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Germination and Initial Growth of *Fagus orientalis* Seedling under Different Stand Canopies

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Abstract: Germination and early growth of *Fagus orientalis* seedling were studied in four stands with different canopy closures (closed, semi-closed, relatively-opened and opened stands) under a dominant beech forest, located in north of Iran. For this purpose, 196 beech seed-sown plastic pots (in four plots of 49 units) were set up under each canopy closure. In the beginning of the first growing season germination rate ranged between 78.1 and 84.7% in different stands but there was no statistically significant difference of this term in the stands. In the end of the first growing season survival rate of seedlings was 73.9-76.1% under closed and semi-closed stands. It decreased significantly to 31.7 and 18.0% under relatively-opened and opened stands, respectively. Shoot length was, in the order 70 and 90 mm in closed and semi-closed stands. It decreased to 40 and 30 mm in relatively-opened and opened stands, respectively. Vitality appeared mostly with high quality in closed and semi-closed stands and with low quality in relatively-opened and opened stands. Leaf biomass reduced in closed stand. There was an increase for leaf area in semi-closed stand and for Specific Leaf Weight (SLW) in relatively-opened and opened stands. Generally, the investigation shows that in the first growing season most characteristics of beech seedling were benefited from more favorable conditions in the denser stands (closed and semi-closed canopies).

Key words: Canopy closure, oriental beech, seedling, shoot length, survival

INTRODUCTION

Investigations on beech seedling, especially from viewpoint of survival and growth at different light regimes or in various canopy openings have been reported by many researchers including Burschel and Schmaltz (1965), Madsen (1994) and Larsen and Buch (1995). Most of literatures have been made on *Fagus sylvatica* L., but several reports on *Fagus porientalis* Lipsky. Majority of the reports represent survival of beech seedlings enhances in denser stands or in smaller gaps (Giannini, 1971; Peltier *et al*., 1997; Shahnawazi, 2000; Tabari *et al*., 2005). In spite of the fact that the greatest height growth of beech seedlings occurs in smaller gaps (Johnson, 1997; Mousavi, 2000) the results conducted by others especially Suner and Rohrig (1980), Sagheb-Talebi (1996) and Shahnawazi (2000) indicate the increased growth occurs by enlarging canopy opening. Shahnawazi (2000) claims that vitality quality in beech seedling promotes as radiation supply decreases.

In the Caspian forests of Iran some investigations have been made on regenerating beech (*Fagus orientalis*) (Amani and Hasani, 1999; Sagheb-Talebi and Shütz, 2002) but a few on condition of beeches planted or seeded in canopy openings. Leaf litter is thick in some stands of these forests and seed germination as well as natural regeneration is restricted particularly in the dense stands where beech is dominant. To this reason, the current research, conducted in such stands with various canopy closures, aims to find the optimum canopy closure to elevate seed germination of beech and characteristics of seedlings emerged and grown by direct seeding. Seed sowing could be carried out in the forest ground followed the leaf litter removal but the soil characteristics might be different in the stands; therefore, plastic pot filled by a homogenous soil was employed for this purpose. The study period could not continue for following years, due to the smallness of plastic pot and rooting development of beech seedling. Similar research can be carried out with direct seeding or soil scarification together with broadcast seeding under further canopy closures for longer periods.

MATERIALS AND METHODS

Study site: The study is situated in a dominant oriental beech (*Fagus orientalis* Lipsky) forest, in north of Iran. Depending on site condition, tree species such as *Carpinus betulus*, *Acer velutinum*, *Acer laetum*, *Tilia cordata*, *Alnus subcordata* and to a small extent, *Quercus castaneifolia* with a top height of 30-35 m are accompanied with *Fagus orientalis.* The physiographical characteristics of the site are presented with elevation of 1400 m a.s.l., north-facing with slope about 15%. According to census of the nearest meteorological station, situated at 2 km from the experimental site and characteristics given in Table 1, the climate condition is realized as humid with cold winters and dry summers based on categorization of Emberger (1932).

Table 1: Some climatic characteristics in the site study (census years of 1970~2000)

Mean annual rainfall (P)	800 mm
Mean max. temperature of the warmest months (M)	22°C
Mean annual rainfall in July	10 mm
Mean annual rainfall in August	14 mm
Mean min. temperature of the coldest months (m)	-4°C
Pluviotermique index (Q_2)	101
Vital dry days (dry index)	50 days (Jul., Aug.)

Table 2: Some physico-chemical properties of the pot soil

Texture	Sandy-Loam
pH	6.70
EC (mS cm^{-1})	1.30
Organic matter (%)	13.90
C (%)	8.80
N (%)	0.80
P (ppm)	205.00
K (ppm)	936.00
C/N	11.00

Experiment design: The study site was a dominant beech forest. The natural regeneration was much poor, due to a dense undecomposed litter layer. Four adjacent stands were chosen with different canopy closures, such as (i) closed (ii) semi-closed (iii) relatively-opened and (iv) opened, corresponding with about 11, 27, 68 and 95% of full day light, respectively. Canopy closures were come about following cutting trees in 1995. Light recording was carried out by a Lux-meter unit (Weston Illumination Meter) and taken during overcast and sunny weather for four weeks between 8 and 20 h in July and August, when canopy leaves were fully developed.

In December 1999, following the stands identification, beech seeds were collected from a mature tree. After being cleaned, seeds were soaked with Monkazeb fungicide, put in gunnysack and placed in outside for stratification. In February 2000, 784 plastic pots (25 cm long and 8 cm wide) were filled with compound of 81% nursery soil, 16% tea wastes, 3% wheat bran (with physico-chemical characteristics listed in Table 2). Then a pre-treated seed was sown in each pot. In center of each stand immediately after clearing herbal vegetation four plots of 1×1 m were designed and 49 plastic pots installed in each plot (totally 196 units/canopy closure). A min.-max. thermometer was established in center of each stand in order to record the variations process of temperature in warmest months (July and August) (Fig. 1). During the growing period neither irrigation nor weeding was operated in plots.

Soil properties determination: Soil pH and Electrical Conductivity (EC) were measured by preparing a soil solution using distilled water (1 g in 20 mL) and calibrating the solution with an Elico-pH meter (Elico Company, Pradesh, India). Soil textures were estimated by the use of sieves of different meshes. Sieving separated different fractions (different size particles) from the sample and then the relative proportions of each fraction were calculated (Arakeri *et al*., 1967). Soil organic matter was determined as loss-on-ignition of oven-dried soil over 24 h in a muffle furnace at 550°C (Allen *et al*., 1976). To estimate organic carbon the chromic acid colorimetric method (Black *et al*., 1965) was used by preparing standard curves. Carbon values were estimated from the standard curve (Perur *et al*., 1972). Phosphorus levels were estimated colorimetrically by the molybdenum blue method after extraction with Trough's reagent, potassium by the EDTA titration method (Allen *et al*., 1976) and nitrogen by the micro-Kjeldahl alkaline permanganate method (Perur *et al*., 1972).

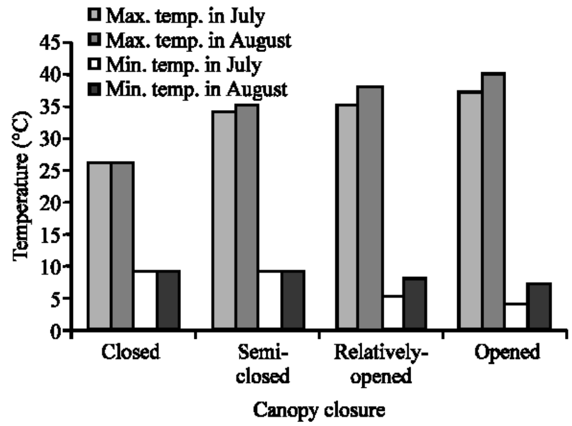

Fig. 1: Min. and max. air temperature in different canopy closures (July and August)

Table 3: Classification of vitality quality of beech seedling (according to United Nations, Economic Commission for Europe and European Commission, 1998)

Foliage discolored	Discoloration degree
up to 10%	None
10~25%	Slight
25~60%	Moderate
>60%	Severe

Measurements: The recording of newly germinated seedlings was conducted in April-May. Vitality quality or foliage discoloration degree of the survived seedlings, based on UN/ECE United Nations, Economic, Commission for Europe and European Commission (1998) classification (Table 3), was registered in mid-August. Measuring shoot length and determining survival was made in late Sep. Likewise, three seedlings were excavated randomly from each plot and their leaves were oven-dried at 70°C for 48 h and weighted by an analytic balance. Leaf area of all leaves was measured by a Li-Cor LI-3000 meter and then specific leaf weight (leaf weight/leaf area) was computed.

Data analysis: Mean germination rate among different canopy closures was analyzed by Kruskal-Wallis test. Shoot length and leaf characteristics were determined by One-Way Analysis of Variance (ANOVA) and tested with Duncan's multiple comparison tests. Differences among the means of survival, after using Kruskal-Wallis test were analyzed by Mann-Whitney's test (Cochran and Cox, 1957). The categorized data of vitality quality was examined by Chi-square (χ^2) analysis (Diggle, 1983). All statistical analyses were performed at $p<0.05$ level of significance, using the statistical package of SPSS, version 12.5.

RESULTS

Seed germination, survival and shoot length: The analysis of seed germination in the onset of the growing season (April-May) indicated a variable between 78.1 and 84.7%. Although germination rate apparently raised with enlarging canopy opening but the analysis conducted by the Kruskal-Wallis test revealed no statistical differences of this characteristics among the different canopy closures ($\chi^2 = 5.42$, $p = 0.086$) (Table 4).

The results obtained using the Mann-Whitney tests followed the Kruskal-Wallis test exhibited that survival reduced in relatively-opened and opened stands at the end of the first growing season (Table 4). It was 73.9 and 76.1%, in the order under closed and semi-closed canopies and 31.7 and 18% in relatively-opened and opened canopies. Survival rate, however, did not significantly differ in closed and semi-closed stands or in relatively-opened and opened stands.

By analysis of variance (ANOVA) and Duncan's test it was revealed that the effect of canopy closure on shoot length was significant whereas it was greater where the canopy was denser (Table 4). No marked differences of shoot length could be detected in the two closed canopies or in the two opened canopies.

Leaf characteristics: Canopy closure had a significant effect on the amount of biomass accumulated by beech seedling leaves. In fact, in the first growing season the lowest carbon gain was observed on seedlings raised under closed canopy. The greater quantities of leaf biomass were yielded under other three canopies but no substantially difference of this term was present among them (Table 4). Leaf area of beech seedlings responded significantly to canopy opening. It was greater in semi-closed stand than in other three stands (Table 4). Specific Leaf Weight (SLW) was influenced by canopy opening. It rose as radiation supply increased (Table 4). In other words, beech seedlings developed the greatest proportion

Table 4: Mean±Standard deviation of seed germination and seedling characteristics of 1-year-old beech seedling under different canopy openings

	Canopy closure			
Variables	Closed	Semi-closed	Relatively-opened	Opened
Germination (%)	78.1±03.0	81.2±2.0	82.1±2.5	84.7±3.5
Survival (%)	73.9±05.0^a	76.1±6.0^a	31.7±3.0^b	18.0±2.0^b
Shoot length (mm)	70.0±12.0^a	90.0±7.0^a	40.0±5.0^b	30.0±2.0^b
Leaf biomass (mg)	17.0±02.0^b	25.0±3.0^a	24.0±3.0^a	24.0±2.5^a
Leaf area (cm^2)	4.4±00.4^b	5.6±0.4^a	4.7±0.8^b	4.8±0.3^b
Specific leaf weight (mg cm^{-2})	3.9±00.4^c	4.5±0.7^b	5.1±0.4^a	5.0±0.7^a

Different letter(s) after the means in each row show significant difference among the canopy openings, at 5% prob. level

Table 5: Percentage of foliage discoloration of beech seedlings in different canopy closures

	Canopy closure			
Foliage discoloration	Closed	Semi-closed	Relatively-opened	Opened
None discolored	40	42	-	-
Slightly discolored	20	16	-	-
Moderately discolored	14	18	12	8
Severely discolored	26	24	88	92

of SLW when grown under relatively-opened and opened fields, while the lowest was produced where high shade was appeared (in the closed stand).

Vitality quality: By the Chi-square's test it was appeared that in the first growing season vitality quality (foliage discoloration degree) of beech seedlings was not independent from canopy density ($\chi^2 = 12.80$, $p = 0.040$). About 60% of seedlings growing in closed or semi-closed stands were not to slightly discolored and about 40% moderately to severely discolored (Table 5). In relatively-opened and opened stands about 90% of seedlings were severely discolored and only about 10% moderately discolored. As a matter of fact, not any seedlings with high vitality quality could be found under these both canopy closures.

DISCUSSION

The current investigation revealed that germination rate of oriental beech was not different in the various canopy openings. It was showed by a fairly high rate in all stands; however, no difference of this attribute could be detected between present research (84.7%) and the yielded *in situ* (88.0%), a finding made by Shahmoradi (1987). In the present study under the closed canopy, survival was statistically similar to that under the semi-closed canopy; however, it decreased as the canopy opening increased. This is supported by Mousavi (2000), Giannini (1971) and Peltier *et al.* (1977), who affirm the lowest survival rate of beech is observed in bigger canopy openings. In another speaking it can be brought up the results made by Leibundgut (1993), Korpel (1995) and Burger *et al.* (2001), who emphasize beech natural regeneration in eastern Europe dominantly occurs in small openings.

In the research area shoot length does no show significant difference in closed canopy and semi-closed canopy but, as a whole, this characteristic is demonstrated with lower rates in more opened canopies. This, in other words, can be confirmed by Mousavi (2000), who underlines the higher growth of *F. orientalis* is produced in the smaller canopy gaps. Besides, Allgaier (1991) shows total height of *F. sylvatica* seedlings and saplings increases with rising shade. Conversely, the reports made by Welander and Ottosson (2000) on *F. sylvatica* and *Quercus robur*, grown in a greenhouse with different light supplies (2, 4, 9, 21, 43 and 70%), reveals that shoot growth of both species reduces as shading increases. The air temperature in researches made by the recent authors is different with that in the present experimental site. In reality, in the greenhouse it does not exceed 18°C but in the opened stand of our investigation it amounts up to 37~40°C.

In present study about 60% of the seedlings growing in the denser stands are observed as none- and slightly discolored. In thinner stands about 90% of seedlings appear with severely discolored and the remaining with moderately discolored. It implies that in open field as vitality quality of beech seedling declines its growth decreases. The results of the present study can also be in line with Kharitonenko (1972), who declares the best vitality quality of *F. orientalis* regeneration occurs in the thick stands where radiation is practically weak. Similarly it can be referred to study of Shahnawazi (2000), who represents that the better vitality of *F. orientals* seedling is perceived in the smaller canopy openings.

In the current investigation, seedling development in term of leaf biomass was somewhat proportional to canopy opening condition, a finding in line with other studies on beech (Madsen, 1994) and birch (Atkinson, 1984). Leaf area varied with canopy closure status. Indeed, seedlings established in moderately-closed stands showing a low light availability in the understorey developed leaves with larger dimensions. This is while that in study of Minotta and Pinzaut (1996) it did not differ for 1 year beech seedlings growing under intermediate light intensity with those under low or high light supplies. Specific Leaf Weight (SLW) changed positively with increase of canopy opening, as reported for European beech by Masrovicova and Minarcic (1984), Masrovicova and Stefancik (1990) and Minotta and Pinzaut (1996) and for other tree species by Callaway (1992) and Gottschalk (1987, 1993).

By this investigation it can be concluded that most characteristics of one-year beech seedlings are better suited under the closed and semi-closed canopies. On the whole, it may be noted that, in the closed and semi-closed stands of the study site, as well as in the adjacent beech stands, where the leaf litter is thick and natural regeneration is missing; instead of potted seed sowing, direct seeding of *F. orientalis* together with removal of litter layer can be useful for supplementary regeneration.

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