Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 5, No. 3, p. 158-169, 2014
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Drought stress response in caucasian hackberry: growth and morphology

Sayed Abdolhossein Tabatabaei[1*], Hamid Jalilvand[2], Hamid Ahani[3]

[1]*Department of Silviculture and Forest Ecology, Faculty of Natural Resources, University of Agricultural Sciences and Natural Resources, Sari, Iran*

[2]*Department of Forestry, Faculty of Natural Resources, University of Agricultural Sciences and Natural Resources, Sari, Iran*

[3]*Department of Forestry, Faculty of Natural Resources, University of Agricultural Sciences and Natural Resources, Sari, Iran*

Article published on September 10, 2014

Key words: Nursery irrigation, Seedling, Repeated measures, Principal components analysis, *Celtis Caucasica*.

Abstract

In order to evaluate the effect of drought stress on *Celtis caucasica* Willd seedlings, the research was conducted based on completely randomized design on summer season. On the watering regimes (2th and 4th day after drought), the morphological-related parameters were measured. Traits were measured including: height, diameter, leaf number, leaf area, shoot and root length, freshly and number of root, fresh and dry weight of roots, stem and leaf and ratios of root to shoot, leaf to shoot, leaf area, specific leaf area and leaf weight. Results indicated those terms of height seedling after fortieth day significant at the 5% level and 1% level at the end of growth period under the drought conditions. Average height, number of leaves, leaf area in the second and third months, shoot dry weight, shoot length and leaf area ratio in the drought treatment showed a of 5% significant and the number of leaves was significant at thirtieth and fortieth day by stress condition. Since the fiftieth day to the end of summer this term indicated significantly at 1% probability level. The result of repeated measures analysis showed no significant difference in height between the control treatment and drought stress, but the diameter, number of leaves and leaf area of significantly indicated at the 5% level. Principal component analysis showed that in first axis in drought stress reduced leaf area ratio and specific leaf area and second axis total dry weight increase and leaf to shoot ratio decrease were the most important traits.

***Corresponding Author:** Sayed Abdolhossein Tabatabaei ✉ tabatabaei.h68@gmail.com

Introduction

Drought is one of the most important a biotic stress factors that limit plant growth and ecosystem production around the world (Deeba *et al.*, 2012). In spite of the extensive literature controversy exists with regard to the mechanisms of drought tolerance to plants. In addition to the complexity of drought itself plant's behavioral responses to drought are complex and different mechanisms are adopted by plant when it encounters drought (Shukla *et al.*, 2012). Drought is one of the major environmental constraints that adversely affect plant growth and yield worldwide (Boyer, 1982).

About four-fifths of the world's land in the area is arid and semiarid regions, the water in these areas is a major factor limiting plant production. This limitation has led to reduced net production plant (Koochaki, 1988).

Normally in several studies is proven to reduce the growth morphology of plants to drought stress. Over the years, morphological characteristics such as root volume, root weight, leaf area, dry matter production, have been studied in several maize cultivars grown under limited water supply (Hugh and Davis 2003; Lerner and Dona 2005; Osborne *et al.*, 2002). Mehr-afarin *et al.* (2008) study of evaluation of biodiversity of field bindweed population in Varamin (Iran) with principal component analysis concluded that leaf dry weight was the most important traits. Bibi *et al.* (2012) in study of (*Sorghum bicolor* Var *Moench*) under drought condition with principal component analysis was found root length was the highest towards drought tolerance, indicating root length was least effected by water stress among all the seedling traits. Marron *et al.* (2002) research on various species of two *Populus x euramericana* clones under water stress showed that after 29 days of drought stomatal were closed and the growth rate decreased. Gindaba *et al.* (2004) investigated the effect of water deficit on growth, gas exchange and leaf water potential on two species (*Eucalyptus camaldulensis* Dehn.) and (*E. globules* Labill.) and three species of tree in greenhouse and a check showed that the effect of drought on photosynthesis, water potential leaves and tree growth is reduced. Chiatante *et al.* (2006) examined the effect of stress on the development of the root *Quercus pubescens* wild and *Fraxinus ornal* seedling, and the results showed that it seems the root to shoot ratio, that increasing soil moisture by weight of the shoot increases and the water stress conditions, the shoot plant is affected more than the root growth, in other words stops shoot growth quickly than development of the root and this command increase the root to shoot ratio. Sadrzadeh and Moalemi (2007) effect of water stress and potassium on growth characteristics of young olive plants cvs. Baghmalek and Zard concluded that vegetation characteristics of cvs. Baghmalek was better than Zard olive. In both cultivars, dry and fresh weights of leaf, stem and root and leaf area reduced with decreasing irrigation. Rad *et al.* (2011) examined the effects of drought stress on biomass, several growth parameters and water use efficiency of Eucalyptus (*Eucalyptus camaldulensis* Dehnh) in response to drought stress concluded that biomass production, shoot, root, leaf, root to shoot ratio and shoot to life ratio decreased significantly with reduction in soil water content. Specific leaf area increased significantly with reduction of soil water content. Water use efficiency increased significantly with reduction of soil water content. El Atta *et al.* (2012) study of morphological and anatomical response of *Acacia ehrenbergiana* Hayne and *Acacia tortilis* (Forssk) Haynes subsp. *raddiana* seedlings to induced water stress that water stress caused significant (P=0.05) decrease in relative water content, leaf number and area and leaf water potential, chlorophyll content, and stem height and diameter. Emiliano Quiroga *et al.* (2013) Drought in the species examined *Trichloris crinita* (grass native to northwestern Argentina) in the form of leaves biomass and a greater leaf began. Their stress levels in control (irrigation three times per week) and drought (watering once a week) and imposed six weeks. Their results showed that five percent of the biomass and greater leaf indicated significantly at one percent level. Munawarti *et al.* (2014) study of morphological responses of (*Saccharum spontaneum*

L.) accessions to drought stress concluded that height, diameter and number of leaves decrease significantly under drought stress.

Caucasian Hackberry tree with the scientific name (*Celtis caucasica* Willd.) is a deciduous tree in the family Ulmaceae (Myrbadyn, 2009). This genus (Celtis) has 60-70 species in the entire world (Whittemore, 2005); *Celtis caucasica* have a leaves oval, diamond and body stretched than leaf Hackberry (*Celtis australis* L.). This species distributed in arid and duriherbosa regions of the country, growth in the Zagros and Alborz and in heights of 800 to 2700 meters (Sabeti, 2007). Wood of Caucasian Hackberry use in construction, manufacturing tableware, cane, paddle and carpentry, wagon making, woodturning and coal preparation (Myrbadyn, 2009); the wood is very firm so that which is called iron wood (Sabeti, 2007).

The quality of the seedlings is one of the key factors for obtaining stands of high productivity. This quality is expressed by morphological, physiological and nutritional characteristics resulting from of genetic factors as well as the management procedures of the nursery (Silva, 1998).

This research at the first one was done on the morphological traits of *C. caucasica* and the objectives of this study are to determine to investigate the effects of severe drought stress on the morphological traits and water use of the seedlings of *Celtis caucasica* willd.

Material and methods

Description of study area and plant material

In this study the effect of drought stress on morphological characteristics *C. caucasica* species that seed from accessions were used in Khorasan to produce the mother plants. The experiment was done in 2013 at Torogh nursery of Mashhad (the length of 59°38' geographical Eastern and 36°16' north latitude, altitude 990 meters). Seedlings after transfer to pots containing sandy loam, up to three months (Bagheri *et al.*, 2011) in terms of the usual nursery of irrigation were in the well water treatment (every two days). Then physical experiments for determining relative particles (percentage of clay, silt and sand) were performed using the hydrometer Baykas on particles smaller than two mm. (Rezaipoorbaghedar *et al.*, 2011) tested soil characteristics are given in table 1. From early summer treatments was conducted on *C. caucasica* seedlings to the drought conditions (four days a time by irrigation) and without stress (a common method of irrigation nursery two days a time by irrigation of 150 mL day^{-1}) with four replications and five individuals in each replicate were examined to the end of the summer and to maintain them under shade.

Table 1. Physico-chemical properties of soils in (0-30 cm) experiment start.

Soil properties	Value	Soil properties	Value
pH	7.4	Soil texture	Sandy loam
EC(ds m^{-1})	6.61	P(mg kg^{-1})	54.8
Organic matter (%)	1.04	K^+(mg kg^{-1})	353
Sand (%)	67	Moisture (%)	9.8
Silt (%)	23	bulk density (g m^3)	1.42
Clay (%)	10		

Growth and morphology

Stem growth characteristics were every ten days monitored by measuring length (from substrate surface to the apical meristem) and diameter (at the base) and by counting the number of leaves and leaf area per month, so that the base of each treatment, five selection seedling and each seedling five leaf selection of basic randomized to using Auto CAD software in meters squared size was measured. Three plants were harvested at the end of the experiment in early fall 2013 and divided into leaves, stem and roots fresh weight was calculated. Biomass samples were dried (70°C, 48 h) to constant and weighed (Yin *et al.*, 2005; Sapeta *et al.*, 2013).

Root to shoot ratio: ratio between the shoot and root dry weight (Yin *et al.*, 2004). Leaves to shoot ratio: to obtain the dry weight of the leaves and shoot, the ratio was calculated (Rad *et al*., 2011). Leaf area ratio: an index of the amount of spilled leaves the plant. For each plant the ratio between total leaf area and dry weight. The quotient is the ratio of leaf area, but the term has become more common. Specific leaf area: a measure of leaves. For each plant the ratio between total leaf areas and total dry weight of leaves. Leaf weight ratio: a measure of the amount of assets against the dry leaves of the plant. For each plant is the ratio between the total dry weight of leaves and total dry weight (Karimi and Azizi, 1994).

Data analysis

The experiment was arranged in the based on completely randomized design. The normality tested by Kolmogorov-Smirnov using SPSS version 19, data collected were subjected to correlation between various parameters, Analysis of Variance (ANOVA); mean comparison was carried out using SNK multiple comparison tests with significant results were assumed for $p \leq 0.05$, regression and replication analysis measurements of height, diameter, leaf number and leaf area in nine times using the statistical software SAS version of the 9.1 and using PC-ORD software version 4.17 to principal component analysis (PCA). Diagrams were drawn using the Excel software for growth average between height, diameter, leaf number and leaf area was conducted by stress condition initiation until end of the experiment.

Results

Effects of drought on morphological trait

The results indicated that the height of the end of the season and height mean in drought stress and non stress conditions are not correlated with each other. Diameter end of the season in both treatments showed a positive correlation with the diameter mean at one percent level. Slenderness index average and growth of the end of the season for control and drought stress condition at one and five percent level, respectively, showed a negative correlation. The number of green leaves at the end of the season and the average leaf number in non-stressed conditions showed no correlation but with drought stress had a positive correlation at the one percent level. Changes in the total number of green leaves with a diameter mean of no stress condition were not correlated, but with the drought treatment showed a negative correlation at the one percent level (Table 2).

Table 2. Correlation coefficients among some morphological traits with diameter mean under control-drought treatment.

Treatment		h8	hm	d8	(h/d)m	(h/d)g	nl8	nl	nlm
Control	Diameter mean	0.02^{ns}	-0.02^{ns}	0.99^{**}	-0.71^{**}	-0.58^{**}	0.22^{ns}	0.07^{ns}	0.28^{ns}
Drought		0.39^{ns}	0.43^{ns}	0.99^{**}	-0.50^{*}	-0.49^{*}	0.59^{**}	-0.58^{**}	0.75^{**}

h8: End of the period height, hm: Height mean, d8: End of the period diameter, (h/d) m: Slenderness index mean, (h/d) g: Slenderness index growth, nl8: End of the period No. of leaves, nl: No. of leaves, nlm: No. of leaves mean. ns: Not significant, * $p<0.05$ and ** $p<0.01$.

Analysis of variance indicated those terms of height seedling after fortieth day significant at the five percent level and one percent level at the end of growth period under the drought conditions. Average height, leaf number, leaf area in the second and third months, fresh and dry weight of roots, shoot length and leaf area ratio in the drought treatment showed a of five percent significant and the number of green leaves was significant at thirtieth and fortieth day by stress condition. Since the fiftieth day to the end of summer this term indicated decreased significantly at one percent probability level. Results the comparison mean indicated that in all traits has significant decreased in the drought stress as compared with control (Table 3).

Table 3. ANOVA results and mean comparisons morphological trait; Mean±SE.

Morphological traits	Day	Mean Square	t-value	Control	Drought
Height	Fortieth	230.40	2.28*	29.45±1.43^{A}	24.65±1.53^{B}
	Fiftieth	390.625	2.76**	31.05±1.63^{A}	24.80±1.55^{B}
	Sixtieth	435.60	2.78**	31.45±1.78^{A}	24.85±1.55^{B}
	Seventieth	525.625	2.86**	32.10±2.00^{A}	24.85±1.55^{B}
	Eightieth	525.625	2.86**	32.10±2.00^{A}	24.85±1.55^{B}
Height mean	-	254.36	2.47*	29.29±1.36^{A}	24.25±1.51^{B}
Number of leaves	Thirtieth	1932.10	2.41*	55.60±4.20^{A}	41.70±3.95^{B}
	Fortieth	2190.40	2.56*	56.10±4.17^{A}	41.30±5.98^{B}
	Fiftieth	4020.025	3.55**	56.40±4.24^{A}	36.35±3.73^{B}
	Sixtieth	3062.50	3.10**	52.80±4.33^{A}	35.30±3.60^{B}
	Seventieth	2856.10	2.94**	51.30±4.57^{A}	34.40±3.48^{B}
	Eightieth	2941.22	2.95**	51.05±4.68^{A}	33.90±3.42^{B}
Number of leaves mean	-	2224	2.69*	53.90±4.15^{A}	38.90±3.69^{B}
Leaf area	Second month	0.0016	3.23*	0.050±0.007^{A}	0.025±0.003^{B}
	Third month	0.0088	2.81*	0.082±0.02^{A}	0.022±0.005^{B}
Shoot fresh weight	-	6.78	2.78*	4.21±0.67^{A}	2.08±0.37^{B}
Shoot length	-	560.66	2.86*	49.66±5.78^{A}	30.33±3.48^{B}
Shoot dry weight	-	3.98	3.63*	3.14±0.41^{A}	1.51±0.16^{B}
Leaf area ratio	-	0.000066	3.19*	0.011±0.0018^{A}	0.004±0.0009^{B}

* p<0.05 and ** p<0.01.

Repeated measures analysis of such statistics, Wilks' Lambda, Pillai's Trace, Hotelling-Lawley Trace and Roy's Greatest Root of the time×treatment morphology traits of the measures indicated that the height of the control-drought treatment there is no significant difference but in the diameter, leaf number and leaf area showed significant differences at the five percent (Table 4).

Table 4. Effect treatment×time morphological traits control-drought treatment.

Morphological traits	Wilks' Lambda	Pillai's Trace	Hotelling-Lawley Trace	Roy's Greatest Root
Height	0.69 2.05^{ns}	0.30 2.05^{ns}	0.44 2.05^{ns}	0.44 2.05^{ns}
Diameter	0.62 2.35*	0.37 2.35*	0.60 2.35*	0.60 2.35*
No. of leaves	0.57 2.89*	0.42 2.89*	0.74 2.89*	0.74 2.89*
Leaf area	0.28 8.68*	0.71 8.68*	2.48 8.68*	2.48 8.68*

ns: Not significant, * p<0.05 and ** p<0.01. The number of second rows for each term showed statistics equivalent F.

First and second axis Eigen value treatments is greater than the statistics Broken-Stick a result of the first and second axis of variation accounted for a significant share of the mean and of the use is analysis and other axes are not significant (Table 5).

Table 5. Variance extracted of control-drought treatment.

Treatment	Axis	Eigen value	Percent of Variance	Broken-stick Eigen value
Control	1	7.18	51.33	3.25
	2	6.81	48.66	2.25
Drought	1	8.72	62.29	3.25
	2	5.28	37.71	2.25

Principal component analysis showed that PC1 drought treatment, leaf area, root to shoot ratio, freshly, leaf area ratio, specific leaf area, leaf weight ratio, root length and number of root were the most significant and relationship among root to shoot ratio, root length and number of root with other traits were negative. In PC2 leaf dry weight, root dry weight, total dry weight, branch and leaf to stem ratio and stem length of the most important component and the relationships with other plant traits were negative. Therefore, the with decreasing water potential and increases transpiration, plants with reduced leaf number and root length increased to cope with changes in their stiffness causes and root weight increase due to the increased total weight of the plants and reduced leaf area, leaf area ratio, specific leaf area and leaf weight and fresh plant also decreases (Table 6).

Table 6. Principle Component Analysis coefficients of morphological trait.

Morphological trait	Control		Drought	
	PC_1	PC_2	PC_1	PC_2
dry weight leaf	0.33*	0.17	-0.18	-0.37*
dry weight stem	0.35*	0.13	-0.27	0.25
dry weight root	0.34*	-0.15	0.18	0.36*
total dry weight	0.37*	-0.04	0.04	0.43*
leaf area	0.33*	0.16	-0.32*	0.13
root to shoot ratio	-0.28	-0.25	0.31*	0.15
leaf to shoot ratio	-0.28	0.24	0.04	-0.43*
freshly	0.15	0.35*	-0.31*	-0.18
leaf area ratio	-0.21	0.31*	-0.34*	-0.04
specific leaf area	0.35*	0.11	-0.34*	-0.02
leaf weight ratio	0.09	0.37*	-0.33*	0.08
stem length	0.05	0.38*	0.07	-0.42*
root length	-0.11	-0.36*	0.31*	0.16
No. of root	0.14	0.35*	0.33*	-0.06

*Eigen value more than 0.3

End of the growth period showed average height and diameter growth, leaf number and leaf area in drought stress value of decrease height growth than thirtieth as compared with control treatment start and continues to the end of the experiment period, but Forty days showed significant mean (p=0.0284). In drought treatment than the controls showed a little diameter growth from beginning to end of the experiment gradually but no significant between the two treatment groups. Effect of leaf fall than thirtieth day was significant indicated (p=0.021) and continues until end of the experiment period and leaf area decrease after drought stress until end of the experiment as compared with non stress treatment but the second and third months showed significant (p=0.012 and p=0.022 respectively). As it has been shown is in table 7 the final nonlinear regression model, the coefficient of determination, correlation coefficient, coefficient of variation, standard deviation error, variance inflation factor control and drought stress treatments for morphological traits characters of height, diameter and leaf number. Polynomial growth curve with a slope to the general a second, reducing the impact of drought on growth traits height, leaf number and leaf area (Fig 1). Analysis of variance for nonlinear regression that indicated number of leaves there is no significant difference in control but in the height, diameter and leaf number showed in control and drought stress significant differences at the one percent (Table 8).

Discussions

In this study it was observed that the heights, number of leaves, leaf area, fresh and dry weight of roots, shoot length, leaf area ratio and specific leaf area in drought stress compared to the control decreased and root to shoot ratio and root length increase significantly. Morphological changes induced by drought stress in seedlings were also studied by several authors who observed the reduction in shoot biomass, root and total (Coopman *et al.*, 2008), reduction in height (Oliva *et al.*, 1989; Coopman *et al.*, 2008), changes in the root/shoot (Myers and Landsberg, 1989), reduction number of leaves (Oliva *et al.*, 1989) and the leaf area (Lemcoff *et al.*, 1997; Coopman *et al.*, 2008). The change in root to shoot dry mass ratio has been considered as one of the mechanisms involved in the adaptation of plants to drought stress (Turner, 1997). Drought stress reduces both root and shoots growth. However, root growth seems to be less affected (Liu and Stützel, 2004). The root to shoot weight ratio was poorly associated with drought stress, however when root length and weight were normalized per unit leaf area, those originating from xerotic environments had the highest root to shoot ratio as well as weight per unit leaf area as expected for desert species (Rieger and Dummel, 1992).

Table 7. Nonlinear regression model growth for morphological traits.

Morphological traits	Treatment	Regression	R^2	R	Coef var	Std. error	VIF
Height	Control	$y=-0.1037x^2+2.2348x-2.606$	98.52%	0.99	15.43	1.02	1.00
	Drought	$y=-0.1173x^2+1.6318x-1.3345$	98.18%	0.99	25.91	0.33	1.00
Diameter	Control	$y=0.0005x^2+0.0419x-0.0595$	96.25%	0.98	16.21	0.04	1.00
	Drought	$y=-0.0011x^2+0.055x-0.0539$	99.12%	0.99	7.55	0.03	1.00
No. of leaves	Control	$y=-0.2277x^2+1.9321x-2.494$	75.68%	0.86	-4113.40	0.73	1.00
	Drought	$y=-0.0918x^2-0.5642x+2.0012$	90.18%	0.94	-42.10	1.54	1.00

x= Measurement time and y= Height, diameter and No. of leaves traits

Variance Inflation Factor (VIF)

Table 8. ANOVA results of nonlinear regression model growth for morphological traits.

Morphological traits	Treatment	Mean Square	F-value
Height	Control	86.04	129.39^{**}
	Drought	12.65	19.47^{**}
Diameter	Control	0.13	182.92^{**}
	Drought	0.11	574.77^{**}
No. of leaves	Control	7.14	2.14^{ns}
	Drought	131.86	53.52^{**}

ns: Not significant and ** $p<0.01$

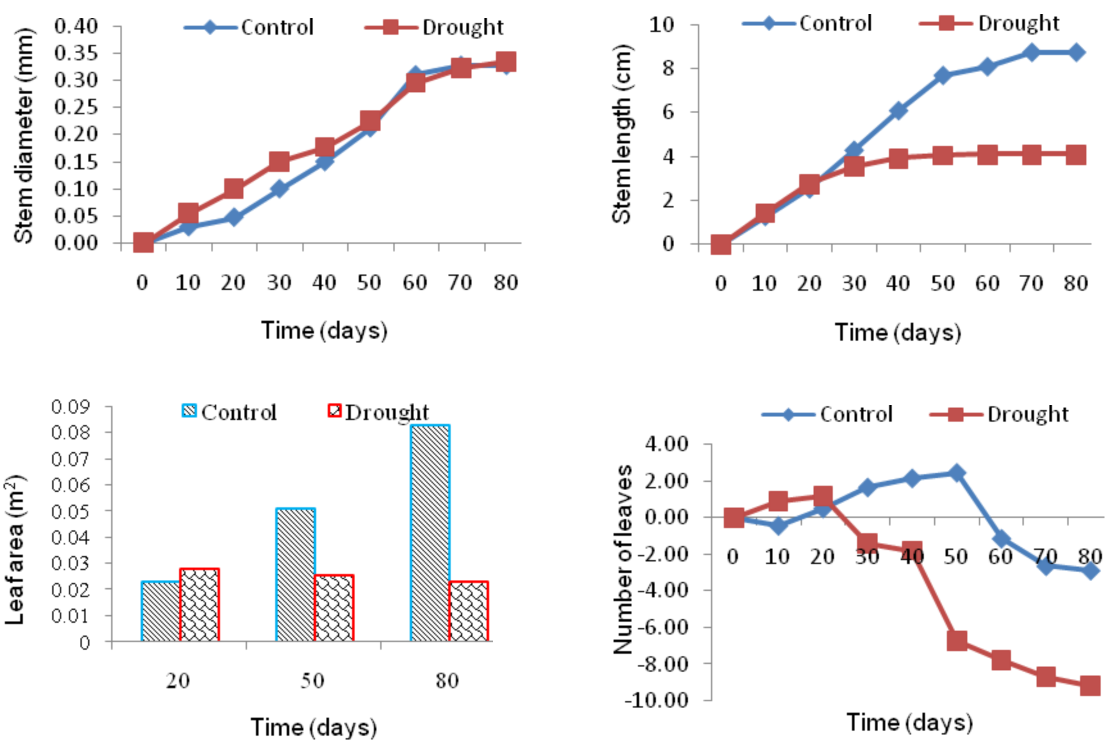

Fig. 1. Average growth rates over time for stem length and diameter, leaf number and leaf area of *C. caucasica* subjected to varying effect of drought stress. Day 0 represents the first day the experimental treatments were applied.

Reduction in leaf area and plant height in seedlings can be regarded as an adaptive morphological response to drought (Taiz and Zeiger, 2002). Stem length was decreased in *Albizzia* seedlings under drought stress (Patel and Golakia, 1988). Similar results were observed in *Erythrina* (Pita and Pardes, 2001), *Populus x euramericana* and *Eucalyptus* seedlings (Marron *et al.*, 2002; Gindaba *et al.*, 2004), and Populus species (Nicholas, 1998).

Indicating he was Sadrzadeh and Moalemi (2007) in young olive plants cvs. Baghmalek and Zard concluded that in both cultivars, dry and fresh weights of leaf, stem and root and leaf area reduced with decreasing irrigation. Shaban *et al.* (2009) in their studies on strains resistant to drought leaf water potential determined by the species *Celtis caucasica* (Caucasian Hackberry) is a moderate drought tolerance. Rad *et al.* (2011) effect of drought stress on *Eucalyptus* species showed a decrease in soil moisture have a significant effects on reducing the production of components biomass (shoots and leaves). Chiatante *et al.* (2006) on study of *Quercus pubescens* wild and *Fraxinus ornal* seedling, in conditions of water stress, concluded that the plant shoot is affected more than the root growth, in other words stops shoot growth quickly than development of the root. El Atta *et al.* (2012) showed that water stress on *Acacia ehrenbergiana* Hayne and *Acacia tortilis* (Forssk) Haynes subsp. *raddiana* seedlings to cause decrease leaf number and area and stem height. Sapeta *et al.* (2013) showed the drought stress on *Jatropha curcas* that drought stress decrease stem growth, leaf number and total leaf area; of the same opinion.

Specific leaf area (SLA), an indicator of leaf thickness, has often been observed to be reduced under drought conditions (Marcelis *et al.*, 1998). Decrease in SLA in drought plants may be due to the different sensitivity of photosynthesis and leaf area expansion to soil drying. Drought stress affects leaf expansion earlier than photosynthesis (Jensen *et al.*, 1996; Tardieu *et al.*, 1999). Reduction of SLA is assumed to be a way to improve water use efficiency (WUE) (Wright *et al.*, 1994; Craufurd *et al.*, 1999). This is because thicker leaves usually have a higher density of chlorophyll and proteins per unit leaf area and, hence, have a greater photosynthetic capacity than thinner leaves (Liu and Stützel, 2004).

Multivariate analysis handles simultaneously a number of variables of common effects whereby similar data patterns being summarized, noise removed and the internal or sometimes hidden structures of the data being elucidated. Principal component analysis (PCA) is the most frequently used multivariate method. Principle component analysis revealed that higher root length, shoot length with lower leaf water potential, osmotic potential and turgor pressure under water stress could be utilized as selection criteria for drought tolerance in sorghum at seedling stage (Bibi *et al.*, 2012).

The morphological characteristics of the reduction can be justified, the lack of permanent water, a long time continues to be a major factor in this phenomenon survival or destruction of the plant is soil moisture. Reduction in shoot length, leaf area and plant dry weight and leaf fall signs of growth decrease is a drought stress response. The lack of moisture in the soil water osmotic potential becomes more negative. (Jalili Marandi, 2010). Reduce the amount of water available to make the morphology changes. The most important parameters for evaluation of the effects of drought morphological behavior dry weight of biomass, including is root and shoots (Abdalla and El-Khoshiban, 2007). Shoots and leaves when water is supplied to the roots, as they continue to grow. Also materials provide the root from the shoot, as they continue to grow. In case of water shortage, the balance was change and reduced leaf number and area but photosynthetic activity, to be comforted are less affected. (Jalili Marandi, 2010). Drought stress in during the period of growth is causes to dwindle in size leaves. Also the leaf area index, crop maturity and reduce the amount of light absorption by plants (Levitt, 1980); Leaf has a special role in the plant photosynthetic unit, genotypes with higher number of leaf photosynthetic stress conditions can are high, but this is at with the more transpiration of plants in these circumstances. Evidence suggests that a weak association between the characteristics of shoot in reduced transpiration and increased water yield (Palled *et al.*, 1985). Drought adaptation of woody plants with reduced leaves and small exposure in sunken stomatal and stomatal closure, shiny leaves and eventually appears to be leaf fall (Kozlowski and Pallardy, 1982; Kozlowski and Pallardy, 1997).

In dry conditions the less growth fluffs on the leaf epidermis. The number of stomatal per unit leaf area increases. The other Abscisic acid is a well known stress hormone that has multiple functions, including induction of genes involved in water stress protection and stomata closing (Seki *et al.*, 2002). Believed that the root of the perceived drought stress, and leaf production ABA be transferred and be led to stomata closure. This will reduce water loss and reduced photosynthesis well as the spongy tissue of the leaf; the less will develop and dry conditions, there is more to be strong mechanical tissue (Jalili Marandi, 2010).
Leaf fall can be caused by water shortages and reduce the level of transpiration way to resist is dry. This increase in plant adaptation to drought; ethylene produced by stress, such as a secondary messenger for reactions to plant operation. Ethylene synthesis could be a dominant process and increasing density polyethylene reduced auxin transport in the petiole of the leaf area is subject to separate. Leaf fall reduced leaf area and the operation of the plant efficiently susceptible to water balance (Jalili Marandi, 2010).

Conclusion

In summary, it is concluded that water management influence on the quality of Caucasian Hackberry (*Celtis caucasica* Willd) seedlings, as it altered morphological characteristics. Drought stress significantly affected relative heights, number of leaves, leaf area, fresh and dry weight of roots, shoot length, leaf area ratio and specific leaf area in drought stress compared to the control decreased and root to shoot ratio and root length increase. It therefore influences growth through its effect on the parameters. To the full viability of these species can resistance of their show in nursery under drought stress conditions. Long term studies on performance of dormant and growing seedlings under drought on actual forest regeneration sites are needed before recommendations can be made. Further studies are needed to confirm these preliminary conclusions.

Acknowledgements

The authors would like to thank the following people for supported by master forestry management and afforestation the department of watershed and the natural resources of the province Razavi Khorasan city of Mashhad, Mr. Soltani and of the Honorable responsible Torogh nursery of Mashhad, Mr. Ghazi. The research was supported by national great plan of acknowledge and technology of sea and salt water using for agriculture, drinking and industry (no.1-1-5). The authors wish to thank the University of Agricultural Sciences and Natural Resources Sari of Iran for the M.Sc funding granted to do this study.

References

Abdalla MM, El-Khoshiban NH. 2007. The influence of water stress on growth, relative water content, photosynthetic pigments, some metabolic and hormonal contents of two *Triticium aestivum* cultivars. Journal of Applied Sciences Research, **3**, 2062-2074.

Bagheri V, Shamshiri MH, Shirani H, Rusta HR. 2011. Effects of arbuscular mycorrhizal fungi and drought stress on growth, water relations, proline accumulation and soluble plant two basic varieties of domesticated pistachio (*Pistacia vera* L.). Iranian Journal of Horticultural Science, **42**(4), 365-377.

Bibi A, Sadaqat HA, Tahir MHN, Akram HM. 2012. Screening of Sorghum (*Sorghum bicolor* Var *Moench*) for drought tolerance at seedling stage in polyethylene glycol. The Journal of Animal & Plant Sciences, **22**(3), 671-678

Boyer JS. 1982. Plant productivity and environment, Science, **218,** 443-448.

Chiatante D, Di-Iorio A, Sciandra S, Stefania G, Mazzoleni S. 2006. Effect of drought and fire on root development in *Quercus pubescens* wild and *Fraxinus ornal* seedlings. Environmental and Experimental Botany, **56**, 190-197.

Coopman RE, Jara JC, Bravo LA, Sáez KL, Mella GR, Escobar R. 2008. Changes in morpho-physiological attributes of *Eucalyptus globulus* plants in response to different drought hardening treatments. Electronic Journal of Biotechnology, **11**(2), 1-10.

Craufurd PQ, Wheeler TR, Ellis RH, Summerfield RJ, Williams JH. 1999. Effect of temperature and water deficit on water-use efficiency, carbon isotope discrimination, and specific leaf area in peanut. Crop Sci. **39**, 136–42.

Deeba F, Pandey AK, Ranjan S, Mishra A, Singh R, Sharma YK, Shirke PA, Pandey V. 2012. Physiological and proteomic responses of cotton (*Gossypium herbaceum* L.) to drought stress. Plant Physiology and Biochemistry **53**, 6-18.

El Atta HA, Aref I, Ismail Ahmed A, Rasheed Khan P. 2012. Morphological and anatomical response of *Acacia ehrenbergiana* Hayne and *Acacia tortilis* (Forssk) Haynes subsp. *Raddiana* seedlings to induced water stress. African Journal of Biotechnology, **11**(44), 10188-10199.

Emiliano Quiroga R, Ferna´ndez RJ, Golluscio RA, Blanco LJ. 2013. Differential water-use strategies and drought resistance in *Trichloris crinita* plants from contrasting aridity origins, Plant Ecology, **214**, 1027–035.

Farhoodi R, Safahany Langroodi AR. 2011. Environmental stress physiology in plants. Shushtar University Press, first edition, 155 pages.

Gindaba J, Rozanov A, Negash L. 2004. Response of seedlings of two *Eucalyptus* and three deciduous tree species from Ethiopia to severe water stress. Forest Ecology and Management, **201**, 119-129.

Hugh JE, Davis F. 2003. Effect of drought stress on leaf and whole canopy radiation efficiency and yield of maize. Agro. J. **95**, 688–696.

Jalili Marandi R. 2010. Environmental stress physiology and mechanisms of resistance in horticultural plants. Urumie, Jahad University Press, 636 pages.

Javadi T, Bahramnejad B. 2010. Relative water content and gas exchange of wild pear genotypes under stress conditions. Journal of Horticultural Science, (Agricultural Sciences and Technology), **24**(2), 223-233.

Jensen CR, Mogensen VO, Mortensen G, Andersen MN, Schjoerring JK, Thage JH, Koribidis J. 1996. Leaf photosynthesis and drought adaptation in field-grown oilseed rape (Brassica napus L.). Aust. J. Plant Physiol. **23**, 631–644.

Karimi M, Azizi M. 1994. Analysis of crop growth. Jahad Mashhad University Press, 111 pages.

Koochaki A. 1988. Aspects of drought resistance in sorghum grain. Journal of Agricultural Sciences and Technology. **2**(2), 54-48.

Kozlowski TT, Pallardy SG. 1982. Water supply and tree growth, Part I. Water deficits. Forest. Abstr. **43**, 57-95.

Kozlowski TT, Pallardy SG. 1997. Physiology of woody plants. Ed. 2. Academic Press, San Diego, CA.

Lemcoff JH, Garau A, Guarnaschelli A, Prystupa P. 1997. Water stress in seedlings of *Eucalyptus camaldulensis* clones and its effects on growth characteristics. In: IUFRO Conference on Silviculture and Improvement of Eucalypt. Proceedings. Colombo: EMBRAPA-Centro Nacional de Pesquisa de Florestas.

Lerner BL, Dona MN. 2005. Growing Sweet Corn. Purdue University Cooperative Extension Service.

Levitt J. 1980. Stress terminology. In: N. C. Turner and P. J. Kramer. (eds.). Adaptation of plants to water and high temperature stress. Willey, New York. 437-439 pages.

Liu F, Stützel H. 2004. Biomass partitioning, specific leaf area and water use efficiency of vegetable amaranth (*Amaranthus* spp.) in response to drought stress. Scientia Horticulture **102**, 15-27.

Marcelis LFM, Heuvelink E, Goudriaan J. 1998. Modelling biomass production and yield of horticultural crops: a review. Sci. Hort. **74**, 83–111.

Marron N, Delay D, Petit JM, Dreyer E, Kahlem G, Delmotte FM, Brignolas F. 2002. Physiological traits of two *Populus x euramericana* clones, Luisa Avanzo and Dorskamp, during a water stress and re-watering cycle. Tree Physiol, **22**(12), 849-858.

Mehr-afarin A, Maighany f, Baghestani MA, Mirhadi MJ. 2008. Evaluation of biodiversity of field bindweed population in Varamin (Iran). Rostaniha, **9**(1), 100-112.

Myrbadyn AR. 2009. Consolidated Forestry appropriate trees and shrubs. Institute of Applied Agriculture Press, first edition, 237 pages.

Munawarti A, Taryono, Semiarti E, Sismindari S. 2014. Morphological and Biochemical Responses of Glagah (*Saccharum spontaneum* L.) Accessions to Drought Stress. The Journal of tropical life science, **4**(1), 61-66.

Myers BJ, Landsberg JJ. 1989. Water stress and seedling growth of two eucalypt species from contrasting habitats. Tree Physiology, **5**, 207-218.

Nicholas S. 1998. Plant resistance to environmental stress, Curr. Opin. Biotechnol. **9**, 214–219.

Oliva MA, Barros NF, Gomes MMS, Lopes NF. 1989. The development of dieback symptoms in *Eucalyptus camaldulensis* seedlings as related to moisture stress and mineral nutrition. Revista Árvore, **13**, 19-33.

Osborne SL, Schepers JS, Francis DD, Schlemmer MR. 2002 .Use of spectral radiance to in season biomass and grain yield in nitrogen and water-stressed corn. Crop Sci. **42**, 165-171.

Palled YB, Chandara Shekharaiah AM, Radder GD. 1985. Response of Bengal gram to moisture stress. India Journal Agronomy, **30**, 104-106.

Rad MH, Assare MH, Meshkat MA, Soltani M. 2011. Effects of drought stress on biomass, several growth parameters and water use efficiency of eucalyptus (*Eucalyptus camaldulensis* Dehnh) in response to drought stress. Iranian Journal of Rangelands and Forests Plant Breeding and Genetic Research, **19**(1), 13-27.

Patel MS, Golakia BA. 1988. Effect of water stress on yield attributes and yield of groundnut (*Arachis hypogaea* L.), Indian J. Agric. Sci. **58**, 701–703.

Pita P, Pardes JA. 2001. Growth, leaf morphology, water use and tissue water relation of *Eucalyptus globules* clones in response to water deficit, Tree Physiol. **21**, 599–607.

Rezaipoorbaghedar A, Hakimi M.H, Sadeghinia M, Azimzadeh HR. 2011. Effect of Some Soil Properties on Distribution of Eurotia ceratoides and Stipa barbata in Baghedar, Bafgh Rangelands. Journal of Rangeland Science, **2**(1), 417-424.

Rieger M, Dummel MJ. 1992. Comparison of drought resistance among Prunus species from divergent habitats. Tree Physiol. **11**, 369–380.

Sabeti H. 2007. Forests, trees and shrubs of Iran. Yazd University, Press, 806 pages.

Sadrzadeh M, Moalemi N. 2007. Effect of water stress and potassium on growth characteristics of young olive plants cvs. Baghmalek and Zard. Agricultural research, water, soil and agriculture, **6**(4), 1-10.

Sapeta H, Costa JM, Lourenco T, Maroco J, van der Linde P, Oliveira MM. 2013. Drought stress response in *Jatropha curcas*: Growth and physiology. Environmental and Experimental Botany, **85**, 76-84.

Seki M, Ishida J, Narusaka M, Fujita M, Nanjo T, Umezawa T, Kamiya A, Nakajima M, Enju A, Sakurai T, Satou M, Akiyama K, Yamaguchi-Shinozaki K, Carninci P, Kawai J, Hayashizaki Y, Shinozaki K. 2002. Monitoring the expression pattern of around 7,000 Arabidopsis genes under ABA treatments using a full length cDNA microarray, Funct. Integr. Genomics, **2**, 282-291.

Shaban M, Khajedin SJ, Karimzade HR, Panahpur A. 2009. Study on Drought Resistance wood species suitable for the development of green space. Journal of Research in Science, Agricultural Science, **5**(1), 57-67.

Shukla N, Awasthi RP, Rawat L, Kumar J. 2012. Biochemical and physiological responses of rice (*Oryza sativa* L.) as influenced by Trichoderma harzianum under drought stress. Plant Physiology and Biochemistry, **54**, 78-88.

Taiz L, Zeiger E. 2002. Plant Physiology. 3rd edition. Sinauer Associates Inc. Sunderland.

Tardieu F, Granier C, Muller B. 1999. Modeling leaf expansion in a fluctuating environment: are changes in specific leaf area a consequence of changes in expansion rate? New Phytol. **143**, 33–43.

Turner NC. 1997. Further progress in crop water relations. Adv. Agron. **58**, 293–338.

Whittemore AT. 2005. Genetic Structure, Lack of Introgression and Taxonomic Status in the Celtis laevigata-C. reticulata Complex (Cannabaceae), Journal of Systematic Botany, **30**(4),809–817.

Wright GC, Rao RCN, Farquhar GD. 1994. Water-use efficiency and carbon isotope discrimination in peanuts under water deficit conditions. Crop Sci. **34**, 92–97.

Yin C, Duan B, Wang X, Li C. 2004. Morphological and physiological responses of two contrasting Poplar species to drought stress and exogenous abscisic acid application. Plant Science, **167**, 1091-1097.

Yin C, Wang X, Duan B, Luo J, li C. 2005. Early growth, dry matter allocation and water use efficiency of two sympatric Populus species as affected by water stress. Environmental and Experimental Botany, **53**, 315–322.