9

Growth Characteristics of Rainfed/Irrigated *Juniperus excelsa* Planted in an Arid Area at North-Eastern Iran

Masoud Tabari and Mohammad Ali Shirzad
Tarbiat Modares University, Iran

1. Introduction

Many dry regions of the world due to shortage enough water resources are lacking vegetation cover. This is while that the severe deforestations happened during short time has decreased their surface area in recent decades. Using the drought-tolerant species for rehabilitation of these regions and compensation of water deficit is promising (Tabari et al., 2011) Although, in dry regions the survival rate of planted seedlings managed as rainfed is low and watering causes enhanced survival and growth (Koroori and Khoshnevis, 2000; Lichter, 2000; Shirzad, 2009), because of low and irregular rainfall, long dry period, insufficient water resources, only drought tolerant tree species are able to recompense the scarceness of vegetation cover (Boers, 1994; Kozlowski, 1987). These species owing to the high capacity of water storage at stem and branch, and the good rooting in soil are able to well bear the drought status and to overcome the drought stress (Oliet et al., 2002; Tabari et al., 2011). Since the vast regions of world have dry climate, strategies for perfect use of the water resources and the drought-resistant species, which are able to highly benefit from the soil moisture, can be the main targets of plantation in such regions (Oliet et al., 2002; Sanchez-Coronado et al., 2007).

Juniperus excelsa is distributed in vast areas of Irano-Touranian growing regions (Zare, 2001). It tolerates high dryness and coldness and is able to restore deforested areas in mountain arid and semi-arid zones (Hampe and Petit, 2010). Of course, except *Juniperus excelsa,* other conifers have been also investigated for rehabilitation of such lands. Baquedano and Castill (2006), Oliet et al. (2002) and Castro et al. (2005) state that *Pinus halepesis* seedling is successfully able to overcome drought stress and it is a good species for plantation in arid and semi-arid areas. Khosrojerdi et al. (2008) and Ghasemi (1996) in the order put forward *J. excelsa* and *J. polycarpos* for plantation in semi-arid regions of Iran. Likewise, plantation with *J. phoenicea* in Mediterranean semi-arid regions of Jordan, and with *J. scopulorum* in semi-arid regions of northeastern United State has been reported by Alrababah et al. (2008) and Bjugstad and Ardell (1984), respectively.

Because water resources in arid and semi-arid regions of Iran is a serious obstacle for plantation development, so researches to apply suitable methods with the drought-tolerant species is imperative. Thus, the researches necessary in order to assessing the primary establishment of *J. excelsa* in arid zones of the country is unavoidable. Although, in the

country few researches with *J. polycarpos* and *J. excelsa* have been reported in semi-arid zones (Ghasemi, 1996; Khosrojerdi et al., 2008; Shirzad and Tabari, 2010), but none on *Juniperus* planted in an arid zone was reported. This investigation is aimed to determine establishment and growth characteristics of *J. excelsa* seedlings under rainfed/irrigated conditions in a region with 231 mm annual precipitation and 6 months vital dry period.

2. Materials and methods

This investigation was conducted in southern elevations of Mashhad city located in north-eastern Iran (59˚ 27′ E, 36˚ 30 N′, 1450 m a.s.l.). Based on synoptic station of Mashhad, the mean annual precipitation is 231 mm and the region benefits from a dry climate. The dry season is 6 months, starting from mid-May and lasting in mid-October. In this research 270 three-year old seedlings (1+2) of *J. excelsa* were planted on a natural soil in the site study. Experiment was made as factorial with randomized completely design, with three irrigation levels including control (rainfed), 20-days interval irrigation and 40-days interval irrigation. Watering was made 15 lit/period in spring and summer. In order to inhibit drought stress the rainfed seedlings were watered once at plantation time. The planting distance was 4 m, planting depth 40-50 cm and mean width of pits 80 cm (Photos 1 and 2).

Experiment was done for three years. At the end of each growing season, survival, crown width and total height (with meter, Photo 3) and stem collar base (with digital apparatus) of seedlings were measured and the increments for each period calculated. Soil pH and EC were 7.9 and 0.9 milmos/cm^2, respectively. Phosphorous and Potassium were 2 and 96 ppm, respectively. Nitrogen, using the Kjeldahl method, was 0.09% and Co_3Ca and Carbon, using Walkey-Black method, were 0.43 and 32.1, respectively. The soil texture was sandy loam. Analysis data was conducted by SPSS. Quantitative factors as increments of total height, crown width and stem collar base followed determining normality was conducted by Kolmogorow-Smironov test and equality data with Levene test. For comparison of means one-way Anova and Duncan tests were used. Survival was transferred into the normal data by Arc sin (Zar, 1999).

Photo 1. A view of site study (front) and air pollution (background) of Mashhad city

Photo 2. A part of *J. excelsa* plantation on a mountain hill (h= 1450 m) in the arid region of south of Mashhad city

Photo 3. Height measurement of *J. excelsa* in year 3 after plantation

3. Results

The results of the first, second and third years indicated that only in the first year height growth was significantly affected by irrigation treatment (Table 1). The greatest height growth was detected in 20-days interval irrigation and the least in rainfed condition (Table 2). Height growth, stem collar base and survival rate differed with irrigation (Table 1). Comparison of means in second year revealed that height growth was greater in 20-days interval irrigation than 40-days interval irrigation and control, and no significant difference was found between 40-days interval irrigation and control. Stem collar base was greatest in 20-days interval irrigation and least in rainfed status. Survival rate was highest with seedlings irrigated in intervals of 20 and 40 days. The results of third year showed that increments of stem collar base and crown width were affected by irrigation treatment (Table 1). The greatest and least increments stem collar base were found in 20-days interval irrigation and control, respectively. Crown width increment was greatest in 20-days interval irrigation (Table 2).

Characteristics measured	Year 1			Year 2			Year 3		
	d.f.	F	P	d.f.	F	P	d.f.	F	P
Height growth (cm)	2	7.3	0.02*	2	13.5	0.006**	2	0.4	0.69 ns
Stem collar base growth (mm)	2	0.7	0.53 ns	2	16.9	0.003**	2	8.8	0.02*
Crown width growth (cm)	2	0.6	0.56 ns	2	3.1	0.12 ns	2	15.2	0.005**
Survival (%)	2	1.8	0.24 ns	2	5.6	0.04*	2	3.4	0.10 ns

* Significant at level of 95% probability, ** Significant at level of 99% probability, ns Non significant

Table 1. One-Way Anova of Characteristics measured of *J. excelsa* seedlings affected by irrigation in different years

	Irrigation treatment	Height growth (cm)	Stem collar base growth (mm)	Crown width growth (cm)	Survival (%)
Year 1	20-day	7.2 ± 0.7a	0.7 ± 0.2	3.5 ± 0.3	93.33 ± 3.8
	40-day	3.4 ± 0.8b	0.5 ± 0.1	3.6 ± 0.5	75.28 ± 2.1
	Rainfed	2.3 ± 1.2	0.4 ± 0.1	2.9 ± 0.6	69.65 ± 15.2
Year 2	20-day	14.6 ± 0.3a	5.1 ± 0.4a	9.4 ± 0.1	74.87 ± 5.9a
	40-day	9.5 ± 0.9b	3.9 ± 0.1b	7.3 ± 0.5	74.67 ± 4.8
	Rainfed	5.1 ± 2.0b	2.5 ± 0.3c	6.5 ± 0.8	47.77 ± 9.0b
Year 3	20-day	19.1 ± 2.4	8.6 ± 0.1a	17.1 ± 1.0a	74.67 ± 7.4
	40-day	15.4 ± 5.4	7.3 ± 0.5ab	10.5 ± 1.3b	74.33 ± 8.7
	Rainfed	14.7 ± 5.1	5.6 ± 0.6b	10.3 ± 0.5b	47.67 ± 8.9

In each column, different letters are significant among irrigation treatment of each year

Table 2. Comparison of means (± sd) of Characteristics measured of *J. excelsa* seedlings affected by irrigation in different years

4. Discussion

The results of the present investigation at the end of the first, second and third years showed survival rate of seedlings irrigated in intervals of 20 days was 99.3, 74.87 and 74.67%, respectively. In intervals of 40 days it was 75.28, 74.67 and 74.33, respectively in mentioned years. Alrababah et al. (2008) in plantation with *J. phoenicea* found that watering reduced soil moisture stress and enhanced survival rate. They stated that at the end of the first and second growing season survival was 42% and 32%, respectively. Castro et al. (2005), working with *Pinus sylvestris*, with irrigation in intervals of 10 days (2 liter/seedling) observed that survival rate was 30% and 22% an the end of years 1 and 2, respectively.

Likewise, Bjugstad and Ardell (1984) in semi-arid region of Wyoming situated in north-eastern of United State found the significant effect of soil moisture on establishment of *Prunus americana*, *Pinus ponderosa* and *J. scopulorum* irrigated as dripping. As a matter of fact, the 5 years finding of mean survival rate of three species was ~ 29%. According to their idea the dry summer, particularly in initial years was a limiting factor for seedling establishment.
As a whole, although in the dry regions, survival and growth rate of rainfed planted seedlings is mainly low, under such a condition watering causes increase of these characteristics, but owing to low and irregular precipitation, lacking sufficient water resources and long dry period only drought-tolerant species are able to recompense the rareness of vegetation cover (Boers, 1994; Kozlowski, 1987). However, because of deficient water resources, successful establishment of water-managed plantations would not be secured. Therefore, using the low-moisture demand species or species able to establish at water-lacking status can remove to a great extent criticizes of drought in plantations of such regions (Oliet et al., 2002; Sanchez-Coronado et al., 2007).
Rainfed planted *J. excelsa* seedlings, especially in years 1 and 2, due to deprived rooting and low moisture and nutrient uptake showed higher sensibility to environmental stresses, particularly to drought. So, watering regimes induced enhanced survival. In this respect, it can be stated that because the summer drought in arid zone is a factor affecting growth and establishment of plantations, therefore watering causes decreased the soil moisture stress and increased the establishment and survival rates of seedlings, especially in the primary years (Bjugstad and Ardell, 1984; Garcia, 2001; Maria et al., 2002; Castro et al., 2005). This is while, that in year 3 watering regime did not raise the survival rate. This may me because of appropriate distribution of rooting for soil moisture uptake and also suitable adaptation of seedlings with environmental conditions in the third year after plantation (Tabari et al., 2011). As a matter of fact, the fairly suitable survival of rainfed planted seedlings at the end of years 1, 2 and 3 (69.65, 47.77 and 47.67%) confirms that *J. excelsa* seedling benefits from the ecological adaptation in this arid area and is able to overcome drought stress following planting, and to establish successfully in the area.
In literature, various reports have been cited on adaptability circumstances of *Juniperus* genus in arid zone and semi-arid zone of the world. According to Bjugstad and Ardell (1984), survival rate of *J. phoenicea* seedling at the end of the 2nd year was 32%. In the report of Khosrojerdi et al. (2009, on *J. polycarpos*) and Ghasemi (1996, on *J. excelsa*) survival rate of seedlings was 88.61% and 96.3%, respectively. This is while that Khademi et al. (2005) observed the full mortality of *J. Virginiana* plantation after 10 years. The findings on *Pinus* genus were different, too. In this respect, it can be paid to some researches including Oliet et al. (2002), who showed that 88.5% of seedlings of *P. halepensis* grown in a semi-arid area survived at the end of the 1st growing season. They observed that *P. halepensis* seedling is successfully able to overcome drought stress after planting and to establish in this area.
Generally, native drought-resistant and compatible species with high ecological elasticity are able to a large extent recompense the damages induced by strict environmental variations and water deficiency. Particularly, *J. excelsa* and *J. ashei* that with penetration of their roots in soil depths and stone layers access soil moisture and overcome drought stress (Weaver and Jurena, 2008). As a result, plantation with these species in arid and semi-arid areas is of high success.

In this investigation, in different years, with enhanced irrigation in the dry seasons, height growth and stem collar base growth of *J. excelsa* were increased. Because, the drought stress causes moisture stress in plant and threats its growth, consequently moisture required of plant decreases the drought stress and increases the growth (Matice, 1982; Lantz et al., 1988). The findings of the current investigation are in line with Brisette and Chamber (1992) on *Pinus echinata*, Kowsar (1995) on *Cupressus arizonica*, Antonio (2001) on *Pinus halepensis*, and Svistula and Tarasenko (1985) on *Juniperus* genus.

5. General conclusion

From the results of the present research it can be concluded that at the end of third year the growth characteristics of rainfed planted seedlings did not much differ with those in watering treatments, particularly in watering applied with interval of 40 days. Likewise, establishment of seedlings responded well (about 47%) to rainfed status. As a whole, although under rainfed status survival rate of the *J. excelsa* seedlings was satisfactory; however, for caution and help in higher assurance of establishment and growth it is better that for plantation development of this species in this arid area and the same ecological regions some irrigations to be applied in the primary years.

6. Acknowledgment

Many thanks go to the Tarbiat Modares University and the Municipality of Mashhad (Khorasan Razavi Province) for the financial support provided. We also would like to acknowledge Dr. E. Khosrojerdi and Eng. H. Daroudi for their kind assistance rendered in this research. Our sincere appreciations also go to all anonymous experts in the Research Center of Agriculture and Natural Resources of Khorasan Razavi Province for the help provided during the course of the field work.

7. References

Alrababah, M.A.; Bani-Hani, M.G., Alhamad M.N. & Bataineh, M.M. (2008). Boosting seedling survival and growth under semi-arid Mediterranean conditions: Selecting appropriate species under rainfed and wastewater irrigation. *Arid Environments*, 72, 1606- 1612

Antonio, R.; Luis, G. & Jose, A. (2001). Effect of water stress conditioning on morphology, physiology and field performance of *Pinus halepensis* Mill. seedlings. *New Forests*, 21, 127–140

Baquedano F.J.; & Castillo, F. (2006). Comparative ecophysiological affects of drought on seedlings of the Mediterranean water-saver *Pinus halepensis* and water-spenders *Quercus coccifera* and *Quercus ilex*. *Trees*, 20, 689–700

Bjugstad, A.J.; & Ardell. (1984). Shrub and tree establishment on coal spoils in northern high plains, USA. *Environmental Geochemistry and Health*, 6, 3, 127- 130

Boers, TM. (1994). Rain water harvesting in arid and semi-arid zones. International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands, 133 pp.

Brisette, J.C.; & Chamber, J.L. (1992). Leaf water status and root system water flux of short leaf pine (*Pinus echinata* Mill.) seedling in relation to new growth, after transplanting. *Tree physiology*, 11, 3, 289-303

Castro, J.; Zamora, Jose, R.A. & Jose, M. 2005. Alleviation of summer drought boosts establishment success of *Pinus sylvestris* in a Mediterranean mountain: an experimental approach. *Plant Ecology*, 181, 191–202

Garcıa, D. (2001). Effects of seed dispersal on *Juniperus communis* recruitment on a Mediterranean mountain. *Journal Vegetation Sciences*, 12, 839–848

Ghasemi, R. (1996). Determining best transfer age of *Juniperus polycarpos* seedling from nursery to plantation site. Iranian Forest and Rangeland Institute, 76p.

Hampe, A. & Petit, R.J. (2010). Cryptic forest refugia on the 'Roof of the World'. *New Phytologist*, 185, 5–7

Khademi, A.; Adeli. E., Babaei, S. & Mattaji, A. 2005. Study of afforestation (Khojin Forest Park & Hiroabad) in Khalkhal area and present adaptable species. *Journal Agricultural Sciences*, Islamic Azad University, 11, 4, 60-68

Khosrojerdi, E.; Daroudi, H. & Namedoust, T. (2008). Effect of nursery plant and slope exposure on survival and growth of *Juniperus excelsa* seedlings in Hezarmasjed forests. *Iranian Biology Journal*, 21 (5): 760-768.

Koroori, S and Khoshnevis, M. (2000). Ecology of Juniperus sp. habitats in Iran. Research Institute of Forest and Rangeland, 229, 208p (In Persian)

Kowsar, A. 1995. Application of tar in rainfed plantation and effect of the occurred run-off on success and growth of *Robinia pseudoacacia*, *Cupressus arizonica* and *Fraxinus rotundifolia*. *Iranian Forest and Rangeland Institute*, 43, 79p.

Kozlowski, T. (1987). Water Deficits and Plant Growth, Vols. I and II. Academic Press, New York.

Lantz, C.W., Baldwin, B.L. & Barnett, J.P. 1988. Plant them deep and keep those roots straight U.S.A Dept. Agric. Forest Service, *Management Bulleti,* RG-MB, 27, 2 p.

Lichter, J. (2000). Colonization constraints during primary succession on coastal Lake Michigan sand dunes. *Journal Ecology*, 88, 825–839

Maria, J.; Benayas, R. Lopez, A., Garcla, C., Camara, N., Strasser, R. & Gomez, A. (2002). Early establishment of planted *Retama sphaerocarpa* seedlings under different levels of light, water and weed competition. *Plant Ecology*, 159, 201–209

Matice, C.R. (1982). Comparative performance of paper pot and bare root trees in experiments established in northern Ontario from 1977-1980. No. 585044. Matcam Forestry consultants, Inc. *Update Rrp*, 147 p.

Oliet, J.; Planelles R., Lopez, M. & Artero, F. (2002). Soil water content and water relations in planted and naturally regenerated *Pinus halepensis* Mill. Seedlings during the first year in semiarid conditions. *New Forests*, 23, 31– 44

Sanchez-Coronado, ME.; Coates, R., Castro-Colina, L., Buen, AG., Paez-Valencia, J., Barradas VL., Huante P. & Orozco-Segovia, A. (2007). Improving seed germination and seedling growth of *Omphalea oleifera* (Euphorbiaceae) for restoration projects in tropical rain forests. *Forest Ecology and Management*, 243,1, 144-155

Svistula, G.E. and Tarasenko, I.M. (1985). Increasing the ecological capacity of the lower Dnieper sands. Lesovod Stvo.I .Agrolesomel Ioratsiya, 10, 13-16

Shirzad, M.A. (2009). Methods of green space development in south of Mashhad by Juniperus excelsa. M.Sc. thesis, Faculty of Natural Resources and Marine Sciences, Tarbiat Modares University, Noor, Iran, 131p. (In Persian)

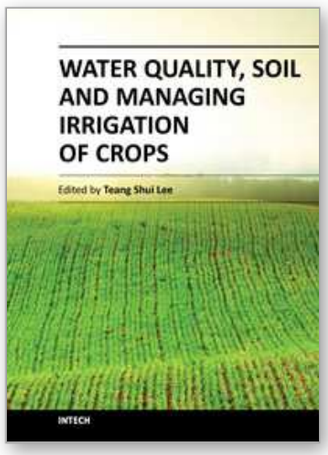
Shirzad, M.A. & Tabari, M. (2010). Effect of some environmental factors on woody plant species in Juniperus excelsa habitat of Hezarmasjed mountains. Journal of Technology and Environment Sciences. (Accepted, In Persian)

Tabari. M.; Shirzad, M.A., Khosrojerdi, E. & Daroodi, H. (2011). Effect of seedling transfer age and soil bed on growth and early establishment of Juniperus excelsa M. Bieb. seedlings in southern hills of Mashhad. Iranian Forest and Poplar Researches, 19, 1,119-127 (In Persian)

Weaver, J.A. & Jurena, P.N. (2008). Response of newly established *Juniperus ashei* and *Carex planostachys* plants to barrier-induced water restriction in surface soil. *Journal of Arid Environments*, 73, 267–272

Zar, J.H. (1999). Biostatistical analysis. Prentice Hall International, Inc 66 pp.

Zare, H. (2001). Native and exotic coniferous in Iran. *Iranian Forest and Rangeland Institute, 498p.*



Water Quality, Soil and Managing Irrigation of Crops

Edited by Dr. Teang Shui Lee

ISBN 978-953-51-0426-1
Hard cover, 242 pages
Publisher InTech
Published online 28, March, 2012
Published in print edition March, 2012

The book entitled Water Quality, Soil and Managing Irrigation of Crops comprises three sections, specifically: Reuse Water Quality, Soil and Pollution which comprises five technical chapters, Managing Irrigation of Crops with four, and Examples of Irrigation Systems three technical chapters, all presented by the respective authors in their own fields of expertise. This text should be of interest to those who are interested in the safe reuse of water for irrigation purposes in terms of effluent quality and quality of urban drainage basins, as well as to those who are involved with research into the problems of soils in relation to pollution and health, infiltration and effects of irrigation and managing irrigation systems including basin type of irrigation, as well as the subsurface method of irrigation. The many examples are indeed a semblance of real world irrigation practices of general interest to practitioners, more so when the venues of these projects illustrated cover a fair range of climate environments.

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

IntechOpen