ARTICLE

EFFECT OF PLANTING BED CONDITIONS ON SOME GROWTH CHARACTERISTICS OF PLANE TREES IN NORTH EASTERN PART OF IRAN

Payam Pakdel[1], Seyed Hossein Nemati*[2], Ali Tehranifar[3], Fatemeh Kazemi[4], Amir Lakzian[5]

Horticulture Department, Ferdowsi University of Mashhad, IRAN

ABSTRACT

Root environment and soil composition play an important role on growth and development of the roots and, consequently, the trees. In this research, the effect of some physical and chemical properties of two soil types, including a typical agricultural soil and an urban soil with three soil depths (0-40cm, 40-80cm and 80-120cm), on the growth of plane trees in an urban environment were examined. Plan trees were selected as the typical tree types planted in Mashhad urban landscape. The agricultural soil type was supplied from local agricultural fields and the urban soils type was sourced from urban street landscapes in Mashhad. The results showed that there were significant differences in all measured traits including soil density, lime percentage, soil pH and EC, organic carbon percentage, nitrogen, phosphorus and potassium content. The results of leaf analysis showed that the trees cultivated in the urban soil had lower nitrogen and phosphorus absorption compared with trees planted in agricultural soil. In urban soils, soil density increased, which can be due to urban planning standards. In addition to soil compaction, nutrient shortages, inappropriate pH and high EC and other adverse soil conditions, tree growth will reduce and shortage of tree nutrients will occur. Due to the importance of trees in the city's life, a suitable planting bed for receiving water and nutrient for trees in urban soils should be provided.

KEY WORDS
Soil density; Plane tree ; early decay; Soil lime; urban soil.

INTRODUCTION

Urban landscapes are major urban structures which provide oxygen for the cities and reduce air pollution. Also, urban landscapes can play a role in creating relaxation environments, controlling floods, creating visual aesthetics and reducing energy consumption. There are credible documents which show trees with shading in the summer and preventing winds in the winter will reduce energy consumption [1]. The ability of roots to explore the belowground environment in urban settings influences tree health, stability, and longevity. Quantitative studies on the response of urban trees to certain factors in bedding and underground environments are found [2].

Of all soil stresses in urban areas, the most common may be poor aeration due to soil compaction. Compaction destroys macro porosity; and because the pore space is reduced, soil resistance, hardness and bulk density are increased. In Washington, recently developed sites were found to have higher soil bulk densities than older sites, presumably due to more stringent engineering standards and more effective compaction equipment. Site development practices often entail removal of upper soil horizons (especially O and A) during grading, leaving denser subsoil at the surface, and the soil underlying pavement is typically compacted to provide structural support [2].

Received: 24 July 2017
Accepted: 14 Aug 2017
Published: 29 Aug 2017

The plan tree (*Platanus orientalis*) is fast-growing, hydrophilic, with high optical requirements, deep-rooted, and dust-resistant roots that are recommended to be applied in temperate and humid areas to prevent soil erosion [3]. Plantain trees cannot grow well in small environments, such as sidewalks and streets [4]. In recent years, plantain trees in Iranian urban environments suffer from many problems, such as early grazing and signs of food shortages [5]. Water stress can limit plane tree life in Easter Europe[6]. Although much research has been done on the plan tree disorder in Iran, there has not been any evidence of the effect of beding effect on the plane tree.

MATERIALS AND METHODS

In this experiment plan tree (*Platanusorientalis*) was selected as the typical tree of landscaping of Mashhad. Mashhad is located in the northeast of Khorasan Razavi province. The city is located at 36.20° North latitude and 59.35° East longitude. By existence of over 60,000 plane trees of different ages in Mashhad urban landscape, this species was the most dominant tree species. Landscape of this city has severe management problems, especially demolition and early stage deterioration severe problems trees.

Two groups of trees were selected. The first group planted in an agricultural soil type and the second group was planted in urban soils with a minimum distance from the first group of planting. The diameter of the selected trees were15-20 cm (measure from 50 cm distance from the soil surface) and the soil samples were taken from 60 to 90 cm radius around the tree trunks. Six soil samples were taken from each of the nine experimental sites selected in different parts of the city which accounted 54 soil samples for whole experiment. In each sample point in the selected sites across the city three soil depths of A= 0- 40 cm, B= 40-80 cm, C= 80- 120 cm for taking the samples were selected. In addition to soil samplings and measurements in each sample point, vitality of the trees was assessed observing general morphological quality the trees at the end of the summer season. The quality measurements were based on the two qualitative factors of visual degree of crown defoliation and the intensity of leaf necrosis. Based on two

***Corresponding Author**
Email:
nematish@yahoo.com

conditions for trees were classified including healthy trees (0–10% defoliation, 0% necrosis) and partly damaged (25–50% defoliation, 5–20% necrosis).

Soil density, soil lime, pH, EC, soil lime, organic carbon %,amount of nitrogen, potassium and phosphorus of the soil and also nitrogen, phosphorus and potassium content of the leaves were measured Then total organic carbon(using the Walkley and Black method) total nitrogen (using the Kjeldahl method), available phosphorus (using the Murphy-Riley method) and available potassium (Flame photometer) were measured.

This research was conducted as a completely design in 6 treatments and 9 replicates. The results were subject to analyses of variance as a factorial experiment based on a completely randomized block arrangement. Mean comparisons was performed based using LSD test 5% probability levels The statistical analyses were conducted using JMP 8 software package.

(A) **(B)**

Fig.1: Soil types used for this experiment. A) Urban compact soil. B) Agriculture soil.

Soil density, soil lime, pH, EC, organic carbon (%), soil nitrogen, potassium and phosphorus content and also nitrogen, phosphorus and potassium content of the leaves were measured. Soil density was determined by manual method and using a cylinder (5 cm height and 5 cm diameter) then dried and soil density was calculated. Soil lime amount was determined by the total neutralizing value (TNV%) method on the basis of calcium carbonate was measured using acid acetic volume consumed to neutralizing carbonates. Soil pH was measured in 1:1 [w/w] soil/water suspension; the electrical conductivity (EC) was measured from the saturation soil paste extract by an EC meter device. Then total organic carbon (Walkley and Black, 1934) total nitrogen determined by the Kjeldahl method (Hinds and Lowe, 1980), available phosphorus was measured by the Murphy-Riley method (1962) and available potassium was measured by Flame photometer device (Jenway-pfp7 model). This research was conducted as a completely design in 6 treatments and 9 replicates. The leafe nitrogen, phosphorus and potassium were measured by the Kjeldahl method (Hinds and Lowe 1980), available phosphorus was measured by the Murphy-Riley method (1962) and available potassium was measured by Flame photometer device (Jenway-pfp7 model). The results were subject to analyses of variance as a factorial experiment based on a completely randomized block arrangement. Mean comparisons was performed based using LSD test 5% probability levels The statistical analyses were conducted using JMP 8 software package

RESULTS

Soil pH

The results showed that there were significant differences between the soil types and depths at 5% probability level [Table 1]. Also, comparing the means [Table 2] showed that the highest soil pH was in0-40 cm depth in the urban soils. Lowest soil pH was in agriculture soil the 0-40 cm depth. Soil alkalinity is a common consequence of urbanization and therefore a more common impediment to tree health. This is mainly due to the use of concrete and other calcareous construction [2].

Previous research has confirmed the results of the present research in that urban soils tend to have higher soil pH than their natural counterparts. In Berlin, Germany, a pH of 8 was observed in street side, compared to a pH of less than 4 within a forest a short distance from the street. Over half of soils sampled in Hong Kong, China, were rated strongly alkaline (pH 8.5–9) to very strongly alkaline (pH 9–9.5), while surrounding soils were acidic at pH 4–5 [7].

Table 1: Analysis of Variance (mean squares) for soil characteristics plane trees in the studied experiment

	df	pH	EC	Density	Lime	O.C.	N	P	K
Soil type	5	1.15*	4.66**	0.51**	76.72**	0.26**	0.39**	209.27**	9183.48**
Error	49	0.39	0.19	0.01	4.73	0.007	0.006	23.34	919.29

**,* and ns: significant at 1 and 5% probability levels and non significant, respectively

Table 2: Mean comparison of the soil characteristics of plane trees in the studied sites

Treat	pH	EC d.s/m	Density gr/cm^3	Lime%	O.C.%	N%	P%	K%
Agricutral soil 0-40cm depth	7.14c	2.24d	1.36e	10.81cd	0.68a	0.74a	25.33a	220.7a
Agricutral soil 40-80cm depth	7.42bc	2.31d	1.47de	8.96d	0.46b	0.36b	19.22b	192.4ab
Agricutral soil 80-120cm depth	7.36bc	2.78cd	1.51d	11.55c	0.26d	0.21cd	12.22c	135.7d
Urban soil 0-40cm depth	8.15a	3.61b	1.97a	17.11a	0.34c	0.23cd	18.44b	206.2ab
Urban soil 40-80cm depth	7.74ab	4.05a	1.82b	14.75b	0.29cd	0.26c	15.22bc	179.1bc
Urban soil 80-120cm depth	7.69ab	3.09c	1.62c	12.22c	0.22e	0.18d	13.22c	154.4cd

In each column, means followed by the same letter are not significantly different at P≤0.05 according to LSD test.

Table 3: Analysis of variance (mean squares) for N, P, K in leaf contents of plane trees in the studied experiment

	df	N	P	K
Soil type	1	0.97**	0.13**	0.13ns
Error	17	0.11	0.009	0.04

**,* and ns: significant at 1 and 5% probability levels and non significant, respectively

Table 4: Mean comparisons of N, P, K leaf content of plane trees in the studied experiment

	N%	P%	K%
Trees planted in agricultural soil	2.45a	0.69a	1.66a
Trees planted in urban soil	1.99b	0.52b	1.49a

In each column, means followed by the same letter are not significantly different at P≤0.05 according to LSD test.

Soil EC

The results showed that there were significant differences among the soil types and depths in terms of soil electrical conductivity (EC) at 5% probability level [Table 1]. Comparison of the means showed that the highest soil EC was in urban soils at 40 to 80 cm depth, and the lowest in agricultural soils with depth of 0-40 cm [Table 2]. In Northeast parts of China, heavy snow in winter is usually accompanied with large amounts of snow-melting salt utilization. This salt utilization probably increases soil EC, and it is likely a pattern that urban central regions had more utilization of these salts [8]. The present findings suggest that, in addition to the above natural factors, human activities also affect soil electrical conductivity in the areas surrounded. Pervious study expressed in the low penetration depth; this reduced soil pore sizes, which furthered capillary rise and promoted high electrical conductivity even after a few days after the rain [9].

Soil density

The results showed that there were significant differences between the treatments at 5% probability level [Table 1]. Comparison of the means showed the lowest soil density was associated with 0-40 cm depth in agricultural soil and greatest in the 0-40 cm depth of urban soil [Table 2]. Perhaps the most important stress in urban soils is the reduction of soil porosity due to increased soil compaction. Soil compaction arising from urban land development and use is a more pervasive cause of root restriction for landscape trees. Compaction occurs as soil is compressed, which degrades structure, diminishes porosity, and increases strength the soil's physical resistance to penetration. Soil compaction in urban areas is widespread. In a study of 48 sites in Moscow, Idaho, and Pullman, Washington, recently developed sites were found to have higher soil densities than older sites, presumably due to more stringent engineering standards and more effective compaction equipment. Site development practices often entail removal of upper soil horizons (especially O and A) during grading, leaving denser subsoil at the surface, and the soil underlying pavement is typically compacted to provide structural support. Root penetration depth can be restricted by soil density [7]. The highest root activity including absorption of water and food and also aeration is carried out at soil depths of 0 to 30 cm. As we know root cells of the trees need to breathe. When breathing, if carbon dioxide produced from the surrounding environment cannot be removed and fresh oxygen is replaced by the atmosphere, the root is tense and cannot well absorb water and food [10]

IIOAB JOURNAL ISSN: 0976-3104

Soil Lime

The results showed that there is a significant difference between the samples at 5% probability level [Table 1]. Comparison of the means showed that the highest amount of soil lime was observed in urban soil and at 0-40 cm depth [Table 2].

In previous research on the urban soil showed increased concentrations of calcium and magnesium were also found, probably a result of contamination from building materials, such as bricks and concrete. Soil reaction is changed by higher concentrations of calcium and magnesium [11].

Total organic carbon

The results showed that there were significant differences between the soil types and depths at 5% probability level [Table 1]. Comparison of the means showed that the highest organic carbon content was observed in agricultural soil and disregarding the soil types total organic carbon decreases as soil depth increases [Table 2].

Due to the operation of submersion in urban soils, the soil layer is removed, which reduces the organic carbon of the soil, reducing the organic matter of the soil, which reduces the quality of root nutrition by the soil. By removing organic matter, the physical conditions of the soil make it harder for the food to be absorbed by the root. The removal of grass clippings, tree leaves, and other organic debris can further reduce inputs to the soil organic matter pool; while, organic additions such as top soil replacement, mulch, root turnover, microbes, earthworms, grass clippings, and leaf litter left on site help to build soil organic matter [9].

Soil nitrogen, phosphorus and potassium

The results showed that there is a significant difference in soil nitrogen, phosphorus and potassium levels between different soil types and depths with a 1% probability [Table 1]. Comparison of the means showed that in agricultural soils with a depth of 0-40 cm depth, the highest amount of root absorbable materials was found and this amount was reduced as the soil depth decreased. However in urban soils due to the structural changes and the removal of surface layer amount of these nutrients is reduced [Table 2]. Urban soils generally lack organic matter cycling and its nutrient contribution that typifies soil of the natural ecosystem. This is mainly because beneficial organic nutrient-containing materials (especially nitrogen, sulfur and phosphorus) such as leaves, litter, and animal remains are removed as wastes, or are produced in small quantities due to stressful conditions. Also, some urban soils do not rest on parent material or bedrock and do not receive the continuing benefit of nutrients released from inorganic mineral weathering [12].

In a study conducted in Beijing in 2014, it was determined that the total nitrogen and the total phosphorus in the soil in urban areas are lower than that in the surrounding area. In this study it was observed that the total P concentration in Beijing had a decreasing trend form the center of the city to its outskirts Compared to other cities around the world, the level of total N in Beijing was lower than that of Stuttgart, Germany (1400 to 7200 mg/kg) and Shanghai (370 to 2260 mg/kg, with an average of 1120 mg/kg) and especially this shortage increased in residential and commercial areas of the city [13].

Nitrogen, phosphorus and potassium of leaves content

The results showed that there was a significant difference ($p <= 0.05$) in nitrogen and phosphorus content of the leaves of the trees planted in agricultural soils and urban soils [Table 3]. Comparison of the means showed that leaves of the trees in agricultural soils had higher levels of adsorption nitrogen and phosphorus than the trees planted in urban soils. There were no significant differences in potassium content of the leaves planted of all both type of soil in this study [Table 4]. Nitrogen and phosphorus are macro nutrients in plant nutrition. Plants need these two elements during their entire growth period. Further nitrogen and phosphorus deficiency can reduce plants' growth and increase physiological disorders in plants and ultimately lead to an inability in the plants to absorb other nutrients.

In desert ecosystems such as that of (Mashhad climatic region), low soil moisture coupled with high soil alkalinity acts to decrease soil N and P availability. Infrequent and low precipitation limits soil weathering, organic matter production, and mineralization, leading to slow P release from primary material, low soil organic matter content, and N bound in organic matter. A study from 224 dry land sites indicated an increased decoupling of carbon (C), N and P with increased aridity resulting in greater P compared to N availability. Plant N fixation rates in arid regions have long been considered to be low because of low soil moisture and high temperatures. In contrast, ammonia volatilization of dry land soils can be high, as volatilization rates are positively related to soil pH, total salt content and $CaCO_3$, and negatively related to soil organic matter, cation-exchange capacity and clay content [14].

Availability of P is also reduced in alkaline soils. Elevated pH may also alter the composition and abundance of endomycorrhizal fungi that inhabit soil, which could influence root system colonization and therefore nutrient uptake capacity [3]

Although urban soils are heterogeneous and can defy generalization, it is common to find impenetrable horizons relatively near the surface; examples include buried asphalt, subsoil's compacted by construction activity, and poorly drained horizons. Analogous conditions in forest settings (e.g., bedrock, hardpans, shallow water tables) result in shallower root systems than occur for the same species on less restrictive

IIOAB JOURNAL
ISSN: 0976-3104

sites. Soil compaction is very common in urban areas and can result in severe root restrictions. Plant species interaction with the environment plays a role here as well [3].

Root depth and extent can be severely limited and highly irregular in urban settings. When root restrictions are minimal, root spread shows a strong relationship with trunk diameter, which is a more reliable predictor than canopy diameter or tree height [3].Soil hardness and lack of ventilation reduce root spread. Also, nitrogen deficiency in cities is one of the most common deficiencies in urban trees. Nitrogen deficiency causes poor trees with a small crown and yellowish-green foliage, causing death in the acute conditions.

CONCLUSION

Urbanization has caused significant changes in the natural environments. Soil, which is the main bed for plant and root activities, has also been changed a lot. Increasing the soil density, reduction in soil aeration, reduction in soil nutrients, changes in pH, EC, have caused green plants especially trees to live in cities with many problems. This research identified some of these problems. Such findings can assist urban planners and managers towards more sustainable urban landscapes in urban environments.

CONFLICT OF INTEREST

There is no conflict of interest.

ACKNOWLEDGEMENTS

We kindly appreciate Ferdowsi University of Mashhad and Muniplicity, parks organization for technical and financial help.

FINANCIAL DISCLOSURE

None

REFERENCES

[1] Watkins JR. [1998] Fertilization and Woody Plant Nutrition in the Context of the Urban Forest Professional Paper submitted to the Faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of Master of Forestry in Forestry.

[2] Day SD, Wiseman PE, Dickinson SD, Harris JR.[2010] Tree root ecology in the urban environment and Implications for a sustainable rhizosphere. Arboriculture and urban forestry. 36 (5): 193–205.

[3] Lakzian A, Feyzi V, Halajnia A, Tehranifar A, Rahmani H, Pakdel P, Mohseni H. [2013] Determination of daisies and assessment of nutritional status of plantain trees (Platanus spp) in Mashhad. Journal of horticulture science. 26(1): 35-44

[4] Javanbakht AH, KiadeliriH, Sheikholeslami A. [2014] The Effect of planting pattern on quantitative and qualitative properties of Platanus orientalis and Robiniapseudoacacia in Tehran, Iran Bulletin of Environment, Pharmacology and Life Sciences. 3 (3): 161-165

[5] Khoshgoftarmanesh AH, Eshghizadeh HR, Sanaei Ostovar A, Taban M. [2016] Assessment of Iron (Fe) Chlorosis in Plane Trees (Plantanus orintalis L.) Grown in Green Space of Isfahan City, I: Leaf Mineral Concentration J Sci & Technol. Agric. & Natur. Resourc, Water and Soil Sci. 20(76): 15-27

[6] Paunov M, Dankov K, Dimitrova S. [2015] Effect of water stress on photosynthetic light phase in leaves of two ecotypes of Platanus orientalis L. *Journal of BioScience and Biotechnology*.1(1) 15-23

[7] Watson G. [2012] Fifteen years of urban tree planting and establishment research. Trees, people and the built environment.32 (4):63-72.

[8] Zhai C, Wang W, He X, Zhou X, Xiao L, Zhang B. [2017] Urbanization drives SOC accumulation, its temperature stability and turnover in forests, Northeastern China. Forests. 8 (130): 1-18.

[9] Scharenbroch BC, Lloyd JE. Johnson-Maynard JL.[2005] Distinguishing urban soils with physical, chemical, and biological properties. Pedobiologia. 49(1): 283–296

[10] Harris RW. [1992] Arboriculture: Integrated management of landscape trees, Journal of Arboriculture 11 (11):330-339.

[11] Cekstere G, Osvalde A. [2013] A study of chemical characteristics of soil in relation to street trees status in Riga (Latvia). Urban forestry and urban greening. 12(1): 69-78

[12] Craul PJ. [1985] A description of urban soils and their desired characteristics. Journal of Arboriculture 11(11): 330-339

[13] Zhao X. Xia X. [2012] Total nitrogen and total phosphorous in urban soils used for different purposes in Beijing, China. The 18th biennial conference of international society for ecological modeling.

[14] He M, Dijkstra FA, Zhang K, Li X, Tan H, Gao Y, Li G. [2014] Leaf nitrogen and phosphorus of temperate desert plants in response to climate and soil nutrient availability. Scientific reports. 4(1): 1-7