.Also, if the soil acidity is in the range of 7.5 to 8.5, the soil is in the category of calcareous and saline soils.Absorption of large amounts of mineral elements in calcareous soils is slow. In this type of soils, due to the presence of lime and calcium ions, the absorption of trace elements is done with many problems.In a studyby Tavakoliet al. (2008), the most important cause of drying of Cupressus arizonica trees was the unsuitability of soil and water salinity.Cupressus arizonica needs light, well-drained soil. The nutritional and physiological disorders have arisen and the trees have gradually weakened and after a while have dried up due to the salinity of water and soil and

the accumulation of salts and absorption by trees.In a study byWarrington & Whittaker (1990), the cause of death of forest trees, especially Pinus eldarica, in the afforestation of Shiraz airport was mentioned as increasing soil salinity and damage to the roots of trees due to salt accumulation around the roots, inadequate irrigation and drainage conditions.In a study by Sheybani et al. (1997) the cause of wilting of Pinus eldarica in Chitgar Park in Tehran was the lack of irrigation and poor soil nutrients.Pruning almost withered trees, regular watering of trees and improving soil condition by adding fertilizer and leaf soil can be effective in improving the condition of the stands. In Tehran Chitgar Park, the most important factor in grading the freshness of trees is the condition of texture and soil organic matter(Mirbadian, 1994).To improve the condition of trees, some management practices of soil and forest stands improvement have been suggested.In a study to improve phosphate soils using Cupressus arizonica tree, it was indicated that this species has the highest survival rate (about 70%) in sandy-clay soils and the lowest survival rate (about 20%) in clay soils (David, 2001). One of these afforestation projects that is currently experiencing a lot of drought is the afforestation of Cupressus arizonica and Pinus eldarica trees in Isfahan and around a 93-hectare refinery.This type of afforestation can be seen in different conditions on the outskirts of the city.These conditions are divided based on the degree of proximity to the factors causing human stress;Conditions that include proximity to population, industrial, agricultural centers and so on.Some parts of afforestation are separated by communication routes.Relationships between soil and vegetation is the topic that have always been considered in forest management and forest soil sciences.In some cases, the effect of physical and chemical properties of water and soil on vegetation is very serious and destructive and causes a lot of environmental and economic losses.The purpose of this study was to investigate some quantitative and qualitative characteristics of two Cupressus arizonica and Pinus eldarica stands around Isfahan refinery along with soil analysis of the region to determine the cause of drying of these stands.

Materials and Methods

Study Area

The study area with an area of 93 hectares is located in the refinery area of Isfahan City.This region is located between east longitudes ″56 ′31 51˚ to ″33 ′32 52˚ and north latitudes ″28 ′47 ˚32 to ″24 ′48 33 ˚.The construction of this park backs to 2007 and the purpose of its construction was to prevent air pollution, create a green belt in Isfahan and soften the air.The average annual rainfall in the region, according to the 20-year statistics of Isfahan Synoptic Station, is 114.5 mm and the rainy months are December, January, February, March and April.The average annual temperature is 15 ° C, the maximum daily temperature (42.6 ° C) is observed in July and the minimum daily temperature (-17.5 ° C) in January.Annual evapotranspiration is 1723.25 mm. The climate of the region is arid according to the De Marttone classification and dry and cold in the Embereger classification.The conifers in the study area are Cupressus arizonica and Pinus eldarica with a planting distance of 3×4 meters. The predominant species planted in this area is Pinus eldarica, which has an area of about 91.4%.

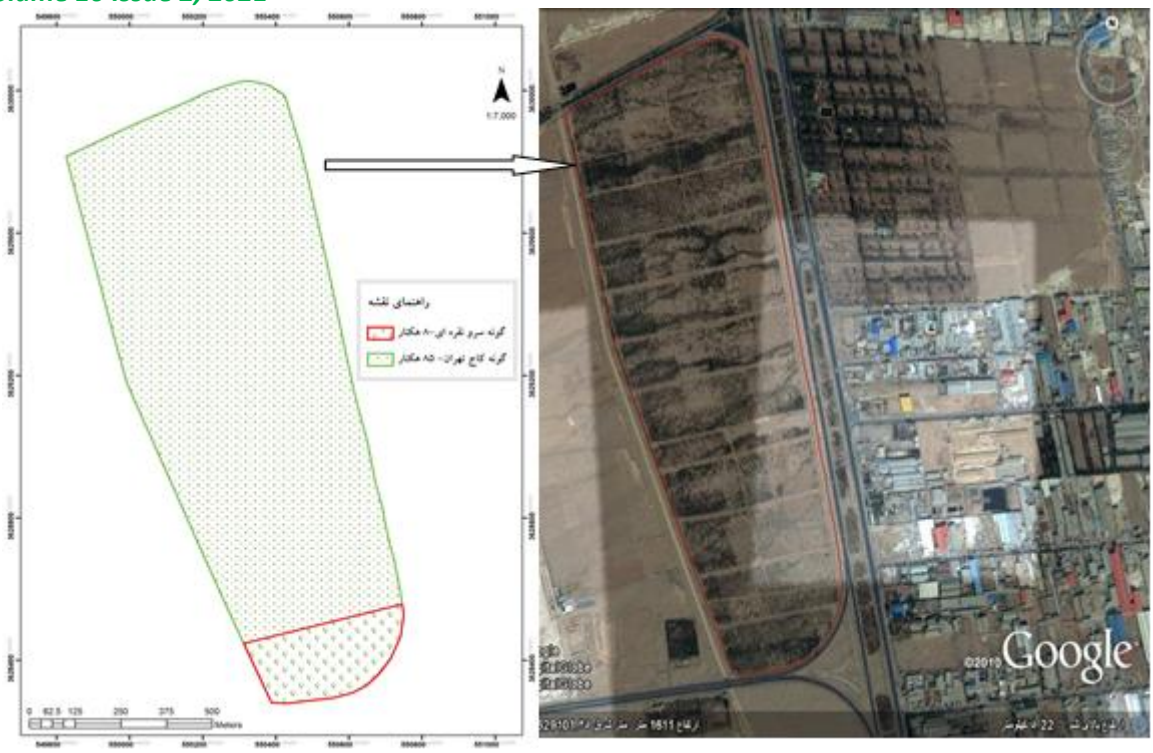

Figure 1. afforested area with Cupressus arizonica and Pinus eldarica

Research Procedure

GPS and Google Earth satellite imagery were used to map the forest area. Then the available data were entered into Arc Gis 10 software, a digital map of the area was prepared and the planting areas of Cupressus arizonica and Pinus eldaricawere separated.The area of the sample plot after full identification of the study area and due to time and financial constraints and also considering at least 15-10 trees in each sample plot was considered twenty R (2000 square meters), (Zobeiri,1994). The shape of the sample pieces was considered rectangular (40 × 50 m). A total of 26 twenty rsample plots were implemented in the study area. To implement the sample plots, according to the shape of the stands, random-systematic sampling method was used. The distribution of sample plots was not located at the edge of the stands and were mostly in the center of afforestation units; the distribution of sample plots was in the way that measurements were made in the whole stands. The census network had dimensions of 160 × 290 meters.Quantitative and qualitative information of trees in each sample plot included DBH(diameter at breast height), total height, canopy area, number of dried rootstocks, species freshness and tree health.The number of soil samples evaluated also included 26 samples at depths of 0-30 and 30-60 cm in the center of each plot and four soil samples at depths of 0-30 and 30-60 cm from two control areas and without any cultivation and afforestation around the study area. The samples were then analyzed in the laboratory.Duncan's multiple range test in SPSS 16 software was used to compare the mean of vegetative variables.

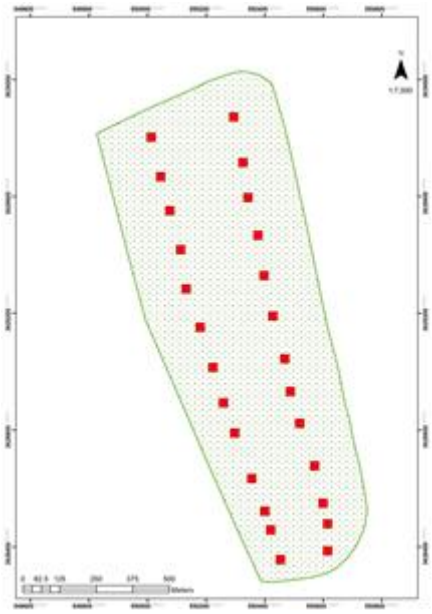

Figure 2. Distribution of sample plots in the afforested area with Cupressus arizonica and Pinus eldarica

Results

- Specifications of the measured parameters in the sample plots related to Pinus eldarica standsat the level of 85 hectares

Twenty two samples were takenfrom the Pinus eldarica stands, , based on that it was determined that the average DBH of the Pinus eldarica standsis 12.68 cm, the average total height is 5.53 meters and the average canopy area is 8.11 square meters. Also, according to the studies, it was found that the number of dried rootstocks in each plot varies from at least 4 ones to a maximum of 20 ones.The vigor of Pinus eldarica rootstocks was not suitable so that no breeding operations such as pruning the lower branches of trees inside thestands, and the care and maintenance operations are very poor and pests and diseases including skin-eating pests were observed (Table 1).

Table 1. Specifications of quantitative parameters in Pinus eldarica stands

Plot number	Average DBH (centimeter)	Average total height (Meter)	Average canopy level (Square meters)	Number of complete dry rootstocks
1	11/95	6/3	7/9	5
2	10/64	5/6	6/5	20
3	11/5	6/4	7/2	4
4	12/6	5/3	8	10
5	14/4	4/3	9/2	15
6	12/2	5/1	8	8
7	11/8	5	7/5	11
8	13/5	5/8	8/5	6
9	15/1	6/5	10	5
10	14/5	6/1	9/5	8

11	13/8	5/5	9	12
12	10	4/5	6	15
13	12/5	5/3	8/1	10
14	15	6/5	9/5	8
15	14	6	9/2	12
16	12/8	5/5	8/5	10
17	11	4/5	7	20
18	10/5	4/5	6	5
19	11/5	5	7/5	9
20	13/4	6	8/5	7
21	12	5/5	7/5	9
22	14/2	6/4	9/5	6
average	12/68	5/53	8/11	

- Pedologyspecifications of Pinus eldarica stands

Table 2.Soil specifications of Pinus eldarica stands

pircseDt & Depth cm	SP	EC ds/m	pH	T.N.V %	OC %	N %	P a.v.a p.p.m	K a.v.a p.p.m	Gyps. %	Physical Tests			
										% S	%Si	% C	Text
0 – 30	22	4.6	7.80	63	0.06	0.006	4.9	302	0.0	69	16	15	S.L
30 – 60	23	4.3	7.80	70	0.04	0.004	2.1	187	0.0	74	12	14	S.L

- Study of The Results of Pinus eldarica Sample

EC: The electrical conductivity or so-called salinity of soil samples is moderate, which is not limiting for plants such as Pinus eldarica.

pH: The acidity of soil samples is the same and in the range of alkali and normal.

T.N.V: The level of lime in the soil sample is very high and undesirable.

OC, N: Severe soil poverty in terms of nitrogen and organic matter is observed in both layers.

P, K: In total, two layers of severe deficiency of the phosphorus absorbed by the plant in the soil is observed; the absorbable potassium in the surface layer is relatively desirable, but in the second layer, the deficiency of this element is observed.

Gypsum: In these soil samples, gypsum is not observed.

Texture: The texture of soil samples is the same in two layers; it is moderate to light and desirable.

- Specifications of the measured parameters in the sample plots related to the Cupressus arizonica stands at the level of 8 hectares

Four samples were takenfrom the Cupressus arizonica stands, based on that it was determined that the average DBH of the Cupressus arizonica standsis 13.66 cm, the average total height is 3.28 m and the average canopy area is 8.75 square meters. Also, according to the studies, it was found that the number of dried bases in each plot varies from a minimum of 0 to a maximum of 2 ones. The vigor of the silver cedar stands was good and no pests or diseases were observed (Table 3).

Table 3. Specifications of quantitative parameters in Cupressus arizonica stands

Plot number	Average DBH (centimeter)	Average total height (Meter)	Average canopy level (Square meters)	Number of complete dry rootstocks
1	11/41	3	7/5	0
2	15/25	3/5	9/5	1
3	13/2	3/1	8/5	2
4	14/8	3/5	7/5	2
average	13/66	3/28	8/75	

- Pedology Characteristics of Cupressus arizonica stands

Table 4. Soil characteristics of Cupressus arizonica stands

pircseDt & Depth cm	SP	EC ds/m	PH	T.N.V %	OC %	N %	P a.v.a p.p.m	K a.v.a p.p.m	Gyps. %	Physical Tests			
										%S	%Si	%C	Text
0 – 30	54	4.0	7.70	54	3.67	0.37	* 843	462	0.0	69	19	12	S.L
30 – 60	32	2.0	7.70	62	1.31	0.13	* 1036	234	0.0	66	21	13	S.L

- Study of The Results of Cupressus arizonica Sample

EC: The electrical conductivity or so-called salinity of surface layer soil samplesis moderate;in the second layer, the level of this factor is low and desirable, and in general, these conditions do not limit the trees such as Cupressus arizonica.

pH: The acidity of soil samples is the same and in the range of alkali and normal.

T.N.V: The level of lime in the soil sample, especially in the second layer is very high and undesirable.

OC, N: The soil surface layer is quite rich in terms of nitrogen and organic matter, and in the second layer, a relative deficiency of these substances is evident (fertilization has been done with organic fertilizers).

P, K: In total, two layers of the potassium phosphorus absorbed by the plantis desirable for trees such as Cupressus arizonica and Pinus eldarica, but the amount of phosphorus absorbed is abnormally high and undesirable (the presence of these amounts of phosphorus in the soil is not desirable at all and will interfere with root uptake,it prevents the absorption of important elements such as iron and zinc and it is necessary to observe moderation in the use of fertilizers).

Gypsum: In these soil samples, gypsum is not observed.

Texture: The texture of soil samples is the same in two layers; it is moderate to light and desirable (Table 4).

- Soil Specifications of The Control Area (Without Any Cultivation and Afforestation)

Table 5. Specifications of control sample soil

pircseDt & Depth cm	SP	EC ds/m	PH	T.N.V %	OC %	N %	P a.v.a p.p.m	K a.v.a p.p.m	Gyps. %	Physical Tests			
										% S	%Si	% C	Text
0 – 30	28	1.6	7.70	61	0.21	0.02	10.5	179	0.0	61	26	13	S.L
30 – 60	36	1.6	7.70	50	0.64	0.06	19.7	236	0.0	57	30	13	S.L

- Studyof The Results of Control Sample Soil

EC: The electrical conductivity or so-called salinity of soil samples is the same and low.

pH: The acidity of soil samples is the same and in the range of alkali and normal.

T.N.V: The level of lime in the soil sample is very high and undesirable.

OC, N: In total, two layers of severe nitrogen and organic matter deficiency are observed (the amount of nitrogen and organic matter in the second layer is slightly higher than the surface layer).

P, K: In general, the amount of absorbable phosphorus in the two layers is desirable, but there is a lack of absorbable potassium (although the amount of these elements in the second layer is more than the surface layer, which is not common).

Gypsum: In these soil samples, gypsum is not observed.

Texture: The texture of soil samples is the same in two layers; it is moderate to light and desirable (Table 5).

Discussion

- Comparison of Vegetative Parameters in Two Studied Stands

Comparison of vegetative parameters in two studied stands shows that in terms of vegetative characteristics, the average diameter is equal to the chest and the average canopy area of the Cupressus arizonica stand is significantly different from Tehran pine stand and has a higher growth.There is a significant difference betweenPinus eldaricastandsandCupressus arizonica stands in terms of average total height (Table 6).Also, there is a significant difference betweenPinus eldaricastands andCupressus arizonica stands in terms of drying,and the yield of dried rootstocks in Pinus eldaricais more than Cupressus arizonica.

Table 6. Comparison of vegetative parameters in two studied populations

Row	The name of stands	Average DBH (centimeter)	Average total height (Meter)	Average canopy level (Square meters)
1	Pinus eldarica	^{b}12/68	^{a}5/53	^{b}8/11
2	Cupressus arizonica	^{a}13/66	^{b}3/28	^{a}8/75

- Comparison of Soil Samples in Two Studied Standsand the Control Area

EC: The electrical conductivity or so-called salinity of soil samples of two studied stands is much higher than the salinity of soil samples in the control area, which can be due to the conditions of water samples.

pH: The acidity of soil samples is the same and in the range of alkali and normal.

TNV: The amount of lime in soil samples in the control area is very high and undesirable in the surface layer, while the amount of lime in both soil samples is very high and undesirable in Pinus eldaricastands; the amount of lime in soil samples of Cupressus arizonica stands, especially in the second layer is too much and undesirable.

OC, N: In soil samples of the control area, two layers of severe nitrogen and organic matter deficiency is observed (The amount of nitrogen and organic matter in the second layer is slightly higher than the surface layer). In Pinus eldaricastands, severe soil poverty in terms of nitrogen and organic matter is observed in both soil layers is obviousand in the Cupressus arizonicastands, the surface layersoil is completely rich in terms of nitrogen and organic matter, and in the second layer, the relative deficiency of these materials is evident (fertilization is done with organic fertilizers).

P, K: In the soil samples of the control area, a total of two layers of phosphorus absorbable for the plant is desirable, but there is a lack of absorbable potassium (although the amount of these elements in the second layer is more than the surface layer, which is not common). In Pinus eldaricastands, two layers of severe deficiency of phosphorus absorbable forthe plant in the soil is observed.In Cupressus arizonica stands, the amount of potassium phosphorus

absorbable forplant is desirable intwo layers, but the amount of absorbable phosphorus is abnormally high and undesirable (the presence of these amounts of phosphorus in soil is not desirable at all. It will interfere with root uptakeand prevent the absorption of important elements such as iron and zinc;Therefore, the moderation in the use of fertilizers is necessary).

Gypsum: In these soil samples, gypsum is not observed.

Texture: The texture of soil samples is the same in two layers; it is moderate to light and desirable.

Conclusion

In the case of Pinus eldaricaand Cupressus arizonica trees, they like light soil and semi-arid climate in the main habitat and have moderate tolerance in terms of salinity tolerance, however in many areas outside the main habitat, they face with some problems despite similar ecological conditions.In the forest parkof Bakhtiar Dasht inIsfahan, planting of Pinus eldaricaand Cupressus arizonica trees was successful in the early years of planting, but over the time and tree growth, the problem of gradual drying of trees arose.A combination of ecological and physiological factors has caused the drying of Pinus eldaricaand Cupressus arizonica trees. The tree is gradually weakeneddue to inadequate soil and salinity of irrigation water.On the other hand, the lack of leaching of salts has caused the accumulation of salts and excessive salinization of the soil, which is quite evident in the case of salinity of the soil in the control area with the salinity of afforested areas;The reason is related to irrigation with salt water.This is consistent with Warrington & Whittaker (1990) research on afforestation with Pinus eldaricaspecies around Shiraz Airport. This case is consistent with theresearch by Warrington & Whittaker (1990) on afforestation with Pinus eldaricaspecies around Shiraz Airport.The cause of death of forest trees, especially Pinus eldaricain Shiraz Airport afforestation is increased soil salinity and damage to the roots of trees due to the accumulation of salt around the roots, inadequate irrigation and drainage conditions. Also, in another study, the cause of wilt of Pinus eldaricain Chitgar Park of Tehran city is the lack of irrigation and poor soil nutrients, which is consistent with the results of this study.One of the problems in the soils of the study area is alkaline pH, i.e., pH above 7. Lack of rainfall in Isfahan and an arid and semi-arid climate causes the accumulation of exchange stands in the soil and as a result progress to alkaline soil. Another problem is that the soil is calcareous, which increases pH of the soil.Alkaline pH causes a decrease in the solubility of essential nutrients for the plant and a lack of nutrients required by the plant is observed. The main factor that contributes to these deficiencies is high lime.Considering that the first drying of trees in the area was observed in early 2011, it can be said that initially the trees in this area were irrigated using canal that branched from Zayanderud, but with a decrease in river water ofZayanderud and the lack of water flow in this canal, the green space trees of Bakhtiar Dashtregion were irrigated with water from several wells that had been dug.The dryness of the trees has increased since the green space of Bakhtiar Dashtregion was irrigated with the water of these wells. Analyzing the water of the wells by theAgriculture Faculty of the Azad University, Khorasgan Branch, it was determined that the water solutes of two wells with which the green space of Bakhtiar Dashtis irrigated,were too much.The use of water from these wells has caused the pores of the drippers to be blocked and the necessary water does not reach the plant through the drippers and only the soil at the stand of trees was wet.Of

course, it seems that in addition to the hardness of water, the nutrients needed by the plant were not present in the soil of this region, which was identified and proven in the soil analysis of this region.Dr. Tumanian, Assistant Professor of Research at the Agricultural and Natural Resources Research Center of Isfahan Province and Director of the Soil Surveying Group of Isfahan Province, has stated that the soil of Bakhtiar Dashtregion was alluvial and coarse-grained with different layers consisting of gravel and lime soil. There are dense layers in this area that prevent the vertical growth of tree roots at 60 cm above the soil surface.The soil of this area is not fertile and the trees do not receive the required nutrients from the soil. He stated that the water hardness standard number for pressurized irrigation in Iran is four and stated that according to the analysis, the water hardness of two wells out of three wells was 6.8 and 6.9.Therefore, it can be concluded that considering the beginning of tree drying, oil spills from upstream forestry industries in Bakhtiar Dasht region were considered as the main cause of tree drying.However, it seems that in addition to inaccuracy in the correct and principled selection of species, a very important factor that has affected the quantitative and qualitative characteristics of the stands in question is the soil and irrigation water, and considering that afforestation operations in arid and semi-arid regions are costly.Therefore,the issue in terms of species selection and soil and water analysis of the region is important.

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