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The Role of Seed Provenance in the Growth and Nutrient Status of Black Locust (*Robinia pseudoacacia* L.)

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ABSTRACT

Black locust (*Robinia pseudoacacia*) has worldwide economic and ecological importance and cultivated widely at the rate of three million hectare globally. A greenhouse experiment was carried out to investigate the role of seed provenance in growth and nutrient status of *Robinia*. Seeds from different geographical locations were planted in the same ecological conditions. After six months, all *Robinia* trees were harvested and separated into leaves, stems and roots. Element concentrations of P, S, K, Ca, Mg, Fe, Al, Mn and K in organic materials (leaves, stems and roots samples) were measured by ICP-AES. A significant difference was detected among seeds provenances of *Robinia*. regarding height (160-240 cm) and diameter (4.2-6.8 mm). Different *Robinia* seed provenances showed significant different concentrations of potassium (K) in leaves and calcium (Ca) in stems while no significant differences was observed in terms of other investigated nutrients.

Key words: Black locust, *Robinia pseudoacacia*, provenance, nutrient status

INTRODUCTION

Black locust (*Robinia pseudoacacia* L.), native to North America (Barrette *et al.*, 1990), is one of the most effective nitrogen fixing tree species in the world (Olesniewicz and Thomas, 1999). It has global economic and ecological importance and planted widely in temperate North America, Europe and Asia at the rate of three million hectare globally (Hanover *et al.*, 1991).

The nutritional status of plants is directly related to their growth and productivity (Mengel and Kirkby, 2001). It is strongly influenced by some key parameters like the nutrient availability in soils, the genetically nutrient uptake potential and some environmental boundary conditions like soil fertility, elevation, slope and climate conditions (Wu *et al.*, 2007; Van den Driessche, 1974).

According to the European community definition, provenance is the place where the stands of trees (whether native or not) are growing (Ford-Robertson, 1971). The effects of seed source on the physiological and phonological characteristics of trees were investigated in several studies (Oleksyn *et al.*, 1992; Varelides *et al.*, 2001; Eysteinsson *et al.*, 2009). Also, it is proved that the nitrogen fixation ability of *Robinia pseudoacacia*, *Acacia nilotica* and *Faidherbia albida* is affected by seed provenance (Moshki and Lamersdorf, 2011a; Beniwal *et al.*, 1995; Gueye *et al.*, 1997).

Moshki and Lamersdorf (2011b) showed that the soil properties have significant role in nutrient status of *Robinia* in arid and semi-arid regions of Iran. However, so far, no study was carried out to investigate the seed provenance effect on nutrients status of *Robinia*.

MATERIALS AND METHODS

Greenhouse experiment: Seeds provenances of *Robinia* were selected in Iran and Hungary. Selected areas show different environmental conditions in terms of amount of precipitation, average temperature and elevation (Table 1). The greenhouse experiment was conducted in Göttingen, Germany (51°33' N and 9°57' E at elevation of 205 m). Collected seeds were scarified using abrasive paper, were soaked in water over the night and planted. After three weeks preliminary growth, they were transplanted into pots containing commercial potting soil (Table 2). The temperature of greenhouse was adjusted constantly on 18°C. The photoperiod was eight hours per day. All of plants received same amount of water two times per week. The height and diameter of each plant were measured after three months and continued at an interval of one month up to end of experiment (six months). A Completely Randomized Design (CRD) was used, consisting of four treatments of *Robinia* seed sources, one for each collection provenance (i.e., Hosszupalyi, Karaj, Sanandaj and Semnan). We replicated each treatment six times.

Sampling and chemical analysis: After six months, *Robinia* trees were harvested and separated into leaves, stems and roots. Samples were washed with distilled water, dried at 60°C for 48 h, weighted and ground. Element concentrations of P, S, K, Ca, Mg, Fe, Al, Mn and K in organic materials (leaves, stems and roots samples) were measured by ICP-AES (Spectroflame, Spectro Analytical Instruments, Kleve, Germany) after pressure digestion of samples with 65% of concentrated HNO_3 (Heinrichs, 1989).

Statistical analyses: Data were analysed using one-way ANOVA, followed by mean comparisons using the Duncan test at 95% confidence level test to identify the statistical differences of measured parameters among *Robinia* seed origins. The STATISTICA software version 7.0 was used for statistical analysis.

Table 1: Locations of seeds collecting areas

Origin of seeds (Country/city)		Elevation (m)	Latitude (N)	Longitude (E)	Annual mean temperature (°C)	Annual precipitation (mm)	Period of sunshine (h/year)
Iran	Semnan	1117	35°36'	53°30'	18.3	141	3018
	Karaj	1275	35°44'	51°10'	15.8	244	2952
Hungary	Sanandaj	1397	35°14'	47° 00'	14.2	459	2829
	Hosszupalyi	105	47°24'	21° 45'	10.1	567	1982

Table 2: Soil properties used for greenhouse experiment

Soil properties	pH ($CaCl_2$)	(KCl) (g L^{-1})	(OM) %	N (mg L^{-1})	P_2O_5 (mg L^{-1})	K_2O (mg L^{-1})
	5.9	2.0	35	300	240	350

OM: Organic matter

RESULTS AND DISCUSSION

A significant difference was found among *Robinia* seed origins in terms of height (160-240 cm, Fig. 1) and diameter (4.2-6.8 mm, Fig. 1). Through continuous measurements, Hosszupalyi always had significantly higher values and Semnan had lower values than other seed provenances regarding height and diameter growth. However, no significant difference was found between two other provenances regarding these parameters. Furthermore, *Robinia* seed origins showed different concentrations of potassium (K) in leaves and calcium (Ca) in stems whereas they uptake nutrients from the same pool. However, no significant difference was detected through comparison of other nutrient contents in different *Robinia* provenances (Table 3).

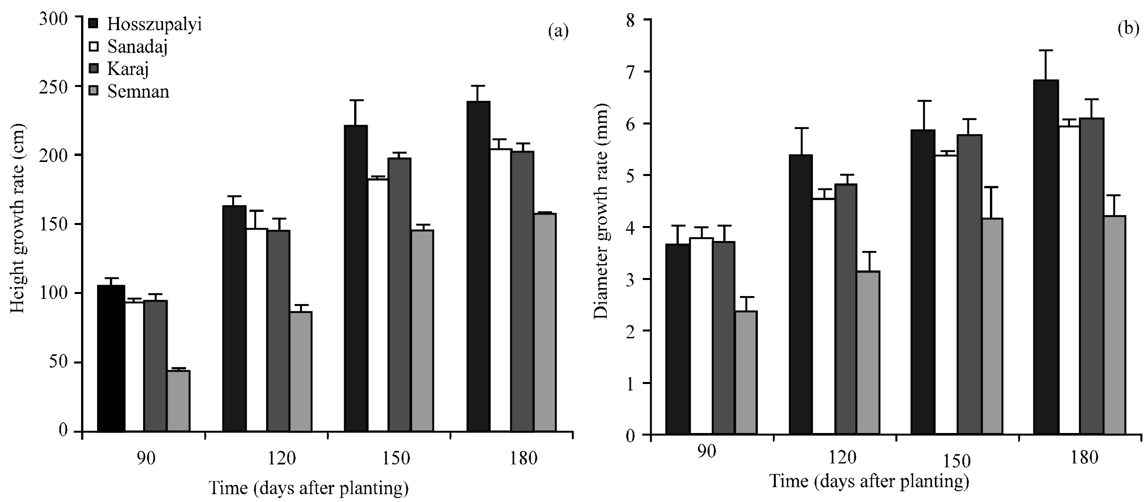

Fig. 1: Mean (SD) of height and diameter growth rate of *Robinia* in different provenances during growing period

Table 3: Nutrients content in leaves and stem of *Robinia* in different study sites

Plant tissue	Provenances	Nutrients (mg g^{-1}) P	S	Na	K	Ca	Mg	Mn	Fe	Al
Leaf	Semnan	4.48±0.86^a	2.77±0.44^a	0.05±0.00^a	28.61±2.73^b	25.09±1.72^a	3.53±0.87^a	0.10±0.00^a	0.15±0.01^a	0.09±0.01^a
	Sanandaj	4.62±0.77^a	2.51±0.29^a	0.05±0.00^a	24.76±1.68^{ab}	24.75±3.66^a	2.63±0.32^a	0.13±0.01^a	0.13±0.01^a	0.07±0.00^a
	Karaj	4.70±1.34^a	2.64±0.32^a	0.06±0.00^a	24.03±1.44^{ab}	25.76±4.69^a	2.55±0.82^a	0.13±0.04^a	0.16±0.02^a	0.09±0.01^a
	Hosszupalyi	4.46±0.54^a	3.05±0.74^a	0.06±0.01^a	21.08±1.16^a	25.56±8.30^a	2.82±0.76^a	0.12±0.01^a	0.17±0.04^a	0.08±0.00^a
Stem	Semnan	3.13±0.80^a	1.25±0.12^a	0.04±0.01^a	11.17±1.29^a	5.02±0.56^a	0.86±0.11^a	0.00±0.00	0.03±0.00^a	0.00±0.00
	Sanandaj	2.68±0.34^a	1.38±0.17^a	0.05±0.01^a	10.90±0.94^a	5.27±0.43^{ab}	1.01±0.05^a	0.01±0.00^a	0.06±0.03^b	0.01±0.01^a
	Karaj	2.89±0.16^a	1.14±0.18^a	0.05±0.00^a	9.95±1.08^a	6.17±1.12^{ab}	0.88±0.14^a	0.01±0.00^a	0.04±0.00^a	0.00±0.00
	Hosszupalyi	2.85±0.30^a	1.35±0.07^a	0.05±0.02^a	10.22±0.36^a	6.84±0.87^b	0.85±0.03^a	0.01±0.00^a	0.04±0.00^a	0.01±0.00^a
Root	Semnan	5.33±0.64^a	4.01±0.40^a	1.05±0.25^a	22.73±2.76^a	4.77±0.68^a	2.83±0.56^a	0.12±0.05^a	0.57±0.20^a	0.60±0.13^a
	Sanandaj	5.48±0.32^a	3.60±0.79^a	0.68±0.21^a	21.37±1.56^a	3.76±0.26^a	3.27±0.72^a	0.16±0.05^a	0.48±0.20^a	0.54±0.17^a
	Karaj	6.58±0.79^a	4.13±0.92^a	1.20±0.21^a	20.48±0.31^a	4.19±0.91^a	3.30±0.52^a	0.08±0.02^a	0.33±0.08^a	0.63±0.30^a
	Hosszupalyi	4.48±0.92^a	3.93±0.70^a	1.15±0.67^a	19.97±0.50^a	4.61±0.92^a	3.26±0.64^a	0.12±0.05^a	0.41±0.02^a	0.64±0.06^a

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

By supporting the results of this study, the seed provenance significantly affect growth of *Robinia* while it affects nutrient status of *Robinia* weakly. Only K in leaves and Ca in stems were different amongst different provenances of *Robinia*.

Three of four provenances used in this study are originated from the arid and semi-arid regions of Iran. These regions are characterised with salt and water stress problems that limit growth of the plants. Both of the Ca and K have significant role in plant growth and physiological functions, where environmental factors such as salt and drought stress limit growth of the plants (Hu and Schmidhalter, 2005; Cakmak, 2005). The growth of the *Robinia* is varied significantly amongst different *Robinia* seed provenances. Therefore, it is expected that the concentrations of Ca and K are varied amongst *Robinia* seed provenances as well because of the role of these elements in growth of *Robinia*.

The seed provenance effect on nutrient status of plants was reported also for *Pinus sylvestris* (Gerhold, 1959; Steinbeck, 1966; Raitio and Sarjala, 2000) and *Pinus nigra* (Oleksyn *et al*., 1987).

As shown in this study, the seed origin has significant role in growth of Robinia and affects softly the nutrient status of *Robinia*. Therefore it should be taken into account as an important factor to enhance success of plantation projects. Hence one testing phase of available seeds provenances is strongly recommended before decision for planting of *Robinia* in any given area.

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