Research Journal of Environmental Sciences 5 (3): 259-268, 2011
ISSN 1819-3412 / DOI: 10.3923/rjes.2011.259.268

Growth and Nutrient Status of Introduced Black Locust (*Robinia pseudoacacia* L.) Afforestation in Arid and Semi Arid Areas of Iran

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ABSTRACT

Under global climate change it is expected that many arid regions in the world will experience enhanced desertification in the next decades. Black locust (*Robinia pseudoacacia* L.) is a one commonly used species for afforestation projects in arid regions of Iran due to its soil rehabilitation capabilities. This study aims to characterize how *Robinia* growth parameters and nutrient status interacted and were influenced soil properties. The experiment was conducted at three *Robinia* plantations in Iran, across a water and nutrient availability and salinity gradient. Sample plots (20×20 m) were set up at each *Robinia* study site in order to measure growth rate and to take leaf, stem and soil samples. Total concentration of macro and micro nutrients in soil and organic samples and also soil exchangeable cations were measured using ICP-OES. *Robinia* growth showed a positive correlation with soil organic carbon, total nitrogen, total phosphorus and Cation Exchange Capacity (CEC) and a negative relationship with soil inorganic carbon. In the study site with higher Exchangeable Sodium Percentage (ESP) *Robinia* absorb more exchangeable potassium than sodium as an adaptation mechanism against soil salinity. The concentration of nitrogen (N), sodium (Na) and calcium (Ca) of leaves was fairly good reflecting the variation in soil element concentrations under *Robinia* plantations. Consequently, mentioned soil properties can be applied practically as indicators for understanding the success or failure of *Robinia* afforestation projects in Iran and similar regions in the world.

Key words: Black locust, arid and semi arid areas, afforestation, soil properties, nutrient status

INTRODUCTION

Desertification as an increasingly global issue of the today's world is the main problem of arid regions (UNEP, 1987; Goudie, 1990). Arid and semi-arid regions are defined as areas with annual amounts of rainfall between 0 to 300 mm and 300 to 600 mm, respectively (FAO, 1987). The most critical consequence of desertification is the loss of vegetation (green cover) and as a result a serious reduction of basic soil functions. This is mainly the ability of soils to store and provide enough water and nutrients for plant growth as well as soil chemical and physical measures to bind organic and other fine soil particles against soil erosion. Honardoust *et al.* (2011) showed soil is one of the most important factors which affect desertification process. It is estimated that desertification affects directly nearly one sixth of the world population (World Bank, 1999). But certain regions might be more vulnerable due to their geographical location and topographical characteristics than others. In Iran for instance, approximately 90% of the total land area of the country is covered by arid or semiarid areas (Chavoshian, 2005). Afforestation projects are a frequent approach to control desertification in arid zones in many countries (Kassas, 1995). However, the species selected for this purpose must be tolerant and ecologically adapted to these areas (Le and McQueen-Mason, 2006). Black locust (*Robinia pseudoacacia* L.) is one such potential species a Nitrogen (N) fixing tree, native to the south-eastern part of North America (Barrette *et al.*, 1990). Plantations with N fixing trees can generally influence soil fertility but also improve the growth of associated trees positively by enriching N and organic matter including other nutrients like Phosphorus (P) (Wang *et al.*, 2005). *Robinia* is a frequently used species in Iranian afforestation projects because of its tolerance to ecological stresses like high temperatures and droughts (Hanover, 1990). It has also the ability to rehabilitate degraded land via erosion control and soil stabilisation (Dagar, 1998). Furthermore, *Robinia* is a well suited species for agroforestry because of its ability to fix high rates of 75 to150 kg of atmospheric N ha^{-1} per year (Boring *et al.*, 1981) and easy establishment from seeds or from coppicing (Nair, 1993). Also, Tabari and Salehi (2008) showed great capability of *Robinia* to increase soil carbon sequestration in arid regions of Iran. However, the precise data of planting areas using this species for Iran are not well known.

To date numerous studies have been carried out on the growth and nutrient status of *Robina* in response to different environmental parameters. For instance, findings by Tsiontsis *et al.* (2001) revealed that the soil pH, the soil structure and the available amount of Ca and Mg are the most prominent parameters which noticeably affect the growth of *Robinia*. A study by Tabari *et al.* (2008) in arid regions of Iran found that the use of waste water for irrigation enriched soils with heavy metals to concentrations that may pose potential long-term environmental and health risks for *Robinia* plantations. In a greenhouse experiment, Tingxiu and Guofan (1988) indicated that the enhanced growth of *Robinia* occurring in neutral, low calcareous and weakly acid soils and reduced growth occurred in strongly acidified and highly calcareous soils.

Although, *Robinia* is used in many afforestation projects in Iran, there is still insufficient knowledge about the response of this species on different ecological conditions. Thus the objectives of the given study were (1) to basically characterise and compare the nutrient status and some growth parameters of introduced *Robinia* plantations under different soil and climatic conditions in Iran and (2) to look for obvious correlations between applied soil and growth parameters in order to find some indicators for understanding the success or failure of *Robinia* afforestation projects Iran and similar regions.

MATERIALS AND METHODS

Study sites: Robinia is planted in nearly all arid and semi arid afforestation projects of Iran. After pre-selection of available *Robinia* stands in different locations of Iran, three stands of *Robinia* were chosen for further investigations (Fig. 1). The selected study sites were located in different climatic conditions in terms of amount of precipitation, average temperature and elevation. Using the FAO (1987), Semnan and Karaj study sites are classified as arid and Sanandaj as semi arid areas, respectively. According to Dawan and Famouri (1964) soils in Semnan are characterized as Sierozems and in Karaj and Sanandaj as calcareous Lithosol. It is supposed that these study sites are representative for arid and semi arid areas in Iran. Climatic data of the three study sites were provided by the Iran Meteorological Organisation for 40 years from 1965 to 2005 (Table 1).

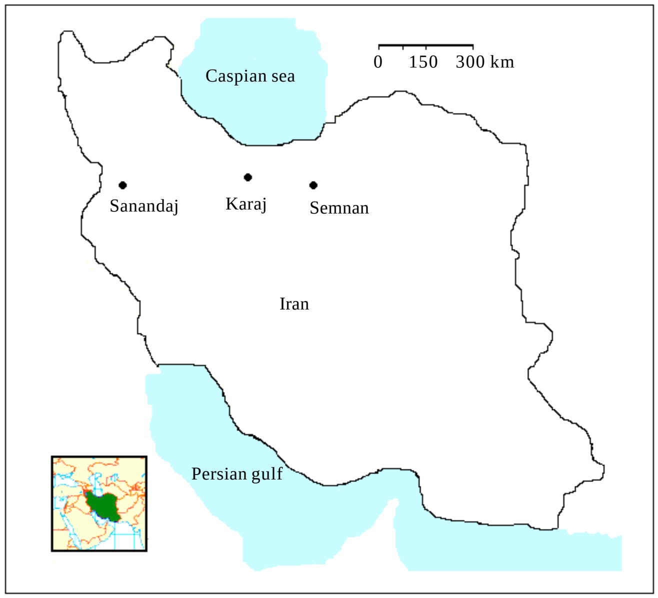

Fig. 1: Geographic location of selected study sites in Iran

Table 1: Basic site conditions for selected areas

Study sites	Elevation (m)	Latitude	Longitude	Annual temperature (°C) Min.	Max.	Average	Annual precipitation (mm)	Period of sunshine (h year^{-1})
Semnan	1117	35°36' N	53°30' E	12.4	23.8	18.3	140.8	3018
Karaj	1275	35°44' N	51°10' E	8.7	21.2	15.8	243.8	2952
Sanandaj	1397	35°14' N	47°00' E	5.5	21.4	14.2	458.4	2829

Field sampling and measurements

Soil and plant sampling: The field study was established in spring 2008 (growing season). At each study site, three sample plots (20×20 m) were randomly placed and soil samples were taken with six replicates in each plot and mixed together to make two representative composite samples (finally six soil samples for each study site). In addition, three stem cores samples randomly taken in each sample plot (nine core samples in each study site) at breast height of *Robinia* trees in order to determine the nutrient status of the stem. Young and vigorous leaves were collected (from the same trees used for the stem core samples) from top of the crown where it's exposed to sunlight (Habibi Kaseb, 1992).

Plantations yield survey: At each sample plot, tree height was measured from the soil surface to the canopy's tallest branches using an Abney Level instrument (Zobeiri, 2000). The crown diameter was determined by the measuring average distance of the widest branches of each individual tree in four main directions. Tree diameter was measured at 1.3 m (breast height) above the ground surface. Using the diameter and tree height data, the volume of tree was calculated using Eq. 1 (Zobeiri, 2000).

$$V = 0.4*H*D^2 \quad (1)$$

where, V is volume, H is total tree height and D is diameter at the breast height

Mean annual increment of growth parameters was calculated by dividing mean value of height, diameter and crown diameter of *Robinia* at each study site by the age of the stand.

Laboratory analysis: Before further processing, leaf samples were washed with distilled water. Samples were subsequently dried at 40°C for mineral soil samples and 60°C for organic material samples, then sieved (2 mm) and ground. Total concentrations of phosphorus (P), sulphur (S), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn) and potassium (K) in soil and organic samples (leaves and stem) were measured by ICP-OES (Spectroflame, Spectro Analytical Instruments, Kleve, Germany) after pressure digestion of samples with 65% of concentrated HNO_3 (Heinrichs, 1989). The total C and N content was analyzed by dry combustion with a C/N analyzer (Vario ElementarAnalysensyteme, Hanau, Germany). Organic carbon (C_{org}) was determined after breaking down inorganic C constituents (C_{inorg}) by boiling down 5 mL of added HCl (5%) per soil sample and re-measuring the total C content. Inorganic carbon was calculated as the difference of total carbon and organic carbon content. Due to the free carbonates in soils, the cation exchange capacity (CEC) was determined according to method described by Mehlich (1953) at a pH of 8.0 with $BaCl_2$. Exchanged cations (Na^+, K^+, Ca^{2+} and Mg^{2+}) were analyzed by the ICP-OES technique. ESP was calculated as the proportion of Na^+ in the CEC. The pH values were measured with a digital pH-meter (WTW GmbH, Weilheim, Germany) in 0.1 mol L^{-1} KCl. Soluble salts (EC) were determined with an electric conductivity meter (WTW GmbH, LF 196, Weilheim, Germany) using the 1:2 soil to water ratio suspension method (Dellavalle, 1992).

Statistical analysis: Data were analysed using a one-way ANOVA, followed by mean comparisons using the Tukey test. All reported differences were statistically significant at $p \leq 0.05$. Standard Deviation (SD) was calculated to show distribution of data around the mean. The STATISTICA software package version 7.0 was used for statistical analysis.

RESULTS AND DISCUSSION

Comparison of soil properties

pH, EC, CEC, ESP and percentage of other exchangeable cations: At the Semnan site, higher pH and EC values were measured in the whole soil profile while no differences in pH and EC were observed for two other study sites at all analysed soil depths (Table 2).

The Karaj site had the highest values of total cation exchange capacity (CEC) through the whole soil profile, compared to two other sites (Table 2). Sanandaj had higher CEC than Semnan in the 5-10 cm and 20-30 cm soil depths in the Sanandaj site (Table 2).

Semnan had a higher ESP (mean of 0-30 cm soil depth = 12%; Fig. 2) and the lowest proportion of Ca^{2+} (mean of 0-30 cm soil depth = 65%; Fig. 2) than two other sites. It also showed higher proportion of exchangeable K^+ in 0-10 cm (10%) and Mg^{2+} (10%) in 0-5 cm soil depth than the two other study sites. No differences were found between the Sanandaj and Karaj sites for the proportion of exchangeable Ca^{2+} and ESP in whole profile and also no differences were observed between Semnan and Karaj regarding the K^+ and Mg^{2+} ions content in 10-30 cm. However, Sanandaj had the lowest K^+ proportion (mean of 0-30 cm soil depth = 3.84%) and Mg^{2+} (mean of 0-30 cm soil depth = 6.69 %) values throughout the whole profile (Fig. 2).

Table 2: Soil characteristics in three *Robinia* plantations in Iran

Depth	Study sites	pH (Kcl)	EC (dS m^{-1})	CEC (Mmol kg^{-1})	C_{org}	C_{inorg}	N_t	P_t	S_t
					(mg g^{-1})				
0-5	Semnan	7.84±0.26b	4.96±0.31b	179.05±24.87a	22.27±2.15a	40.34±1.72c	1.55±0.62a	0.71±0.02a	2.27±0.47c
	Sanandaj	7.24±0.22a	0.46±0.12a	205.10±40.88a	32.46±7.01a	2.40±0.73a	3.11±0.91a	0.79±0.10a	0.52±0.17a
	Karaj	7.00±0.24a	0.72±0.06a	419.79±78.00b	70.00±12.17b	15.94±3.99b	5.56±1.09b	1.20±0.09b	1.12±0.20b
5-10	Semnan	7.80±0.23b	3.92±0.41b	76.80±12.97a	5.14±0.75a	39.59±4.54c	0.59±0.15a	0.63±0.03a	2.20±0.48b
	Sanandaj	7.16±0.24a	0.16±0.02a	130.21±5.52b	9.07±0.02b	0.95±0.33a	1.68±0.17c	0.66±0.06a	0.15±0.02a
	Karaj	7.26±0.17a	0.37±0.04a	184.72±10.08c	12.84±1.54b	7.36±1.15b	1.20±0.12b	1.11±0.07b	0.43±0.07a
10-20	Semnan	7.99b±0.10	3.35±0.47b	72.12±4.58a	1.33±0.22a	38.26±0.69b	0.36±0.08a	0.55±0.03a	1.94±0.28b
	Sanandaj	7.04±0.26a	0.15±0.03a	104.84±51.40a	5.39±1.71b	0.39±0.30a	1.43±0.20b	0.63±0.03b	0.12±0.01a
	Karaj	7.17±0.11a	0.31±0.08a	157.64±21.50b	5.93±1.87b	3.68±1.83a	0.72±0.11a	1.05±0.05c	0.32±0.06a
20-30	Semnan	7.86±0.22b	4.89±0.76b	55.40±12.38a	0.91±0.10a	42.07±4.73b	0.28±0.03a	0.48±0.03a	2.41±0.67b
	Sanandaj	6.88±0.37a	0.10±0.02a	133.03±11.04b	3.26±0.87b	0.38±0.23a	1.26±0.04b	0.62±0.02b	0.11±0.01a
	Karaj	7.12±0.22a	0.28±0.08a	156.18±6.98b	4.14±0.96b	2.93±1.98a	0.60±0.05a	1.02±0.08c	0.28±0.02a

Values are as Mean±SD. Different letters in same columns indicate significant ($p<0.05$) differences

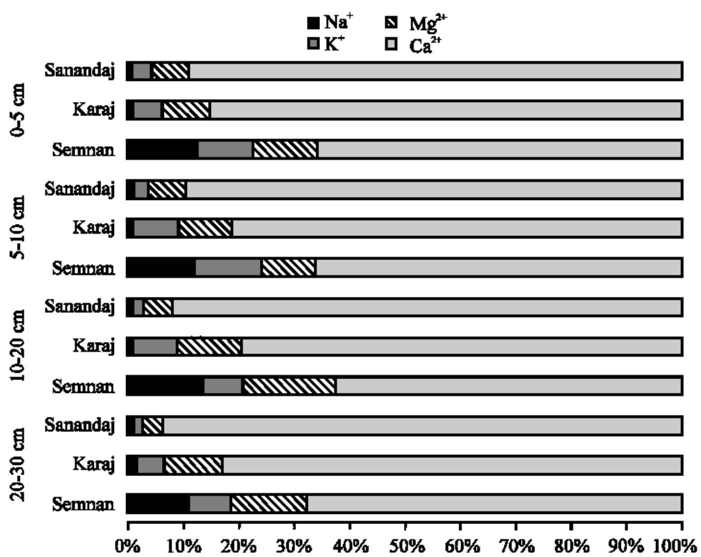

Fig. 2: Proportion of Na^+, K^+, Mg^{2+} and Ca^{2+} ions through the whole soil profile in *Robinia* study sites in Iran

Organic and inorganic carbon and nitrogen: The Karaj site had higher organic carbon content (C_{org}) and total N in top 5 cm of soil (Table 2), whereas, no differences was found between Semnan and Sanandaj in this respective horizon. Throughout the deeper soil layers, Semnan showed lower C_{org} and total N values (mean = 2.5 mg g^{-1}) than two other study sites (Table 2). From 10-30 cm soil depth Sanandaj had higher N values than two other sites (Table 2). Semnan showed the highest inorganic carbon contents (C_{inorg}) throughout the whole profile (mean of 0-30 cm = 40 mg g^{-1}, Table 2). No difference was found between Karaj and Sanandaj for C_{inorg} in 10-30 cm soil depth (Table 2).

Total phosphorus and sulphur: The Karaj site had the highest P values than the two other study sites in the whole profile (Table 2). No difference was analysed between Semnan and

Table 3: Height, diameter at breast height, crown diameter and volume of *Robinia* plantation in arid and semi arid area of Iran

Study site	Stand age	Height (m)	Diameter (cm)	Crown diameter (m)	Volume (m^3)
Semnan	31	7.44±0.87a	5.36±0.36a	4.96± 0.27a	0.02±0.01a
Sanandaj	31	7.75±1.02a	7.35±0.69ab	5.27± 0.41b	0.04±0.01a
Karaj	26	12.48±1.23b	10.82±0.93b	5.20± 0.82b	0.13±0.03b

Values are as Mean±SD. Different letters in same columns indicate significant ($p<0.05$) differences

Table 4: Nutrients content in leaves and stem of *Robinia* in different study sites

Tissue	Study sites	N	P	S	Na	K	Ca	Mg	Al	Fe	Mn
		(mg g^{-1})									
Leaf	Semnan	32.52±2.31ab	1.33±0.10a	3.04±0.40ab	0.09±0.02b	16.47±1.29b	22.57±6.51a	4.28±0.45b	0.37±0.10a	0.32±0.09a	0.05±0.02a
	Sanandaj	28.39±0.02a	1.26±0.10a	2.40±0.51a	0.08±0.01a	6.60±1.27a	39.57±3.16b	4.67±0.37b	0.78±0.10b	0.69±0.06b	0.25±0.09b
	Karaj	33.74±1.95b	1.26±0.10a	3.24±0.32b	0.07±0.02a	11.31±0.67ab	30.14±1.42a	3.47±0.24a	0.30±0.05a	0.31±0.04a	0.09±0.01a
Stem	Semnan	2.06±0.11a	0.04±0.01a	0.15±0.02a	0.03±0.01a	0.65±0.13a	5.05±1.40a	0.34±0.02b	0.03±0.02a	0.05±0.02a	0.00±0.00
	Sanandaj	2.12±0.78a	0.03±0.02a	0.14±0.05a	0.04±0.02a	0.69±0.64a	3.68±2.06a	0.14±0.09a	0.01±0.01a	0.02±0.00a	0.00±0.00
	Karaj	2.93±0.61b	0.05±0.03a	0.26±0.01b	0.04±0.01a	1.08±0.29b	3.91±1.00a	0.19±0.03a	0.09±0.05b	0.06±0.04a	0.00±0.00

Values are as Mean±SD. Different letters in same columns indicate significant ($p<0.05$) differences

Sanandaj in the 0-10 cm soil layer. However from 10 to 30 cm soil depth the Sanandaj site had higher P values than Semnan site (Table 2). Considerably higher S content was analysed for Semnan throughout the whole profile.

Comparison of Robinia growth rate and nutrient status: Trees at the Karaj site had the highest growth rate compared to the two other sites (Table 3). Sanadaj had higher tree diameter and crown diameter than Semnan (Table 3).

Robinia trees at Karaj site showed a higher leaves N and S but a lower Mg values than two other study sites (Table 4). For the Sanandaj site the higher leave concentration of Ca, Mn, Fe and Al were analysed. However, the highest leave concentration of K was detected in Semnan, compared to the two other sites (Table 4). Regarding the nutrient content in stem, again, the Karaj site showed enhanced values of N, S, K and Al and Semnan showed higher Mg values in comparison with the two other sites (Table 4).

The relationship between soil characteristics and growth rates: The C_{org}, the total N of the uppermost soil layer (0-5 cm) and the total P content of the whole soil profile showed strong positive correlations to the height and diameter increment of the *Robinia* sites investigated (Table 5). A negative correlation was found between the inorganic carbon content (C_{inorg}) and the growth parameters. Furthermore, a strong correlation was also found between the CEC and the exchangeable cations K^+ and Ca^{2+} of the whole soil profile and the annual height and diameter increment (Table 5). A negative correlation was identified between the pH in the upper most soil layer (0-5 cm) and the annual height and ring increment. The total S content and the exchangeable proportion of Mg^{2+} in the 0-30 cm soil layer exhibited a negative correlation to the annual crown increment. No strong correlation was found between the EC and the proportion of exchangeable Na^+ to any of the analysed growth parameters (Table 5).

With respect to the basic site conditions (Table 1) and in focus of the given mean annual precipitation of 459 mm, the Sanandaj site should exhibit the relatively best and the Semnan site the relatively worst tree growth results for *Robinia* (Table 3). With only 244 mm of precipitation, the Karaj site can be characterized as a semi-arid location and thus should indicate intermediate

Table 5: Pearson correlation coefficient between growth and soil parameters in three *Robinia* plantations in Iran

Soil depth (cm)	pH	EC	CEC	Na^+	K^+	Ca^{2+}	Mg^{2+}	C_{org}	C_{inorg}	N_t	P_t	S_t
0-5												
H	-0.66**	-0.34	0.87***	-0.22	0.79***	0.80***	0.08	0.85***	-0.08***	0.83***	0.90***	-0.07
D	-0.68**	-0.42	0.92***	-0.28	0.72**	0.86***	0.01	0.84***	-0.17**	0.89***	0.90***	-0.16
C	-0.51	-0.57*	0.43	-0.46	-0.05	0.16	-0.44	0.33	-0.61***	0.41	0.27	-0.53*
5-10												
H	-0.22	-0.30	0.78***	-0.37	0.81***	0.88***	-0.01	0.64	-0.25	0.18	0.88***	-0.26
D	-0.26	-0.41	0.85***	-0.46	0.76***	0.92***	-0.08	0.72**	-0.33**	0.29	0.93***	-0.35
C	-0.47	-0.58*	0.54*	-0.60*	-0.16	0.40	-0.56*	0.48	-0.58***	0.74**	0.22	-0.60*
10-20												
H	-0.24	-0.30	0.65***	-0.34	0.84**	0.86**	0.05	0.44	-0.32	-0.29	0.92***	-0.29
D	-0.35	-0.40	0.70**	-0.41	0.85***	0.89**	-0.05	0.47**	-0.41**	-0.21	0.93***	-0.39
C	-0.61*	-0.51	0.40	0.58	-0.01	0.43	-0.66**	0.35	-0.60**	0.44	0.21	-0.60*
20-30												
H	-0.14	-0.35	0.57*	-0.32	0.87***	0.38	-0.11	0.32	-0.34***	-0.36	0.89***	-0.30
D	-0.27	-0.42	0.66**	-0.41	0.84***	0.49	-0.18	0.36*	-0.45***	-0.28	0.92***	-0.41
C	0.65*	-0.61*	-0.66**	0.63	0.06	0.37	-0.61*	0.13	-0.62***	0.51	0.29	-0.63*

H: Annual height increment, D: Annual diameter increment and C: Annual crown increment. *p<0.05; **p<0.01; ***p<0.001

growth rates. However, our results clearly indicate, that water might not be the only factor controlling the growth of *Robinia* at the investigated sites. The Karaj site showed clearly the highest tree growth rates, combined with partly improved soil conditions, mainly with respect to the CEC and the total N and P content in the soil. Nevertheless, the Semnan site with only 141 mm of annual precipitation-clearly indicating an arid location-showed unbiased the relatively lowest growth rates, combined with reduced CEC and lower total N and P values and in the soil. Furthermore, reduced growth rates at Semnan may also be attributed to the degree of salinization (EC), which is partly more then ten-times higher here, compared to the Karaj site (Table 2). Provided that genetic plant material of the investigated sites was more or less equal and no specific mechanisms of site adaptation for the investigated *Robinia* trees occurred so far, our results might indicate, that above a certain threshold of precipitation (here around 250 mm) the growth limiting factors for *Robinia* should mainly be seen in basic soil conditions like the CEC, the total N, C_{org} and P supply as well as the degree of salinity.

Regarding result of this study, a strong positive relationship was detected between *Robinia* growth and soil CEC (Table 5). It is in contrast with Tingxiu and Guofan (1988) showed a weak correlation (r = 0.24) between the soil CEC and the biomass of *Robinia*. Also results of present study showed that total C of the above soil layer showed a close relationship to the growth of *Robinia*. It is confirmed by Feng *et al.* (2004) increasing carbon uptake caused increased N_2 fixation by *Robinia* and result in enhanced growth of this species. Aronson *et al.* (1993) showed low levels of organic matter directly influence soil features critical to water and root infiltration in arid and semi arid regions. The high correlation was detected between soil total N and P content and growth parameters of *Robinia*. It is agreed by Reinsvold and Pope (1987) who showed direct effect of soil P and N content to increase *Robinia* dry weight of stem, leaves and whole plant in one greenhouse experiment. Nitrogen is a limiting factor of the plant growth due to its contribution in protein and chlorophyll molecule which is involved in photosynthesis process and leading to the plant growth (Mclaren and Cameron, 1996). Also previous studies suggested N as a primary limiting resource for the plant growth in semi arid regions (Krueger-Mangold *et al*., 2004; Paschke *et al*., 2000; McLendon and Redente, 1991). High correlation of P and growth of *Robinia* might be due to high P demand in nitrogen fixation process by *Robinia* root nodules (Marschner, 1995; Tsvetkova and Georgiev, 2003). Soil properties in the first layer (0-5 cm) had the highest relationship to the growth of *Robinia* and could adequately represent the available variation among soils under *Robinia* plantations.

Moreover, results of this study indicated that the soil pH, ranging from 7 to 7.8 had a negative correlation to the measured growth parameters of *Robinia*. These results confirm findings by McComb and Kapel (1942) that states decrease in *Robinia* biomass when the pH increases from 6.9 to 7.7. In contrast, Roach (1965) demonstrated that growth of *Robinia* is not sensitive to the soil pH from 4.6 to 8.2.

Nutritional status of plants is directly related to their growth and productivity (Mengel and Kirby, 2001). In general leaves could represent the nutritional status of plants best, compared to the stem. The concentration of N, Na and Ca was fairly good reflecting the variation in soil element concentrations under *Robinia* plantations. However, the leave P, K and Mg concentrations could not reveal respective soil concentrations truly. Wu *et al*. (2007) showed that some leaves nutrients (i.e., P, Ca, Mg and Fe) were correlated with soil contents while some others (i.e., N, K, Mn and Cu) were not in rain forest trees of Taiwan. So it is suggested that leaf nutrients concentration of trees are affected by many parameters and just soil nutrients content can not be supposed as only determinant factor for nutrient status of *Robinia*. In this study, for instance, the study site having the highest soil exchangeable Na content, had also higher leaves K content despite of lower exchangeable K amount of soil through all investigated sites. A study by Fox and Guerinot (1998) showed the limiting role of Na^+ for uptaking K^+ in saline conditions. However results of this study confirm recent findings of greenhouse study by Bhatt *et al*. (2008) showed higher selectivity of *Ziziphus mauritiana* for absorbing K^+ than Na^+ in saline conditions. It is suggested that *Robinia* resist against soil salinity via absorbing K^+ instead of Na^+.

CONCLUSION

More than 90% of total area in Iran is covered by arid and semi arid regions. *Robinia* used widely in afforestation projects in Iran due to its high capability to adaptation in arid regions. It has this capability to conserve and fertile poor and unstable soils of such regions in Iran. Regarding result of this study soil nutrients of P, N, C_{org} as well as CEC play a key role in growth of *Robinia* in arid region soils of Iran. At the presence of enough nutrients, *Robinia* can well resist against soil salinity which is one of the main limiting parameters in arid regions. In such conditions, *Robinia* absorb more K instead of Na as a mechanism to resist against soil salinity. Leaves are better representative of nutrient status of *Robinia* tree than stem and concentration of N, Na and Ca of leaves can well reflect the variation in soil element concentrations under *Robinia* plantations. It is strongly advised for soil testing phase before plantation due to select right sites or improving soil status and consequently enhancing success of plantation in similar regions.

ACKNOWLEDGMENTS

This project has been funded by the German Academic Exchange Service (DAAD). We are also grateful to H. Ghiyassodin, Y. Salehiyan and A. Tahernejad for their field work support and to O. Van Straaten for his text work assistance.

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