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Early Growth of *Quercus castaneifolia* (C.A. Meyer) Seedlings as Affected by Weeding, Shading and Irrigation

Javad Mirzaei, Masoud Tabari and Hadi Daroodi
Department of Forestry, Faculty of Natural Resources and Marine Sciences,
Tarbiat Modares University, Noor, Iran

Abstract: The influence of shading, irrigation and weeding on survival, growth and morphology of 1-year *Quercus castaneifolia* seedlings was studied in north of Iran. The seedlings were grown under eight treatments including full-light versus artificial shading, irrigation versus non-irrigation and weed presence versus weed removing at three replicates. At the end of the first growing season seedling survival in all treatments was 100%. Weed removing had positive effect on height, diameter growth, slenderness coefficient and leaf area of *Q. castaneifolia*. Irrigation enhanced diameter growth and leaf area and shading increased leaf area. Irrigation had no significant effect on plant growth where the weed was removed. In weed plots seedlings growth and leaf area were greater in shading than in full-light. The results indicated that for 1 year *Q. castaneifolia* seedlings, weeding, in contrast to irrigation, is an essential factor. Where the weed competition is a difficulty, plantation with higher stem length should be applied.

Key words: Growth, irrigation, *Quercus castaneifolia*, seedling, shading, weed competition

INTRODUCTION

Caspian forests are the most valuable forests in north of Iran covering the northern slopes and foothills of Alborz mountain range in southern part of the Caspian Sea. *Quercus castaneifolia* (C.A. Mey.) is one of the most prevalent species growing in these forests (Jafari, 1977). Reduction of standing volume as well as defect of natural regeneration in *Quercus* stands has made concerned Iranian silviculturists. To this reason, its natural regeneration problem has led forest managers to use the artificial regeneration, where regeneration establishment is difficult (Rasaneh *et al*., 2001). Some factors negatively affect growth and establishment of artificial regeneration. In literature has been referred that weeds directly compete with seedlings for soil moisture and nutrients and have a negative effect on its survival and growth (Davis *et al*., 1999). Likewise, strong radiation can limit plant survival and growth by photo damage (Methy *et al*., 1996) and by reducing soil water content through evaporation and transpiration (Rey Benayas, 1998). Numerous studies have addressed the issues of how the performance of planted or naturally established woody seedlings are affected by shade (Ziegenhagen and Kausch, 1995; Rey Benayas, 1998; Bardon *et al*., 1999; Guo Ke and Werger, 1999; Morris *et al*., 2000; Sack and Grubb, 2002; McLaren and McDonald, 2003; Cardillo and Bernal, 2005) herb competition (Morris *et al*., 1993; Caldwell, *et al*., 1995; Owens *et al*., 1995; Gemmel *et al*., 1996; Holl, 1998; Jose *et al*., 2002; Rey Benayas, 2005) and irrigation Fotelli *et al*., 2000; Kolb *et al*., 2003). The interaction of irrigation, shading and weeds on this performance is complicated. For instance, shading may have a positive direct effect on seedling establishment and humid content (Madsen, 1994) but a negative indirect effect mediated by an enhancement of weed growth. In addition, weeds directly compete with seedlings for resources (especially water and nutrient) a negative effect, but they also diminish radiation and may increase low winter temperatures at the ground level, indirect positive effects that may facilitate seedling establishment and increase seedlings growth (Rey Benayas, 2005). Furthermore, soil moisture may have a negative effect due to enhancement of weed growth, but a positive effect on seedling growth and establishment.

Generally, it was believed that in Caspian forests intensive sun light, low water availability and weed competition are the major factors negatively affecting growth and establishment of man-made *Q. castaneifolia* seedlings, particularly in dry season (summer). So, in this

Corresponding Author: Masoud Tabari, Department of Forestry, Faculty of Natural Resources and Marine Sciences, Tarbiat Modares University, Noor, Iran Tel/Fax: +981226253499

experiment, the interaction of shading, irrigation and weeding on early growth and establishment of *Q. castaneifolia* seedlings was studied in the first growing season.

MATERIALS AND METHODS

A field experiment was carried out at Tarbiat Modares University, north of Iran (51°46'E, 36°47'N, 15 m a.s.l.) (Fig. 1). The experiment was conducted in a flat, deep soil and homogenous area that was formerly a mixed oak stand. Mean annual rainfall is 803.4 mm and a distinct rainy season occurs between August and May. Mean annual temperature is 17°C and the dry season comes about between May and August (Fig. 2).

In April 2005, 384 naturally regenerated oak seedlings with height = 10.9 (±0.1) cm, diameter = 2.7 (±0.2) mm and age~30 days were collected together with acorns connected to root, under a mature tree near the experimental area to minimize the variation in genetic composition. The eight treatments were included of the factorial combination of artificial shading (shaded (SH) versus full-light (L) plots), weed removing (weeding (W) versus weed (G) plots) and irrigation (irrigation (I) versus rainfed (R). There were three replicated plots per treatment (24 plots 1×1 m, in total). Some sixteen one-year old

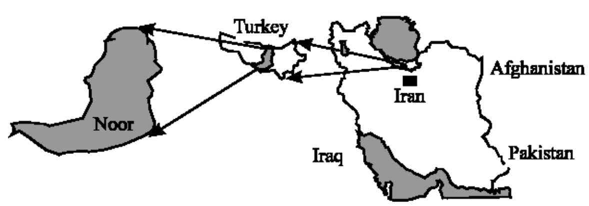

Fig. 1: Position of the study area in north of Iran

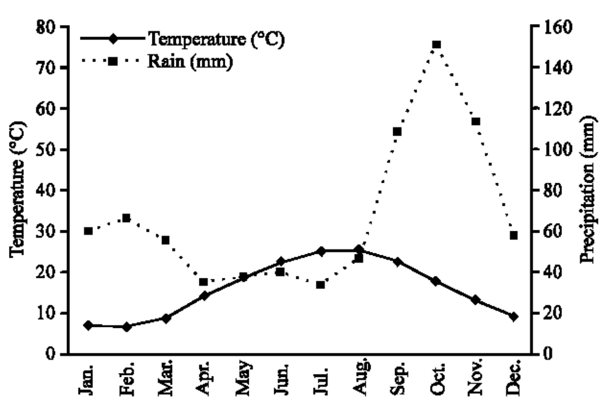

Fig. 2: Embrotermic curve of the study area, based on meteorological data

Table 1: The list of weed species grown in the field experiment frequency

Species	Family	Age	Growth form	Frequency (%)
Myosoroides alopecorus	Poaceae	Annual	Ph	5
Calystegia sepium	Convolvulaceae	Perennial	Th	1
Carex rogusa	Cyperaceae	Perennial	Cr	5
Digitaris sanguinea	Poaceae	Annual	Th	15
Equisetum ramosissimum	Equisetaceae	Perennial	Cr	4
Geranium pyrenaicum	Geraminaceae	Annual	He	3
Oxalis corniculata	Oxalidaceae	Perennial	He	5
Paspalum distichum	Poaceae	Perennial	He	5
Potentila raptanse	Rocaceae	Perennial	He	5
Setaria verticilata	Poaceae	Annual	Th	25
Solanum nigrum	Solanaceae	Annual	He	1
Sorghum halepense	Poaceae	Perennial	Cr	10
Vicia sp.	Papilionaceae	Annual	Th	2

Ph = Phanerophyte, Ch = Chamaephyte, Th = Therophyte, He = Hemicriptopyte

seedlings were transplanted with a regular distribution in each plot, being separated from each other by 20 cm. The experiment was set up as factorial with completely randomized design.

In the field, several wooden frames (120 wide×120 cm long×100 cm tall) were built to support neutral density shade fabric. Fabric densities were draped over the frames to provide two levels of light availability, 100% of full sunlight (no fabric) and 50% of full sunlight. Irrigation was carried out using a sprinkler at 4-day intervals (1.5 L for each seedling) over the growing season. Weeds were removed manually six times through out the growing season. The main weed species in the field experiment have been listed in Table 1.

Diameter (D) and Height (H) of seedlings were recorded at the beginning and end of first growing season. Seedling diameter was measured 5 cm above the ground. Survival was calculated at the end of period following recording the seedlings number. Leaf area was registered by measuring leaves of two seedlings randomly selected in each plot and measured with a Leaf Area Meter at the end of the growing season.

Height growth and diameter growth, leaf area and slenderness coefficient (H/D ratio) were tested with Kolmogorov-Smironov for normality of data. The resulting data were subjected to ANOVA. Means were compared for significant differences using Duncan's multiple range tests.

RESULTS

Seedling survival was not affected by any treatment. It was 100% in all treatments, showing no died seedling was found in any treatment at the end of the first growing season. Only weeding (p = 0.000, df = 1) and interactions of shading and weeding (p = 0.000, df = 1) affected seedlings height growth (Table 2). The best response of height growth was found in weeding-full-light areas, with

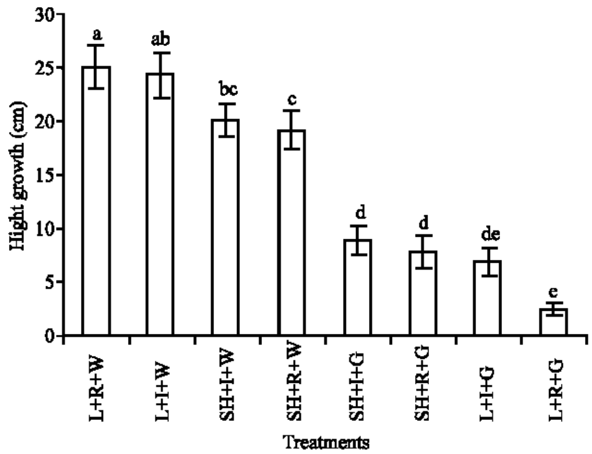

Fig. 3: Height growth of *Q. castneifolia* seedlings at different treatments (L = Full-light, I = Irrigation, G = Grass, W = Weeding, SH = Shading, R = Rainfed, Values are Mean±SE). Columns with the same letter have no significant difference (p = 0.01)

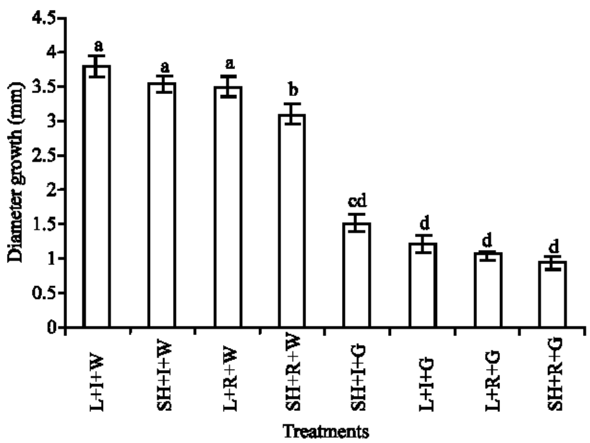

Fig. 4: Seedling diameter growth at different treatments (L = Full-light, I = Irrigation, G = Grass, W = Weeding, SH = Shading, R = Rainfed, Values are Mean±SE). Columns with the same letter have no significant difference (p = 0.01)

and no watering (LRW and LIW) (Fig. 3). In weed plots height growth was lower in shading than full-light. Where the grass was present the greatest height growth was in irrigated- and rainfed-shaded plots; the lowest in rainfed-full-light plots (LRG) and the intermediate in irrigated-full-light (LIG) plots.

Seedling diameter growth was affected by weeding (p = 0.000, df = 1), irrigation (p = 0.000, df = 1) and interaction of shading and weeding (p = 0.008, df = 1) (Table 3). It was greatest in LRW, LIW and SHIW treatments (Fig. 4). This showed where the weeding was done; the seedlings had greater diameter growth particularly in irrigated plots. Where the grass was kept,

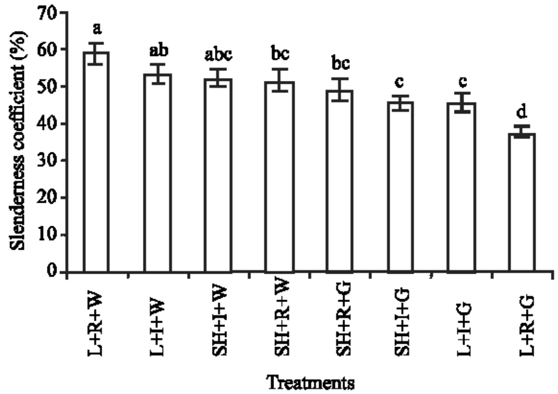

Fig. 5: Slenderness coefficient at different treatments (L = Full-light, I = Irrigation, G = Grass, W = Weeding, SH = Shading, R = Rainfed, Values are Mean±SE)

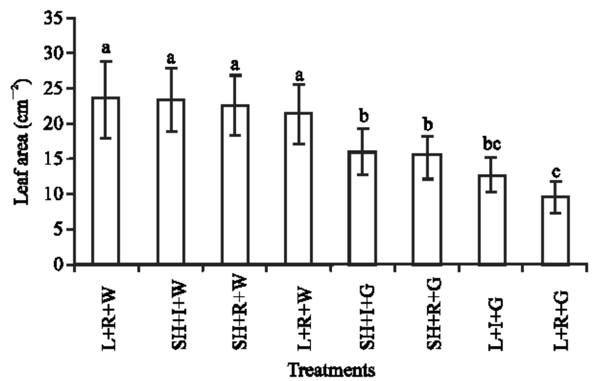

Fig. 6: Seedlings leaf area at different treatments (L = Full-light, I = Irrigation, G = Grass, W = Weeding, SH = Shading, R = Rainfed, Values are Mean±SE). Columns with the same letter have no significant difference (p = 0.01)

Table 2: Three-Way-ANOVA for seedlings height growth

Source	df	f	p-value
Artificial shading	1	0.348	0.556
Weeding	1	189.74	0.000**
Irrigation	1	1.53	0.216
Shading×Irrigation	1	0.115	0.735
Shading×Weeding	1	14.68	0.000**
Irrigation×Weeding	1	1.43	0.232
Shading×Irrigation×Weeding	1	1.19	0.274
Error	374		
Total	382		

** Significant at the 1% level of probability

Table 3: Three-Way-ANOVA for seedling diameter growth

Source	df	f	p-value
Artificial shading	1	2.41	0.121
Weeding	1	779.21	0.000**
Irrigation	1	20.72	0.000**
Shading×Irrigation	1	2.76	0.097
Shading×Weeding	1	7.18	0.008**
Irrigation×Weeding	1	0.00	0.967
Shading×Irrigation×Weeding	1	0.84	0.357
Error	374		
Total	382		

** Significant at the 1% level of probability

Table 4: Three-Way-ANOVA for slenderness coefficient

Source	df	f	p
Artificial shading	1	0.183	0.669
Weeding	1	32.06	0.000**
Irrigation	1	0.00	0.974
Shading×Irrigation	1	0.532	0.466
Shading×Weeding	1	7.18	0.003**
Irrigation×Weeding	1	8.91	0.146
Shading×Irrigation×Weeding	1	6.84	0.009**
Error	376		
Total	384		

**Significant at the 1% level of probability

Table 5: Three-Way-ANOVA for seedlings leaf area

Source	df	f	p
Artificial shading	1	5.79	0.017**
Weeding	1	147.02	0.000**
Irrigation	1	4.42	0.036*
Shading×Irrigation	1	0.41	0.520
Shading×Weeding	1	5.1	0.025*
Irrigation×Weeding	1	0.01	0.901
Shading×Irrigation×Weeding	1	0.00	0.943
Error	376		
Total	384		

*Significant at the 5% level of probability, **Significant at the 1% level of probability

diameter growth was lowest, particularly in non-irrigated plots. Seedlings obtained intermediate diameter growth in SHRW and SHIG treatments.

Weeding and its interaction with shading, as well as interaction of all treatments had significant effect on seedling slenderness (Table 4). In rainfed-full-light plot, where the weeds were removed (LRW), seedlings attained the highest slenderness (Fig. 5). The smallest slenderness coefficient was found in rainfed-shaded treatment where the weeds were kept (LRG). In weed plots the highest slenderness could be detected in rainfed-shaded treatment (SHRW).

Artificial shading, weed removing, their interaction and irrigation increased seedling leaf area (Table 5). Where the herbaceous species were eliminated, leaf area did not significantly differ in shaded and full-light plots or irrigated and rainfed plots but it was greater in weeding than weed plots. In weed plots greater leaves were found in irrigated- and rainfed-shaded plots and the smaller in rainfed-full-light plots (Fig. 6).

DISCUSSION

The study revealed that all treatments influenced height growth, diameter growth, leaf area and slenderness of seedlings but had no effect on seedling survival. Seedling survival in all treatments was very high (100%). Weeding and its interaction with shading had positive effect on height growth and diameter growth, whereas both characteristics were greater in weeding plots than in weed plots. The same results were obtained by Kolb and Steiner (1990) and Lorimer *et al.* (1994). Generally, weeds compete with oak seedlings for moisture and soil nutrient and influence negatively plant growth (Lof *et al.*, 1998; Duplissis *et al.*, 2000; Lhotka and Zaczek, 2001). So, weeding is essential for young oaks (Rey Benayas *et al.*, 2005). The results of current research showed that shading did not significantly affect diameter growth and height growth. This confirms the results reported by Gardiner (1998) on *Q. pagoda*, Welander and Ottosson (1998) on *Q. robur* and *Fagus sylvatica* and Fuches *et al.* (2000) on *Q. garryana*. In the current research the newly regenerated seedlings along with their acorns were transplanted in plots. Acorn reserve could be probably the main reason for growth homogeneity in shaded plot as well as in full-light plots (Gemmel *et al.*, 1996; Gardiner, 1998). This reveals that in the first growing season nutrient reserve of oak acorn is caused growth and establishment become independent of lighting (or shading). In this study it was found that diameter growth was prominently depended on irrigation. This result is supported by Fotelli *et al.* (2000) and Kolb *et al.* (2003) on oak seedling and Madsen (1995) on beech seedling. It was revealed that weeding and its interaction with shading had positive effect on slenderness of seedlings. In fact where the weeds were present, seedlings attained a higher slenderness in shaded than full-light plots. In the similar studies, Phares (1970) and Thadani and Ashton (1995) showed that higher slenderness occurred at low light intensity. Leaf area was affected by weeding, irrigation and shading. As a matter of fact, oak seedlings obtained larger leaves in shaded than in full-light plots. Similar finding was reported by Ziegenhagen and Kausch (1995) on *Q. robur* and Cardillo and Bernal (2005) on *Q. suber*. Generally based on results of this study, weeding-full-light, with and without irrigation (LRW and LIW) and weeding-shaded with irrigation (SHIW) treatments increased growth and development of seedlings. With respect to similarity in some growth characteristics of seedlings grown in irrigated and non-irrigated plots, irrigation is not a demand for *Q. castaneifolia* seedling during the first growing season. However, for better seedling establishment weeding is necessary. Where the weed was present; seedlings in shaded plots compared to full-light plots had higher growth and development. So in clear-cut areas, where the weed is dense, seedling plantation with taller shoot length is advised. Shelter is not essential for seedling growth in its first growth season, so, *Q. castaneifolia* seedlings can be grown in full-light, but weed control is a critical point.

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