Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2019, 9(2), 21-27

ORIGINAL ARTICLE

Soil physico-chemical properties and their effects on *Populus euphratica* growth in desertification areas

A. Huo[1,2], X. Wang[2], W. Guan[3*], J. Zhong[2], X. Yi[2], Y. Wen[2]

[1]Key Laboratory of Subsurface Hydrology and Ecological Effects in Arid Region, Chang'an University, Ministry of Education, Xi'an, Shaanxi 710054, China.
[2]School of Environmental Science and Engineering, Chang'an University, Xi'an, Shaanxi 710054, China.
[3]Afforestation Desert Control Research Institute, Xinjiang Academy of Forestry, Urumqi 830000, China.
E-mail: huoaidi@163.com
Received: 08.03.2019. Accepted: 20.04.2019

Natural vegetation is one of the key factors in the conservation of biological diversity and desertification control. In order to study the physical and chemical properties of soil and their effects on the growth of *Populus euphratica* in desertification-prone areas, this paper took Tarim National Nature Reserve as the research area. Through the field investigation and sample collection, the results by analyzing and comparing indicated as following: Soil grain in the south bank of middle reach of Tarim River mainly composed of silt particles, however, fine sand particles preponderated in the north bank. *Populus euphratica* grew well in the silty loam and sandy loam; the pH value of soil between 7.83 and 8.00 was suitable for the growth of *Populus euphratica*; the soil salinity totality of 0~20 cm deep was greater than 0.4%, and the content of soil organic matters was between 0.33%~0.80% in the studied area; the salt took hydrosoluble sulfate and chloride as the principal substance; they were statistically different in the soil physical and chemical properties of different regions. In the middle reach of Tarim River, soil salinization and alkalization were the dominant factors inhibiting the growth of *Populus euphratica* forest. Reducing the salt amount in soil was a preferential measure for ecological recovery.
Keywords: Desertification; soil properties; *Populus euphratica*; Tarim River

Introduction

As the most basic carrier for the maintenance and normal operation of terrestrial ecosystems, soil interdepend with vegetation in the ecosystem. On the one hand, soil water sakinity is the key factor of the underground environment of vegetation in desertification-prone areas, it affects and restrains the growth of natural vegetation directly(Liu et al., 2012). On the other hand, natural vegetationis a key factor in the conservation of biological diversity and desertification control. (Li and Liu, 2000). Therefore, the spatial distribution characteristics of soil physical and chemical properties and its relationship with vegetation growth are the key fields for the study of restoration ecology (Zheng et al., 2010).

***Populus euphratica* is an ancient Mediterranean reef species in the populus of the family**

Salicaceae, mainly distributed in the central and western desert regions of Asia between 30º-50º North and the Mediterranean Sea, North Africa and southern Europe. The Tarim Basin is the main distribution area of *Populus euphratica* , where accounts for 89.1% of the country's *Populus euphratica* forest area (Philipp, 2005) and 54.3% of the world's *Populus euphratica* forest resources (Wang et al., 2014). In recently decades, with the increasing of population and utilization of water and land resources, the vegetation in the middle and lower reaches of the Tarim River has declined, large-scale of *Populus euphratica* has died, the area of desertification has been enlarged and the ecological environment has been deteriorated, which has become a main factor that restricting the sustainable development of ecological environment and the social economic in the basin (Zhang et al., 2006). The results shows that *Populus euphratica* area in the Tarim Nature Reserve was 62,600 hm^2 in 2007, a decrease of 50% compared with that in 1973 (Jalaldin and Mamat, 2010). In the aspect of soil properties in the middle reaches of Tarim, the existing research shows that pH value is between 8.30 and 8.57 for the soil of 0~20 cm deep,the content of soil organic matters is between 0.62%~1.72% and the total sailinity is between 0.45%~1.27%. With the influence of river water overflowing and plant root system, the value of salinity, pH and nutrients decrease with the increase of soil depth, but not obvious. The soil moisture is the primary factor affecting the plant growth in arid areas. Soil texture, salt content and pH are the main factors affecting the community succession of desert riparian forest (Zhang, 2016). In the middle reaches, the soil nutrients of different succession stages of *Populus euphratica* forests distribute different: young, middle, mature and over-mature forests are concentrated in 0~20cm soil layer, near-mature forest is concentrated in 0~10 cm soil layer and 20~40 cm soil layer below the surface; soil organic matter, alkali hydrolysis (N), available (P), available (K)and mass fraction first increase

then decrease with the succession process of *Populus euphratica* (Wang et al., 2016). According to the groundwater level and the vegetation growth conditions, the riparian forests in the middle reaches of the Tarim River can be divided into three kinds of habitats: riparian zone, transitional zone and desert zone, the coverage of vegetation in riparian zone and the transitional zone can reach over 80%; soil bulk density decreases and salinity content increases in desert areas that vegetation develops poor. Soil organic matter, total phosphorus and total potassium in transitive zone soil with reasonable combination of hydrothermal and heat are the highest. In the transitive zone of the Tieqianlike oasis in the lower reaches of the Tarim River, the organic matter content in 0~50 cm soil layer is between 0.36%~0.84%, pH is between 7.79~8.82, the soil is alkaline, and some areas have strong alkaline. Among the different monitoring areas, the dominant species of vegetation are mostly saline-tolerant shrubs and herbs (Zheng et al., 2010). Similar studies have shown that the soil in the riparian zone of Aqikesu River is alkaline with organic matter between 0.32% -2.77%, and the content of available nitrogen and available phosphorus is much lower than the content of organic matter in the soil. The salinity content of 0~10cm soil layer is not higher, with an average of 0.37%, up to 0.76%; 0-10 cm soil layer of populus under good growth conditions, organic matter content is between 0.8%~2.5%, the salinity content is between 0.5%~0.7% (Zhang and Wang, 2015). In the Lake Aibi wetland, silty sandy loam and sandy loam are the main soil texture, with a high degree of salinization and alkalization. The salinity content of 0-20 cm soil layer reaches 5% in the *Populus euphratica* forest sampling site, and the content of organic matter is low, this spatial variation indicates that river promotes the growth of vegetation along the coast and plays an active role in the accumulation of organic matter (Jin et al. 2010). *Populus euphratica* can not grow with soil salinity content is 16.85%; soil salinization restrains nutrient absorption of *Populus euphratica*, even if the the content of organic matter is higher,the growth of *Populus euphratica* can also be restained (Xu and Zhang, 2012). In the lower reaches of Shule River, the moisture content of topsoil is between 0.8%~4.49%, and the salinity content is between 2.99%~23.75%, the soil moisture decreases while the salinity increases from the middle reaches to the lower reaches. The growth of *Populus euphratica* is stressed by soil water and salt, which is an important reason why the *Populus euphratica* is short,hollow and rotten in the lower reaches (Liu et al., 2011,2012). In the Weigan-Kuqa Delta oasis, tamarix, halostachys caspica and phragmites australis are the dominant plants on oasis saline soil, which are widely distributed in various saline habitats. Soil salinity is the main factor in soil chemical factors that influences the distribution of vegetation (Wang and Chai, 2011).

The succession and development of vegetation will show different growth characteristics with the changes of soil physical and chemical properties, water, nutrients, topography and other factors. At present, *Populus euphratica* resources in the study area have fewer individuals of juvenile stage in the population structure, and the population is difficult to maintain due to the harsh environment, which restrains the germination and survival of the seedlings, so it urgent to save *Populus euphratica* forest. There are fewer studiues on the soil physical and chemical properties under different vegetation development conditions in the middle reaches of the Tarim River and their relationships with the growth status of *Populus euphratica*. In this paper, the protected area is taken as the study area to study the physical and chemical properties of *Populus euphratica* under different growth environments, understand the dynamic changes of nutrients and salinity and their interaction with *Populus euphratica* degradation process, which provides a theoretical basis for the scientific utilization and protection of water and soil resources in the Tarim Basin and the regeneration and rejuvenation of *Populus euphratica* forest.

General Situation of Study Area and Study Methods

General situation of study area

In Xinjiang Bayingolin Mongol Autonomous Region, Tarim Populus National Nature Reserve crosses Weili country and Luntai country , located in the northern margin of the Taklamakan Desert and the middle reaches of the Tarim River Yingbashi - Carvalue Ga paragraph to the Tarim Basin. The *Populus euphratica* desert ecosystem in arid land is the protected object. The reserve is 109.7 km long and 47.1 km wide with a total area of 395,400 hectares. It is located between 40º55'~ 41º15' north latitude and 84º15'~ 85º30' east longitude.

The protected area belongs to temperate continental plain with desert climate. The annual average temperature is 10.9 °C, the annual sunshine duration is 2442~2925 h, the extreme minimum temperature is -25.5 °C, the average daily temperature difference is 14.6 °C, the accumulation of the temperature ≥ 10 °C is 4125.3 °C , the frost-free period is 180~224 d, the average annual rainfall is 65.5 mm, the average annual evaporation is 2024 mm (Zhang, 2016), the annual average wind speed is 1.8 m/s (Wang et al., 2016), prevailing northeast wind throughout the year, followed by the southwest wind. The altitude is 912 m (Wang et al., 2016) and the ground slope is about 1/4000 (Jalaldin and Mamat, 2010). The composition of plants are mainly poplar, Tamaricaceae, Leguminosae, Compositae and Gramineae. The soil mainly consists of *Populus euphratica*, desert soil, saline-alkali soil and sandy soil (Zhang, 2016). The main herbaceous plants in this area are reed, Glycyrrhiza inflata Batalin, Alhagi sparsi, etc. The shrubs are mainly dominated by Tamarix ramosissima and Halimodendron halodendron, and *Populus euphratica* is the major tree species in the arbor layer in the area (Wang et al., 2016).

Tarim River runs from west to east throughout the protected area. The length of the river in the area is 162.2 km. The total length of perennial rivers in the area is 310.2 km. During the flood season in Tarim River, 2.6-3.2 × 108 m^3 of water is consumed due to seepage and overflow across the bank of the river. The 99.2% of the groundwater in the area is transformed by vertical infiltration of surface water (Hamut and Mamut 2008). According to remote sensing image in 2007 analysis, *Populus euphratica* forest area in the reserve is 62,600 hm^2, the area of dry grassland is 166,100 hm^2, the water area is 32,500 hm^2, the farmland area is 11,000 hm^2, the saline-alkali land area is 75,500 hm^2 and the desert area up to 72,200 hm^2 (Hamut and Mamut 2008).

Study method

Sample site settings and presentation: The physical and chemical properties of soil under different habitats of *Populus*

euphratica forest were studied by means of field investigation, site setting, vegetation survey, sample collection, experimental analysis, and so on. In September 2016, during the flood season of Tarim River, a field survey was conducted in the Tarim National Nature Reserve. The habitats of the *Populus euphratica* community were divided into three types: desertification zone, transition zone and riparian zone. Select five sample plots that distributed in a north-south direction. The plots numbered S1, S2 and S3 are located on the south bank of the Tarim River, and the numbers are from S1 to S3 in turn near the river bank. The plots numbered N1, N2, are located on the north bank, N1 is close to river bank and N2 is far away from river bank. The investigation of the growth of *Populus euphratica* includes vegetation types, habitats, coverage, etc. The main plant species are *Populus euphratica*, Populus pruinosa, fruit of Russianolive, medlar, Halostashys Caspica, Halimodendron halodendron, Alhagi sparsifolia, licorice and so on. The survey of vegetation in different plots is shown in Table 1.

Table 1. The growth situation of vegetation in different plots.

Number	Habitats	Vegetation	Total coverage
S1	Transition zone	*Populus euphratica* Tamaricaceae	30%~60%
S2	Riparian zone	*Populus euphratica* Tamaricaceae bulrush	80%~100%
S3	Riparian zone	*Populus euphratica*	80%~100%
N1	Riparian zone	*Populus euphratica* Tamaricaceae Glycyrrhiza uralensis Fisch	80%~100%
N2	Desertification zone	Tamaricaceae Halogeton glomeratus	≤ 30%

Sample collection and testing methods: According to different habitat types of *Populus euphratica* community, soil samples were collected from the north and south banks of the main stream in the river. Samples of S1, S2 and S3 were collected on the southern bank of the Tarim River , N1 and N2 on the northern bank. The sample area was 100 × 100 m square; three 30 × 30 m quadrats were set in each quadrat. Three plots were randomly selected from each quadrat and 0-20 cm thick soil samples were collected at each point. We have obtained about 1 kg by quartering after mixing, and taken 3 soil mixed samples from each quadrat. Samples were processed for the determination of the indicators. Alkali hydrolysis diffusion method was used for the available nitrogen; molybdenum-antimony colorimetric method was used for the extraction of available phosphorus. The available potassium was extracted by NH4OAc-flame photometry. The mechanical composition was determined by Hydrometer method. The pH was determined through the glass electrode method, the organic matter using potassium dichromate external heating method, and salt content was determined by residue drying method.

Data processing method: The coverage as the main index in the survey of plant quantity, it can be obtained from the ratio of the vertical area of vegetation to the area of the sample. After analysis and test of the soil physical and chemical indicators, the results should be averaged and make a chart by using Excel2007 software, use DPS 7.05 software for statistical analysis. Using one-way ANOVA and multiple comparisons to test the significance and differences of soil indexes, with a typical Correlation Analysis Extract typical variable and analyze the relationship between the two groups of variables.

Results and analysis

Physical and chemical properties of soil

Soil mechanical composition: According to the classification of the US granulation, soil particles are divided into three categories: clay (≤ 0.002 mm), silt (0.05~0.002 mm) and sand (2.0~0.05 mm). In the study area, the content of sand is 4.2%~80.5%. The diameter grade of sand is mainly composed of fine sand (0.25~0.10 mm) and very fine sand (0.10~0.05 mm). The content of silt is in the range of 17.4%~88%, the silt content is concentrated in the range of 0.05~0.01 mm, the content of clay is in the range of 2.1%~19.4%. On the whole, the mechanical composition of soil in the study area is dominated by silt and fine sand. The soil texture of different sample plots is as follows: S1 sample: silt, S2 sample plots: silt loam soil, S3 plots: silt loam soil, N1 plots: sandy loam, N2 plots: loamy sandy soil. Soil particle size distribution and texture of soil are shown in Table 2 and Figure 1.

Table 2. The distribution diagram of soil grain in different research plots.

Particle size	The percentage of the mass of soil is less than that of one particle size (%)				
	S1	S2	S3	N1	N2
<0.5	-	-	-	-	100
<0.25	-	100	100	100	96.2
<0.075	100^{a}	93.6^{c}	97.6^{b}	84.2^{d}	80.2^{e}
<0.05	95.8^{a}	77.4^{b}	69.5^{c}	52.3^{d}	19.5^{e}
<0.01	27.9^{b}	46.3^{a}	21.3^{c}	19^{d}	8^{e}
<0.005	14.5^{b}	34.2^{a}	12.2^{c}	14.9^{b}	4.5^{d}
<0.002	7.8^{c}	19.4^{a}	7.4^{c}	12.6^{b}	2.1^{d}

Note: There are significant differences between the different lowercase letters ($p<0.05$).

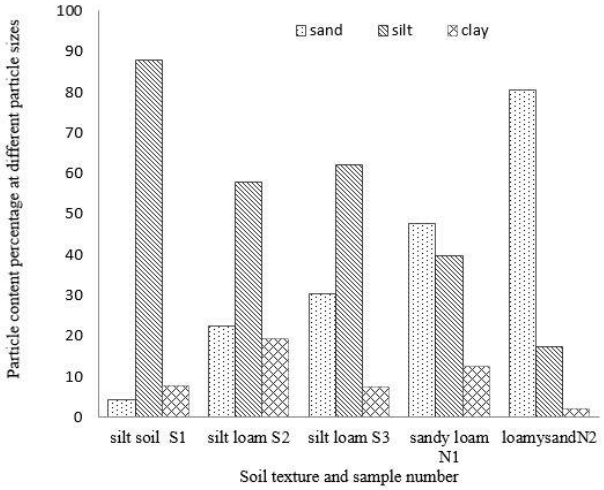

Figure 1. Comparison of the soil texture in different plots.

Soil chemical properties

The results showed that the pH of the soil in the protected area ranged from 7.83 to 8.46, the organic matter content ranged from 0.33% to 0.80%, the content of alkaline hydrolysis nitrogen ranged from 8.8 to 30.6 mg/kg and the available phosphorus content ranged from 3.9 to 21.8 mg/kg, the content of available potassium was 116-758 mg/kg. The contents of organic matter in the S3 and N1 plots were the highest 0.8% and 0.7% (Table 3).

Table 3. Content of soil fertility in 0~20 cm depth in studied area.

Number	pH	Organic matter/ %	Alkaline hydrolytic nitrogen ($mg•kg^{-1}$)	Available phosphorus ($mg•kg^{-1}$)	Available potassium ($mg•kg^{-1}$)
S1	8.46^{a}	0.46^{c}	12.3^{d}	21.8^{a}	116.0^{e}
S2	8.41^{a}	0.33^{d}	8.8^{e}	6.0^{d}	270.0^{c}
S3	7.91^{c}	0.80^{a}	19.3^{c}	11.5^{c}	627.0^{b}
N1	7.83^{d}	0.70^{b}	26.3^{b}	3.9^{e}	758.0^{a}
N2	8.25^{b}	0.34^{d}	30.6^{a}	16.9^{b}	187.0^{d}

Note: There are significant differences between the different lowercase letters ($p<0.05$)

In the study area, the salt content in 0~20 cm soil samples below the surface is more than 0.4%, with the chloride and sulfate being the main salt content, and the content of bicarbonate being lower. Soil samples with S3 and N1 had the highest degree of salinization, and salt content in surface soil more than 1.5%. See Table 4 for details.

Table 4. Content of soil salt in 0~20 cm depth in different plots.

Sample number	Salt content ($mg•100g^{-1}$ ±)					Total salt content (%)
	Ca^{2+}	Mg^{2+}	SO_4^{2-}	Cl^{-}	HCO_3^{-}	
S1	32.57^{c}	30.39^{c}	108.07^{e}	290.75^{c}	28.98^{d}	0.664^{c}
S2	30.06^{d}	18.23^{d}	186.12^{c}	161.33^{d}	35.09^{c}	0.584^{d}
S3	100.20^{b}	69.89^{b}	546.34^{b}	478.67^{b}	50.34^{a}	1.619^{b}
N1	205.41^{a}	121.55^{a}	1873.17^{a}	2087.53^{a}	39.66^{b}	6.284^{a}
N2	30.06^{d}	18.23^{d}	144.09^{d}	108.14^{e}	27.46^{e}	0.415^{e}

Note: There are significant differences between the different lowercase letters ($p<0.05$)

Populus euphratica development status

Vegetation in the study area is dominated by xerophytes and halophytes, which are suitable for growth in sandy soil. Common undergrowth vegetations are medlar, Halostashys Caspica, Halimodendron halodendron, Alhagi sparsifolia, licorice, reeds, halogeton. See Table 5 for details of development status in different sample plots.

Table 5. Variation of vegetation coverage in different plots.

Sample number	*Populus euphratica*		*Cacumen tamaricis*		Undergrowth vegetation
	Height (m)	Coverage(%)	Tuft size (m)	Coverage(%)	
S1	6^{c}	15^{c}	4^{a}	40^{a}	medlar, halogeton
S2	8^{b}	60^{ab}	2^{bc}	20^{bc}	reed *Alhagi sparsifolia*

S3	12^{a}	70^{a}	1^{c}	10^{c}	reed licorice
N1	9^{b}	50^{b}	2^{bc}	30^{ab}	halogeton
N2	6^{c}	10^{c}	3^{ab}	20^{bc}	halogeton

Note: There are significant differences between the different lowercase letters ($p<0.05$)

Typical correlation analysis

The relationship between soil properties (Group 1) and *Populus euphratica* growth vigor (Group 2) was analyzed by grouping the indicators and typical correlation methods. The selected basic variables include pH (x1), organic matter content (x2, %), total salt content (x3, %), silt content (x4, %) Phosphorus (x6, mg·kg^{-1}), calcium (x7, mg·100 g^{-1}), sulfate (x8, mg·100 g^{-1}) and chloride (x9, mg·100 g^{-1}), Populus height (y1, m), Populus coverage (y2, %). The first two pairs of typical variables U1, V1 and U2, V2 with the largest correlation coefficients were extracted from the two groups of basic variables, respectively, which can more adequately summarize the sample information. According to the analysis results, the statistical tests of the correlation coefficients of the first two pairs of typical variables reached extremely significant level ($p<0.01$). The conversion coefficient between the typical variables and the basic variables are shown in Table 6.

Table 6. Standarded canonical coefficients.

Group 1	**U_1**	**U_2**	**Group 2**	**V_1**	**V_2**
X_1	-13.4288	-22.5325	Y_1	1	-1.9325
X_2	-9.885	-19.6324	Y_2	0	2.1759
X_3	-1.1548	-2.9276			
X_4	5.6785	10.8301			
X_5	0.0193	0.6325			
X_6	0.5327	0.6143			
X_7	-0.5271	0.0844			
X_8	-0.4001	-0.0059			
X_9	-0.3121	0.0008			

Discussion

Soil texture and development of *Populus euphratica* forest: Through the analysis of the particle composition of various soil samples in both sides of the Tarim River, we can obtain the soil texture under *Populus euphratica* forest and different habitats, which is the most basic index of soil physical properties and directly affects soil fertility and physicochemical properties (Hamut and Mamut, 2008). The Tarim River water source is greatly affected by the seasons. In summer, the water in the entire basin surges sharply because a large amount of ice and snow melt into the river. The river floods the coastal areas and deposits the sediment upstream. (Wang et al., 2014). Therefore, under the action of sorting and deposition of alluvial plain and diluvial plain in the Tarim River basin and northward movement of the river, the non-zonal distribution of soil texture on both sides of the Tarim River is more complicated. Due to the influence of flooding on the soil structure of riparian forests, the more viscous soil is formed in the middle reaches of the Tarim River (Li et al., 2015). Silty and sandy loam are distributed in the riparian zone with better water conditions, the ability of water retention, water storage capacity and preserving fertilizer is better. The *Populus euphratica* grows best under these conditions. Plants can also accelerate the process of soil formation and increase the content of clay, the root system also played a role in the consolidation of sand (Sun, 2000). With the increase of the distance to river banks, the process of wind erosion separation causes continuous loss of soil fine-grained materials and coarse-grained materials relative increase (Huo et al., 2009; Huo et al., 2008; Huo et al., 2007; Sun, 2000), soil texture changes to dry silt and sandy soil with poor fertility , drastically temperature changes and poor vegetation development.

Relationship between soil nutrients, salinity and the development of *Populus euphratica* forest: The overall status of soil nutrients in the middle reaches of the Tarim River is low in total nitrogen and total phosphorus, and the content of total potassium is high (Wang et al., 2014). Soil moisture is an important factor affecting soil properties and also a major driving factor of ecological processes in arid regions (Zhang et al., 2010). Soil in the study area is generally impoverishment, soil organic matter and available potassium are the highest in the riparian areas with better hydrothermal condition. The soil texture in this area is silty and sandy loam, which is conducive to water conservation and fertilization. However, more plant litter and faster decomposition speed conducive to the accumulation of organic matter, which provides the integrant nutrients for the growth of *Populus euphratica*. The content of available nitrogen and available phosphorus are lower, which do not become the main factor affecting the development of *Populus euphratica* forest. The results shows that the pH is negatively correlated with organic matter, total nitrogen, total phosphorus, available nitrogen and available phosphorus (Wang and Chai, 2011), which indicats that the pH directly affecting the decomposition speed of soil organic matter and thus the availability of soil nutrients. The soil pH of the *Populus euphratica* and Populus- tulsanticulata mixed forest land with good vegetation condition in the study area is relatively lower, ranging from 7.83 to 7.91. The organic matter content is higher, ranging from 0.70 to 0.80. The soil physical and chemical properties are superior.

When salt content of soil epipedon (0-20 cm) exceeds 0.1% (gypsum soil is 0.2%), it can be considered as salinization (Zhao 2012). The degree of soil salt in the study area reflects the salinization phenomenon with surface pellicle salt and salt efflorescence widely distributed. Considering the land reclamation activities such as large-area cotton planting, this is the result of the synergistic effect of primary and secondary salinization. The influence of seasonal flooding and groundwater desalination zone promote the process of soil desalination and reduce the inhibitory effect of over-salt accumulation on vegetation germination and growth. Therefore, more poplar seedlings and young tamarisk plants are distributed in the area.

Typical correlation analysis of soil properties and *Populus euphratica* growth: There is a certainly correlation between plant diversity and quantitative characteristics and soil physicochemical properties. Spatial variability of soil physicochemical properties leads to significant changes in the status of plant growth and affects community succession, while the spatial distribution of plants has a significant improvement on the physicochemical properties of soil (Zhang, 2016). Among the first pair of typical variables of correlation analysis, the coefficient of soil pH value x1 and *Populus euphratica* height index y1 is the largest, which mainly reflects the negative correlation between soil alkalization and Populus height. In the second pair of typical variables, the coefficient of soil index x1 and *Populus euphratica* coverage index y2 is the largest, which reflects the negative correlation between soil alkalization and *Populus euphratica* coverage. In the properties of the soil, pH is the main factor affecting the growth of *Populus euphratica*. The prerequisite for soil alkalization is that the soil contains too much soluble salts. Therefore, salt drainage is the primary during the process of promoting the regeneration and rejuvenation of *Populus euphratica* forest. It can maintain the suitable submersion level through proper irrigation, which can prevent the secondary salinization aggravating. Secondly, sand fixation, fertilizing and planting green manure can gradually improve soil properties.

Conclusion

1. The soil texture in the study area is silty and sandy soil. The soil particles in the southern bank of Tarim River is dominated by silt and the north is dominated by sand. Silt loam soil or sandy loam distribution of radiation is more suitable for the growth of *Populus euphratica*.
2. The soil in the research area is alkaline (pH7.5~8.5) and there is a significant difference in the indexes of soil physicochemical properties in different areas. The accumulation of salinity and higher pH in the soil are the main factors that inhibit the germination and growth of *Populus euphratica*. Soil, which pH below 8, is suitable for *Populus euphratica* to growth.

Acknowledgments

Thanks Xinjiang Academy of Forestry for their full support of field investigation and soil sample collection.

Funding

This work was supported by the National Natural Science Foundation of China (Grants No. 41672255, 41877232, 41402255, and 41790444); High-tech research cultivation project (Grarnts No. 300102268202); Program for Key Science and Technology Innovation Team in Shaanxi Province (Grant No. 2014KCT-27), Promoting Higher Education Reform by Big Data Technology, Energizing Future Exploration in Teachers and Students (FPE, Grant No: 2017B00022) and Shaanxi Provincial Institute of Higher Education 2017 Annual Higher Education Research Project (Grant No: XGH17049).

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

References

Hamut, T., Mamut, A., & Ayup, M. (2008). Populus euphratica Ecosystem Fragility of Tarim River Basin and Protecting Strategy-A Case Study on Tarim Nature Reserve [J]. Journal of Arid Land Resources and Environment, 10.

Huo, A. D., Kang, X. W., Liu, Z. L., & Cao, X. S. (2009). Simplified Split-window Algorithm Model to Retrieve Land Surface Temperature in Aeolian Desertification Area with MODIS Image Data-Taking North Shaanxi Province as an Example. Journal of Earth Sciences and Environment, 3, 16.

Aidi, H. (2008). Research in retrieval of land surface temperature in Aeolian desertification areas from MODIS image data. Chinese High Technology Letters, 18(005), 511-518.

Huo, A. D., Zhang, G. J., Wu, S. L., & Liu, Z. L. (2007). Progressing and problems of domestic and international desertification dynamic monitoring and evaluation. Agricultural Research in the Arid Areas, 25(2), 206-212.

Jalaldin, A., Mamat, K. (2010). Study on land cover change of tarim poplar nature reservation. Journal of Arid Land Resouces and Envirornment, 24, 154-157(in Chinese, with English abstract).

Jin, H. L., Bai, X., Man, Z. L., & Zan, M. (2010). Space difference of soil in Xinjiang Ebinur lake wetland natural reserve district. Journal of Arid Land Resources and Environment, 24(2), 150-157.

Li, L., Zhou, Z. L., Lv, R. H., & Liang, J. Y. (2015). Soil physical and chemical properties of desert riparian forest in different areas of the Tarim River. Journal of Northeast Forestry University, 43(11), 75-78.

Yi, L., & Jianjun, L. (2000). Advance in spatial variability of soil properties. Journal of Shihezi University (Natural Science), 4(4),

331-337.
Liu, P. X., Yao, X. J., Zhang, K. X., & Huo, H. L. (2011). Spatial variation and effects of soil moisture and salt content of populus euphratica Oliv in the middle and lower reaches of the Shule River. Advances in Water Science, 22(3), 359-366.
Liu, P. X., Zhang, K. X., Huo, H. L., & Pan, J. H. (2012). Characteristics and Causes of the Spatial Variations of Soil Water and Salt Content under Populus euphratica Oliv. in the Middle and Lower Reaches of the Shule River Basin. Journal of Natural Resources, 6, 6.
Philipp, P. (2005). The Ecological Amplitude Populus Euphratica at the Middle Reaches of The River Tarim, Western China. Technical University, Berlin, 54.
Sun, B. (2000). Desertification Control Engineering. China Forestry Publishing House Beijing (in Chinese, with English abstract).
Wang, L., Wang, X., & Zhou, Z. (2014). Comparative Study on Soil Physicochemical Properties in the Middle Reaches of Thrim River Northern Horticulture, 23, 148-151 (in Chinese, with English abstract).
Wang, X., Zhang, Y., & Ou, Y. (2009). Economic loss caused by non-point source pollution-a case study of Taishitun Town, upper catchment of Miyun Reservoir, Beijing. Journal of Ecology and Rural Environment, 25(4), 37-41.
Wang, X., Shi, J., & Liu, M. (2016). Physicochemical Properties and Correlations of the Soils in the Populus euphratica Forests of Different Ales in the Tarim River Basin. Journal of Northeast Forestry University, 44, 63-68.
Xu, N., & Zhang, R. (2012). Effects of Soil Characteristics on the Growth of *Populus euphratica* in Typical Areas of Ebinur Lake. Wide-angle Lens, 3, 157-159 (in Chinese, with English abstract).
Zhang, H. (2016). Relationship Between Distribution Characteristics of Soil Physicochemical Properties and Vegetation in Desert Riparian Forest in the Middle Reaches of the Tarim River. Research of Soil and Water Conscrvation, 23, 6-12 (in Chinese, with English abstract).
Zhang, l., & Wang, Y. (2015). Analysis on Soil Physical and Chemical Characteristics under Different Vegetation Coverage in the Riparian Zone of Aqikesu River. Journal of Southwest China Normal University (Natural Science Edition), 40, 168-173 (in Chinese, with English abstract).
Zhang, X. P. (2010). Effects of vegetation restoration on soil physical-chemical properties and activities of soil enzyme in the gully region of the Loess Plateau. Agric Res Arid Areas, 28, 64-68.
Zhang, Y., Zuo, Q. T., Wang, X. P., & Ling, M. H. (2006). Development of water resources analysis system of the Tarim River Basin. Arid Land Geography, 29(6), 823-828.
Zhao, Y. (2012). Soil Environmental Science and Engineering. Beijing Normal University Press, Beijing (in Chinese, with English abstract).
Zheng, T., Liu, X., Li, W., & Wan, J. (2010). Soil heterogeneity and its effect on plant community in qasis desert transition zone in the lower reaches of Tarim river. Journal of Desert Research, 30 (in Chinese, with English abstract).

Citation: Huo, A., Wang, X., Guan, W., Zhong, J., Yi, X., Wen, Y. (2019). Soil physico-chemical properties and their effects on *Populus euphratica* growth in desertification areas. Ukrainian Journal of Ecology, 9(2), 21-27.