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Evaluation of Carbon sequestration in pure and mixed Plantations of *Cupressus arizonica*

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ABSTRACT: The present study was conducted to investigate the effect of tree mixture on Carbon sequestration in *cupressus arizonica* plantations. Emission of carbon dioxide via human activities is known as the main cause of global warming. Therefore, in this study, soil carbon sequestration in mixed and pure stands was measured in order to compare the effect of tree mixture on the amount of carbon stored in the top mineral soil layer. The study site was Khargosh Valley Forest Park, located in Tehran province. This study included 4 different type of stands, the pure *Cupressus arizonica*, the pure *Pinus eldarica,* the mixed *Cupressus arizonica and Pinus eldarica* and the mixed *Cupressus arizonica* with deciduous hardwoods. Sampling method was done with a Systematic random network with dimensions 75 × 75 m. Samples parts were Square with dimensions of 20 x 20 m. At each plot center, forest floor was sampled from the first 10 cm of soil. To analyze the data one way analyses of variance (ANOVA) in SPSS v.20 was used to assess the Soil parameters. Tukey's tests were used to test significant effects ($p \leq 0.05$). Our results showed that the mean Carbon sequestration in the mixed plantations of *Cupressus arizonica* with deciduous hardwoods trees soils was greater than the other stands which in the standing mixed *Cupressus arizonica* and *Pinus eldarica* was lower than the pure stands. Our results Recommended for establishment ofconifer plantation, used mixed culture of Conifers with broadleaf Instead of pure cultures conifers. ©JASEM

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Plantations are primarily established in order to achieve economic objectives, such as the profitable income derived from the timber production and from other wood products. However, plantations are also established for the purposes of soil and water conservation as well as of carbon sequestration during reforestation and afforestation. (Stephens and Wagner, 2007; Bremer and Farley, 2010; chen et al., 2014). Emission of carbon dioxide via human activities is known as the main cause of global warming. Recent concerns about rising carbon dioxide (CO_2) concentrations in the atmosphere and its effects on Earth's climate have initiated the necessity to capture and sequester a large amount of atmospheric carbon pool in terrestrial sinks in a sustainable way. Plantation has been suggested as an effective way to restore degraded ecosystems, also helping to mitigate elevated atmospheric CO_2, and hence contributing towards the reduction of global warming (Liu and Diamond, 2005; Wang et al., 2013). As soil is an important terrestrial sink of carbon and vegetation is the major source of carbon to the soils, this can be achieved through forestation and suitable land use conversions (Srivastava et al., 2014; De Gryze et al., 2004; Pandey et al., 2010).

Appropriate forest management practices can have effective role to mitigate carbon emission as well as adsorbatmospheric carbon (Nguyen et al., 2014).

Converting monocultures into mixed forests has become a common trend of forest management in recent decades owing to enhancement of ecosystem functioning and sustainability due to complementary resource use, environmental benefits and improved soil properties in mixed forests (Wen et al., 2014). Mixed species plantations have the potential to provide increased benefits in terms of carbon sequestration, biodiversity, forest products, bush foods, and increased resilience to diseases and pests (Hung et al., 2011; Le et al., 2014, Nguyen et al,. 2014). Mixed species plantings may also increase community resilience to environmental changes including climate regulation, enhanced hill slope stability and improved carbon sequestration (Richards and Schmidt, 2010; Nguyen et al,. 2014). The results show that mixed plantings had similar or higher productivities, but conclusions on relative productivities depend on the species and growth features, interactions among species, Type of mixture (Mixing with broadleaf or mixing with conifers) and the variables quantified (Redondo and Montagnini, 2006). Therefore, in this study, carbon sequestration evaluated in mixed and pure stands to be determined mixture what type of effect on carbon sequestration.

MATERIAL AND METHODS

Study areas: The study site was Khargosh Valley Forest Park, located In the vicinity of the metropolis of Tehran province in the Iran country, with an area of 67 hectares (Fig 1). Which established in the years 1961-1971 with the purpose of tourism and creation of green spaces? Its geographical location within 51 ˚15 ´29 to 51˚ 15 ´49 " East longitude and north latitude is 35˚ 43 ´04 "to 35˚ 43 ´27 ".

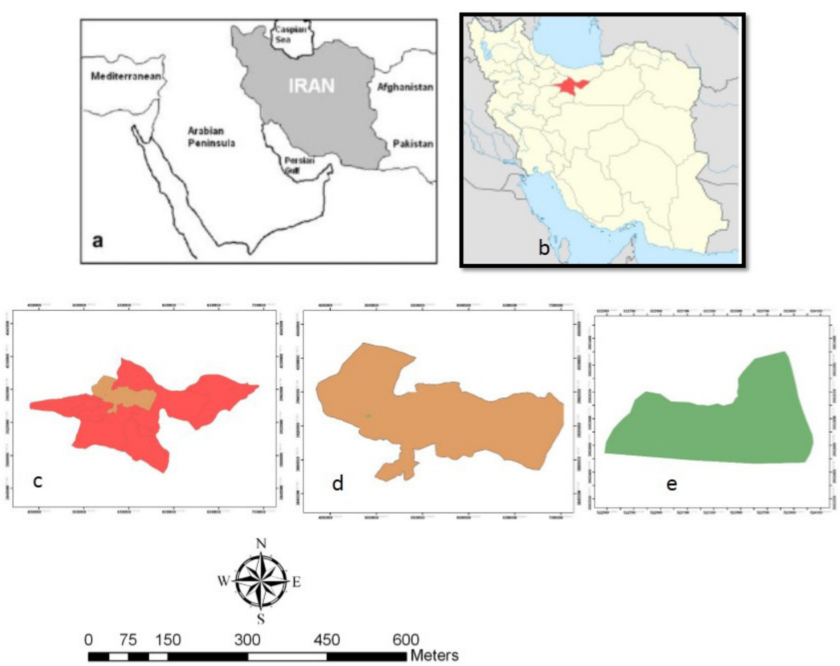

Fig1: location map for observational study site: (a and b) Iran Country. (c) Tehran Province. (d) tehran city. (e) Khargosh Valley Forest Park

Climatic factors: In this regard, was used the data of the synoptic station Tehran Mehrabad nearest station to khargosh Valley Forest Park project. In connection with rainfalls, According to statistics for a period of 24 years from 1980 until 2003, was observed that the highest rainfall in the autumn and winter and beginning of spring, These times coincides with the slow growth of plants or their physiologically. According to information obtained in a 24 year period from 1980 to 2003, The average rainfall over a period of 24 years were 240.3 mm, that In total amount is not sufficient And When the distribution is highly inappropriate. On the other hand, the long dry period is also negative impact on the biological activity of plants. By analyzing the statistical data, was found the highest amount of rainfall in the winter was 110.06 mm and the lowest rainfall in summer with 4 mm.

The temperature: According to the results, Monthly and annual temperature region during the years 1980-2003 in a period of 24 years: Annual average of at least 11.4 ° C and Average annual maximum was 24.2 ° C.

Sampling and data collection: Sampling method was done With a Systematic random network with dimensions 75 × 75 and the confluence of the sides of the network were considered as the center of the plot. Samples parts were Square with dimensions of 20 x 20 m. At each plot center, forest floor was sampled from the first 10 cm of soil.

The field moisture content was determined gravimetrically by drying each bulk density sample in an oven at 105 _C for 48 h. Samples were weighed before and after drying and percentage field moisture were calculated. Soil pH was measured with a pH meter. Bulk density was measured by hunk. Soil Electrical conductivity (Ec) was measured with an Ec meter. The calcium carbonate ($CaCO3_)$ was measured by neutralization.

Statistical and data analysis: Data was analysed after testing for normality (Kolmogorov– Smirnov test) and homogeneity of variance (Levene's test). One way analyses of variance (ANOVA) in SPSS v.20 was used to assess the Soil parameters. Tukey's tests were used to test significant effects at $p \leq 0.05$.

RESULTS AND DISCUSSION

The importance of enhancing the natural greenhouse effect leading to changes in the climate and rise in the global average temperature by increasing concentrations of CO_2 and other greenhouse gases in the Earth's atmosphere is obvious to all and an issue of international concern and current energy policies in all countries are driven predominantly by the need to reduce carbon dioxide emission (Ghorbani et al., 2014). Carbon sequestration in forest soils has a potential to decrease the rate of enrichment of atmospheric concentration of CO_2 Increase in C stock of forest soils can be achieved through forest management including site preparation, afforestation, species management, use of fertilizers and soil amendments (lal, 2005). The proportions of the species in mixtures can have important effects on stand development.

The results of this study showed that the mean Carbon sequestration in the mixed plantations of *Cupressus arizonica* with deciduous hardwoods trees soils was higher than the other stands which in the standing mixed *Cupressus arizonica* and *Pinus eldarica* was lower than the pure stands. Because of this result (highest rate of carbon sequestration in the mixed plantations of *Cupressus arizonica* with deciduous hardwoods trees) could be Increase soil organic carbon in this stsnds. Because mixture of softwoods and hardwoods makes improved rate of decomposition (Thelin et al., 2002; Redondo and Montagnini, 2006). It is well known that the soil organic matter declines in soils under agriculture conditions, depending on the type of crop and soil management. The results show that in the standing mixed *Cupressus arizonica* and *Pinus eldarica* However, its organic carbon was higher than the mixed stands of *Cupressus arizonica* with deciduous hardwoods, but the Carbon sequestration in these stands was lower than the pure stands and Because of this result was low Bulk density in these stands. The results show that (table 1 and table 2) mixed plantings had similar or higher productivities for several of the variables examined, but conclusions on relative productivities depend on the species and growth features, interactions among species, and the variables quantified. In addition, there is a need to continue monitoring over longer time-frames and for further studies of the species interactions and site factors involved, in order to develop reforestation guidelines for a range of objectives and environmental settings (Redondo and Montagnini, 2006). According to the results of this study, Bulk density in mixed stands (mixed plantations of *Cupressus arizonica* with deciduous hardwoods tree and also mixed plantations of *Cupressus arizonica* with Conifers trees) was less than the pure stands. Check pH in four stands showed that pH was highest value in the standing mixed *Cupressus arizonica* with deciduous hardwoods and *Cupressus arizonica* with Conifers trees, but in pure stands of *Cupressus arizonica* and pure stands of *Pinus eldarica* were the lowest level. Soil moisture in mixed plantations of *Cupressus arizonica* with deciduous hardwoods trees was higher than other stands. Between the soil characteristics, Ec and calcium carbonate ($CaCO3_)$, was not significantly different among the stands. Organic carbon and Organic matter were highest value in the standing mixed *Cupressus arizonica* with deciduous hardwoods and in the standing mixed

Cupressus arizonica with conifers raised relative to pure stands but the amount of this increase in this stands wasn't the mixed stands with hardwoods.

Conclusions: And finally, amount of Carbon sequestration in mixed plantations of *Cupressus arizonica* with deciduous hardwoods trees was higher than other stands and in mixed plantations of *Cupressus arizonica* with conifers was lower than pure stands. Our results Recommended for establishment of conifer plantation used mixed culture of Conifers with broadleaf Instead of pure cultures conifers.

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Table 1 - Soil characteristics (± standard error) in the studied stands

Type of stand/ Soil characteristics	pure *Cupressus arizonica*	pure *Pinus eldarica*	mixed *Cupressus arizonica* and *Pinus eldarica*	mixed *Cupressus arizonica* with Deciduous hardwoods
Bulk density	1.6286[a]±0.048	1.7571[a]±0.052	1.1000[b]±0.036	1.0200[c]±0.035
pH	7.2614[b]±0.02882	7.2129[b]±0.02456	7.4171[a]±0.061	7.4586[a]±0.012
Ec	0.3686[ns]±0.04474	0.3671 [ns]±0.0306	0.4043 [ns]±0.043	0.4800 [ns]±0.079
Soil moisture	1.7440[b]±0.08357	1.6643[b]±0.07503	1.7492[b]±0.065	3.6172[a]±0.152
Organic carbon	0.9174[c]±0.01680	0.8447[c]±0.03154	1.5181[b]±0.076	3.4906[a]±0.126
Organic matter	1.5816[c]±0.02896	1.4563[c]±0.05438	2.6173[b]±0.132	6.0177[a]±0.218
Lime	4.607 [ns] ±0.27741	4.6071 [ns]±0.685	5.2143 [ns]±0.586	5.5357[ns]±0.557

Soil characteristics	Source variations	Sum of Squares	Mean Square	F	Sig
	Between Groups	7.098	2.366	225.852	.000
Bulk density	Within Groups	0.251	0.010		
	Total	7.350			
	Between Groups	.296	.099	10.578	.000
pH	Within Groups	.224	.009		
	Total	.520			
	Between Groups	.059	.020	1.009	.406
Ec	Within Groups	.465	.019		
	Total	.524			
	Between Groups	18.945	6.315	89.806	.000
Soil moisture	Within Groups	1.688	.070		
	Total	20.633			
	Between Groups	32.081	10.694	262.118	.000
Organic carbon	Within Groups	.979	.041		
	Total	33.060			
	Between Groups	95.349	31.783	262.118	.000
Organic matter	Within Groups	2.910	.121		
	Total	98.259			
	Between Groups	4.489	1.496	.712	.554
Lime	Within Groups	50.446	2.102		
	Total	54.935			

Table 2 - Carbon sequestration (± standard error) in thestudied stands

Type of stand/ Carbon sequestration	pure *Cupressus arizonica*	pure *Pinus eldarica*	mixed *Cupressus arizonica* and *Pinus eldarica*	mixed *Cupressus arizonica* with Deciduous hardwoods
Carbon sequestration (Kg / m²)	1.4901[b]±0.02666	1.4794[b]±0.01337	1.2118[c]±0.09344	2.0825[a]±0.15245
Carbon sequestration (T / ha)	14.9007[b]±0.2666	14.7937[b]±0.1337	12.1181[c]±0.93441	20.8249[a]±1.52451

Carbon sequestration	Source variations	Sum of Squares	Mean Square	F	Sig
Carbon sequestration (Kg / m²)	Between Groups	2.838	.946	47.111	.000
	Within Groups	.482	.020		
	Total	3.320			
Carbon sequestration (T / ha)	Between Groups	283.832	94.611	47.111	.000
	Within Groups	48.198	2.008		
	Total	332.030			

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