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Comparison of some soil properties under canopy and inter-row trees in different poplar clones in north of Iran

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Abstract
Poplar trees are becoming extremely important as fast growing species due to the increasing need for wood and decreasing productivity of some lands in Iran. The present study aimed to find the effect of canopy of poplar clones as one of the most important effective factors on soil properties compared to the distances inter-row trees. Five poplar clones and species included: *Populus euramericana triplo, P. deltoides 69/55, P. deltoides 63/51, P. euramericana 45/51 and P. caspica* as native species were selected. They were planted about 18 years ago with 4×4 m spacing in frame of completely randomized block design with three replications. The soil samples were taken from 0-20 cm depth of soils under canopy of each tree and inter-row trees. The results showed the impression of the canopy on the soil properties, in a way that many physical and chemical properties of soil under the canopy and inter-row trees have significant differences. *P. deltoides 63/51* clone and inter-row the trees; *P. euramericana triplo* clone had greater positive effects on the soil properties compared to the other clones. Our results suggested that the presence of poplar clones may be an important source of soil spatial heterogeneity.

Keywords: Poplar; Clone; Trees Canopy; Soil properties

Introduction
Natural forests are one of the complex ecosystems, sustainable and valuable genetic resources in the world. As, the harvesting from the world forests steadily is increasing in the world, using of fast growing trees such as poplar is necessary. Guilan province located in north of Iran, has vast plain areas covered by natural forests, crops and poplar plantations.

Poplar as a species of calendar, are developed on the alluvial areas with good drainage, adequate moisture, with at least moderate fertility (Thomas *et al*, 2000). Poplar plantations are developed in north of Iran, because their fast growth and demands of wood industries (such as, poles, pulp, particleboard and fuel) (Kiadaliri, 2003). However, to maximize their growth, it is important to understand the relationship between growth rate, plant nutrient requirements and the ability of soil to supply nutrients (Kelly and Ericsson, 2003).

Singh and Sharma (2007), and Augusto *et al.* (2002) stated tree plantations influence soil physical, chemical and biological properties negatively or positively through litter fall, accretion and decomposition of organic matter. There is a positive relationship between soil fertility and tree biomass amount. It seems that different poplar plantations with various quality and quantity have been able to change some soil properties in recent years in Guilan plain (Kiadaliri, 2003). Trees in forest ecosystems and the form of plantation create fertilize soil through the biogeochemical process under its canopy. Kuchaki (2000) stated that differences in soil nutrient amount under the canopy is related to the nutrient absorbed by the plants in surface and deep roots and nutrients fixation. Barrett (1980) also reported that below the pine canopy the amount of Fe, Mn and Zn were significantly more than between the trees. Zheng *et al*. (2008) stated that N value in the soil under the canopy of *Salsola* sp. is significantly higher than the surrounding soil. Dahlgren *et al*. (2003) in their study in oak forest areas in California showed that the amount of OC, N, P and pH, under the canopy

is more than inter-row trees, especially in surface horizons.

Analysis of the relationships between trees and soil is one of the basic factors in management and planning of forests. Although in Iran and the other neighboring countries, there are some studies about soil characteristics for poplar planting, most of them are related to soil nutrition and classification (Kiadaliri 2003; Sayad *et al*. 2006), and a few studies have focused on the physical and chemical soil properties of poplar plantations under canopy and inter-row trees.

This study investigates the effects of some poplar clones and species on physical and chemical properties of soil under the canopy and inter-row trees in the poplar plantations in the north of Iran.

Materials and Methods

Study location and plant material

The study was carried out in poplar research station of Safrabasteh, Guilan province, north of Iran. The climate is strictly maritime, with an average temperature of 17.5 ˚C and an average precipitation of 1186 mm year^{-1} (longitude 57˚49′ E, latitude 19 37′ N). The soil of study area is formed on the alluvial fine textured sediment and soil texture silty loam. Five poplar clones and species included: *Populus euramericana triplo, P. deltoides 69/55, P. deltoides 63/51, P. euramericana 45/51 and P. caspica* as native poplar species were selected. They were planted about 18 years ago with 4×4 m spacing in frame of completely randomized block design with three replications.

Study design and soil sampling

Poplar clones was planted in frame of completely randomized block design with three replications. In each clone three soil samples were randomly taken from 0-20 cm depth of soils under the canopy and three samples between trees as well. In this way, 30 soil samples were taken from all of mentioned poplar clone and species. Soil samples transferred to soil laboratory for analyzing. All of soil samples were air-dried and passed through a 2 mm mesh. In the lab bulk density (B.D) by clod method, particle density (P.D) by Pycnometer method (Ghazanshahi, 1999), soil texture in hydrometric method (Bouyoucos, 1962), total nitrogen (*N*) by Kjeldhal method (Bremner, 1996), organic carbon (*OC*) by Walkley and Black method (Walkley and Black, 1934) were analyzed. Available phosphorus (*P*) was analyzed according to the standard methods (Olsen *et al*. 1954) and exchangeable potassium (*K*) after extraction using 1 M ammonium acetate (pH=7.0) by flame photometry (Black *et al*.1965).

Statistical analyses

All of soil variables were analyzed using Two-Way analyses of variance (ANOVA). Tukey-HSD test were used to separate the means of dependent variables which were significantly affected by treatment. For statistical analysis, SPSS (version 17.0) were used.

Results

The results of this research didn't show significant differences on physical properties of soil under the canopy of trees at depth of 0-20 cm. Also under the canopy of trees, all of the soil chemical properties except K showed significant differences among the treatments. The amounts of N and P as the most important nutrient elements and also C are higher in *P. deltoides 63/51* clone. Soil surface layer of *P. caspica* showed the lowest amounts of OC, N and P comparing to the other species and clones (Tables 1 & 2).

Table 1- Analysis of variance (ANOVA) of soil properties under the trees canopy

Source of variation	df	P.D	B.D	clay	silt	sand	OC	P	K	N
Treatment (F value)	2	0.19 ns	0.38 ns	0.06 ns	0.01 ns	0.00 ns	2.99 ns	3.83 ns	0.58 ns	2.55ns
Clone (F value)	4	1.45 ns	0.50 ns	0.36 ns	0.21 ns	0.32 ns	8.48**	5.68**	2.35 ns	9.55**

*Significant level %95, **significant level %99, ns: no significant

Table 2- Mean ± (Standard-Error) of soil properties in depth of 0-20 cm under the canopy of trees in the different poplar clones by Tukey-HSD test

Clones / soil properties	*P. caspica*	*P. d. 69.55*	*P. d. 63.51*	*P. e. triplo*	*P. e. 45.51*
P.D (g/cm3)	2.27±(0.06)a*	2.18±(0.04)a	2.16±(0.03)a	2.17±(0.08)a	2.20±(0.06)a
B.D (g/cm3)	1.42±(0.04)a	1.35±(0.05)a	1.28±(0.07)a	1.38±(0.16)a	1.39±(0.06)a
Clay (%)	36.11±(2.01)a	29.50±(1.76)a	26.67±(3.66)a	33.82±(2.83)a	35.84±(2.9)a
Silt (%)	57.02±(1.3)a	59.91±(1.15)a	58.31±(2.4)a	56.62±(2.3)a	55.54±(2.17)a
Sand (%)	6.87±(1.6)a	10.60±(2.4)a	15.02±(1.3)a	9.56±(1.42)a	8.63±(0.88)a
OC (%)	1.61±(0.14)b	2.51±(0.2)ab	2.85±(0.31)a	1.78±(0.13)b	1.7±(0.27)b
P (ppm)	1.17±(0.27)b	2.6±(0.59)ab	3.03±(0.45)a	2.07±(0.34)ab	1.59±(0.16)ab
K (ppm)	1.7±(5.73)a	2.27±(32.59)a	2.5±(26.26)a	1.7±(15.16)a	1.90±(20.66)a
N (%)	0.13±(0.01)b	0.21±(0.01)ab	0.24±(0.02)a	0.22±(0.01)b	0.14±(0.02)b

*Values followed by the same letter are not significant differ at the P=0.05 level.

The soil physical properties of soil inter-row trees showed no significant difference between treatments at depth of 0-20 cm. The results showed that among the soil chemical properties; *OC*, *N* and *P* differ significantly in the inter-row trees (Tables 3 & 4).

Table 3- Analysis of variance (ANOVA) of soil properties inter-row trees

Source of variation	df	P.D	B.D	clay	silt	sand	OC	P	K	N
Treatment (F value)	2	0.04ns	5.13ns	0.00ns	0.17ns	0.11ns	0.99ns	3.67ns	0.51ns	0.88ns
Clone (F value)	4	0.86ns	4.87ns	1.68ns	0.28ns	0.14ns	5.87**	12.81**	0.73ns	6.05**

*Significant level %95, **significant level %99, ns: no significant

Table 4- Mean ± (Standard-Error) of soil properties in depth of 0-20 cm in the inter-row trees at different poplar clones by Tukey-HSD test

Clones / soil properties	*P. caspica*	*P. d. 69.55*	*P. d. 63.51*	*P. e. triplo*	*P. e. 45.51*
P.D (g/cm3)	2.24±(0.02)a*	2.18±(0.03)a	2.14±(0.03)a	2.11±(0.06)a	2.17±(0.01)a
B.D (g/cm3)	1.52±(0.09)a	1.39±(0.03)ab	1.42±(0.04)ab	1.25±(0.07)b	1.29±(0.05)ab
Sand (%)	3.21±(4.48)a	3.63±(5.26)a	3.48±(2.17)a	3.39±(3.57)a	3.35±(2.3)a
Silt (%)	5.45±(3.47)a	5.51±(4.48)a	5.79±(2.45)a	5.49±(1.77)a	5.45±(1.25)a
Clay (%)	9.83±(1.01)a	8.5±(1.04)a	7.33±(0.33)a	1.13±(2.09)a	1.2±(1.52)a
OC (%)	1.28±(0.2)b	1.41±(0.1)b	1.46±(0.38)a	2.09±(0.1)ab	1.67±(0.21)ab
P (ppm)	0.98±(0.08)c	1.31±0.02bc	2.38±0.37ab	2.47±0.4a	1.25±(0.39)c
K (ppm)	1.47±(11.83)a	1.60±(1.51)a	1.83±(21.61)a	1.9±(8.75)a	1.61±(3.2)a
N (%)	0.11±(0.03) b	0.12±(0.02) b	0.14±(0.03)ab	0.19±(0.06)a	0.15±(0.08)ab

*Values followed by the same letter are not significant differ at the P=0.05 level among the treatments

The results of Tukey at 5% level, indicating that the amount of *OC* with mean of 2.85% in *P. deltoides 63/51* is higher compared to the other clones. The increase averaging of *OC* was about 0.77 under the canopy compare to inter-row the trees (Fig 1). The average of *N* and *P* values, in the intervals inter-row trees for *P.eura. triplo* clone and *P.deltoides 63/51* clone are more in comparison to the other clones (Fig 2 & 3). All of soil chemical properties in *P.caspica* have the lowest amount compared to the others clone.

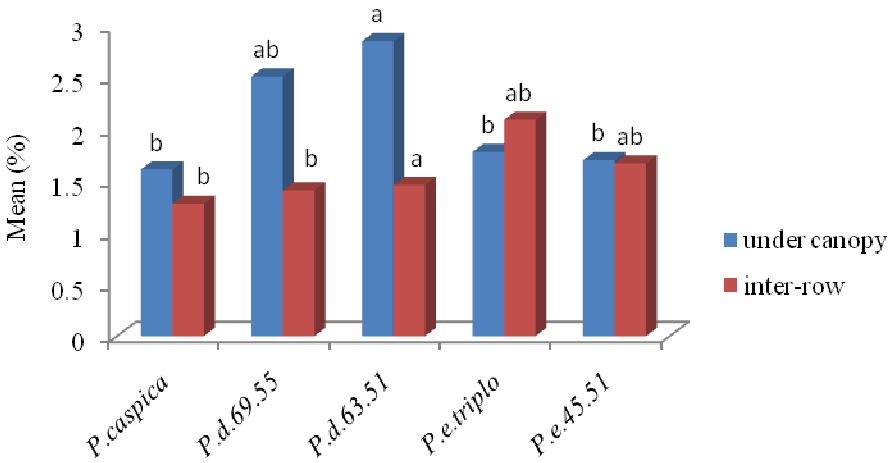

Fig 1. Mean comparison *OC* (%) among the different treatment

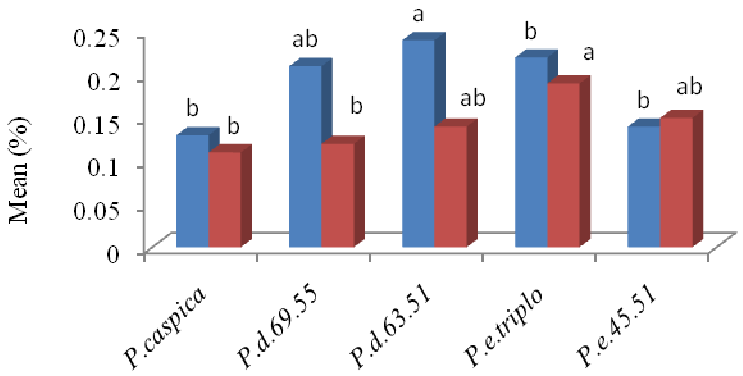

Fig 2. Mean comparison *N* (%) among the different treatment

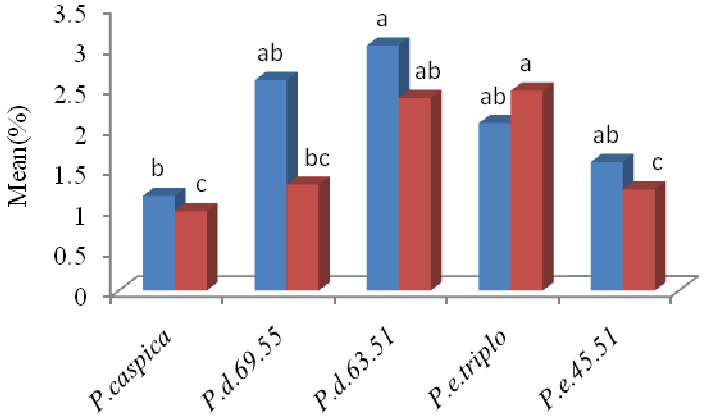

Fig 3. Mean comparison *P* (%) among the different treatment

Discussions

Growth of poplar depends upon various factors such as clone, quality of planting stock, spacing of trees, site quality, nutrient return, climate and management practices (Tewari, 1995). The results of this research didn't show significant differences on the majority of soil physical properties under the canopy and inter-row trees at depth of 0-20 cm. Sayad *et al*. (2007) also did not observe significant differences in soil texture and they concluded that it can be related to age of the plantation. Soil physical properties such as texture and density are related to habitat conditions and soil biological activity. Augusto *et al* (2002) in the review article concluded that trees are directly less important in changing the soils physical properties and it is dependent to change of habitat conditions and biotic communities in the long-term activity.

The results showed that there are significant differences for OC, N and P under the canopy and the inter-row trees treatments. The higher amount of OC, P and N observed in *P. deltoids 63/51* clone. Poplar species like *Alnus* and *Fraxinus* require high N amount for favorite growing (Zarrinkafsh, 2001) and N is introduced as the most important element in poplar growth.

The effect of trees on soil properties occur mostly due to the increase of organic matter and the release of nutrient from it (Salehi, 2005). Augusto *et al*. (2004) stated that canopy tree is the most important nutrient sources in the soil surface. It seems that increasing of canopy and consequently increasing of litter, as the main source of organic matter; produce important nutrients of soil such as N, P and K followed by process of litter decomposition.

Canopy as one of the most important factors affected on soil properties, may cause significant differences in chemical characteristics. Augusto *et al*. (2002), Singh and Sharma (2007) noted the effect of poor quality and quantity of litter on inappropriate decomposition of them and weak nutrient release to the soil. The inter-row the trees, the lack of canopy and low amount of litter is followed that cause in complete decomposition and return of nutrients to the soil. Moody and Jones (2005), explained the distribution of N in *Quercus sp*, stated that nitrate concentrations in the tree trunk is the least, in the middle of the canopy is high and in the edge of the canopy the concentration of it is decreased.

Because of the importance of phosphors at growth of trees, it is considered as important nutrient after nitrogen (Shahuyi, 2006). Regarding the importance of P, higher amount of these elements that is due to higher litter size produced by *Populus deltoides 63/51* clone compared to the other clones. In this study, K under the canopy of trees, showed no significant difference but the amount of it is higher under the canopy compare with the inter-row trees. Olyaee *et al.* (2012) obtained the amount of K in the surface layer under *Quercus* tree, middle and bottom was 667, 384 and 219 mg/kg respectively.

P. deltoides 63/51 clone had higher OC ،N and P in depth of 0-20 cm under canopy than the other poplar clones. It could be because of the widespread canopy and massive litters under the trees. *P. deltoides 63/51* clone in comparison with other poplar clones has positive effects on soil properties. On the base of this study, it is important to consider the ideal tree distances in the plantation to have the highest growth of trees, beside of the best condition for the soil properties.

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