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[Short Communication]

Effects of initial spacing on some allometric characteristics of 12-year-old *Quercus castaneifolia* plantation in central Mazandaran, Iranian Caspian forests

E. Ebrahimi[1] , M. R. Pourmajidian[1] , H. Jalilvand[1] , A. Fallah[1] , S. M. Waez-Mousavi[2]*

1-Dept. of Forestry, Faculty of Natural Resources, Sari Agricultural Sciences and Natural Resources University, Sari, Iran.
2-Faculty of Forest Sciences, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran
** Corresponding author's E-mail:smwaez@gmail.com*

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ABSTRACT
The effects of initial spacing layout on some allometric characteristics of 12-year-old *Quercus castaneifolia* trees grown in Central Mazandaran, north of Iran were examined. Trees were planted in 5 different layouts (1×1, 1.5×1.5, 2×2.5, 2×3 and 4×4 m). Tree height, diameter at breast height, natural pruning height and the survival of trees were recorded in each sample plot. Tree basal area and H/D ratio and standing volume were calculated for all trees. The results of statistical analysis showed that increasing in spacing level from 1×1 to 4×4 significantly increased the average diameter at breast height from 6.93 to 12.42 cm and survival from 53% to 85%. The average tree basal area per ha decreased from 19.98 m^2ha^{-1} to 6.43 m^2ha^{-1} and H/D ratio from 151 to 77 when the distance between trees increased from 1 × 1 to 4 × 4 m. but spacing regime had no significant effect on tree height and natural pruning height. It can be concluded that on the basis of standing volume, H/D ratio and survival rate, the best plantation spacing in this research station was 2 m × 3 m. Statistically, about 95% of the changes in sediment yield was due to the effect of increased dry land farming area in the basin (R^2= 0.95, $\alpha < 0.05$).

Keywords: *Allometric characteristics, Hyrcanian Forests, Plantation, Quercus castaneifolia, Plantation Spacing.*

INTRODUCTION
Forest plantation is a common action in order to restore the degraded forests in the Caspian region (Mohammadnezhad Kiasari *et al*. 2009) which are also called as Hyrcanian forests and are located on the southern parts of the Caspian Sea (Bonyad *et al*. 2012). The genus *Quercus* contains around 530 species worldwide (Rix & Kirkham 2009). Several species of deciduous oaks including *Quercus castaneifolia*, *Q. infectoria*, *Q. brantii* and *Q. libani* are grown in Iran (Ehsanpour & Zahedi 2006, Panahi *et al*. 2011). *Quercus castaneifolia* is one of the typical Hyrcanian species inhabiting the humid forests which curve around the southern coast of the Caspian Sea (Rix & Kirkham 2009). This species also plays an important role in the local industry as well as in folk medicine (Mamedova *et al*. 1993). Spacing and planting layout influence tree growth and form (Cochran *et al*. 1991; Gerrand *et al*. 1997; Williams *et al*. 2006; Hegazy *et al*. 2008). Spacing also has a major impact on the acceptance of timber for products such as sawlog or veneer as it is associated with branch size and number of branches (Neisen & Gerrands 1999; Henskens *et al*. 2001). Other characteristics such as wood density and strength, visually graded wood quality, crown shape and stem taper can also be affected (Deans & Milne 1999; Henskens *et al*. 2001). *Quercus castaneifolia* in Iran is mostly planted to reforest degraded stands and to produce timber for industry. Many publications investigated the effect of spacing on some qualitative and quantitative characteristics of planted trees. In this direction Cochran *et al*. (1991) studied spacing effect on growth of ponderosa pine. Results showed that larger spacing produced larger trees but less volume per hectare than closer spacing. The effect of spacing on yield and some wood properties of *Cupressus lusitanica* in

Northern Tanzania were examined by Malimbwi *et al*. (1992). They reported that with increasing spacing, mortality and total volume decreased while branch diameter and breast height diameter increased. Henskens *et al*. (2001) in an investigation entitled "physiological basis of spacing effects on tree growth and form in *Eucalyptus globulus*" have found that with increasing spacing, stand leaf area index and the proportion of aboveground biomass in stem declined, while mass in foliage and branches increased. Also Hegazy *et al*. (2008) studied the effect of spacing on the biomass production and allocation in *Conocarpus erectus* L. trees grown in Saudi Arabia. The mentioned trees were planted at three different square spacings of 0.7, 1.4 and 2.1 m. The results indicated that the highest yield was produced from close spacing (0.7 m). But total tree biomass was lowest in close spacing and was higher in spacing of 2.1 m. The main objective of this study was to investigate the effects of different initial spacing layout on some allometric characteristics of *Quercus castaneifolia* C. A. M. plantation in lowlands of Hyrcanian forests, Northern Iran.

MATERIALS AND METHODS

Study site description

This study was carried out in Chamestan area, located in central Mazandaran, north of Iran (36° 25′ to 36° 29′ N, 51° 55′ to 51° 59′ E) (Fig. 1). The elevation of the site is about 100 m a.s.l. and its slope ranges from 0 to 3%. The mean annual temperature is 16.3 °C and annual precipitation is about 864 mm. General soil order is Inceptisol.

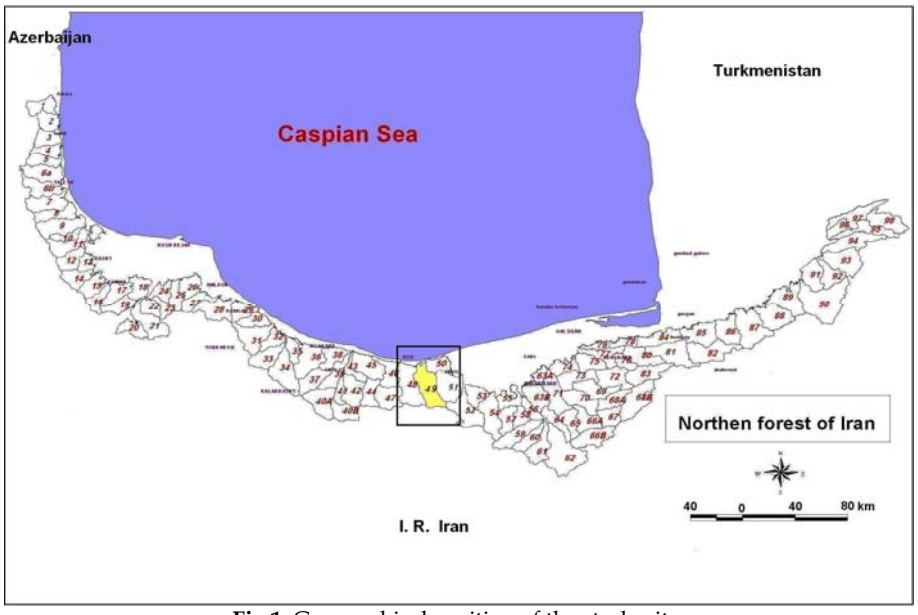

Fig 1. Geographical position of the study site.

Data collection and experimental design

Experiments were conducted in 2006 in a plantation of *Quercus castaneifolia* which was established in 1994. The aforementioned plantations were in 5 different spacing levels of 1×1, 1.5×1.5, 2×2.5, 2×3 and 4×4. The experimental design of the study was randomized complete block design with 3 replicates and 5 treatments (5 spacing levels). 3 plots were designed in each spacing layout. The area of each plot was 400 m^2. In order to eliminate potential edge effects, all sample plots were considered at center of plantations. Due to different spacing layouts, the number of trees in each sample plot was different and ranged from 27 trees in 4×4 m layout to 49 trees in 1×1 m layout. In each plot some allometric characteristics such as diameter at breast height, tree height, natural pruning height (a segment of the stem naturally was pruned due to light shortage) of all trees were recorded. Considering the value of tree height (H) and its diameter (D), H/D ratio was calculated for all trees. As a consequence of tree number per hectare and their diameter (at breast height) the average of tree basal area per hectare was calculated

for all spacing levels. In addition, mortality in each sample plot was recorded in order to compare the survival of trees in different spacing levels.

Statistical analysis

The obtained data were statistically analyzed through analysis of variance for a randomized complete block design using SPSS software. The table and graphs drawing were done in Excel computer program.

RESULTS

The statistical analysis showed that spacing had a significant effect (P< 0.05) on the average diameter at breast height of *Quercus castaneifolia* trees (Table 1). The diameter at breast height significantly increased from 6.93 to 12.42 cm by increasing the distance between trees from 1×1 to 4×4 m. But increasing in spacing had no significant effect on the average tree height, although it trended to decrease slightly from 10.56m for spacing of 1×1 to 9.6 for spacing of 4×4 m (Table 2). Statistical analysis also revealed that the average natural pruning height was not significantly influenced by the spacing level (P< 0.05), but insignificantly decreased from 5.36 m in 1×1 to 3.63 m in 4×4 m spacing level. There also was a significant difference (P< 0.05) between spacing levels in tree basal area (Table 2). The greatest tree basal area per ha found in spacing level of 1×1 m was 19.98 m^2ha^{-1} and the lowest amount observed in spacing level of 4×4 m was 6.43 m^2ha^{-1} (Table 2).

Regarding the percent of mortality, spacing treatment had a significant effect on the survival percent of trees in different spacing layout (P < 0.05). The average value for tree survival increased significantly from 53% to 85% as spacing increased from 1×1 to 4×4 m. The statistical analysis also showed that the H/D ratio of *Quercus castaneifolia* is significantly different among spacing layouts (P< 0.05). The value of H/D ratio for 5 different spacing levels of 1×1, 1.5×1.5, 2×2.5, 2×3 and 4×4 were 151, 133, 109, 86 and 77 respectively which show a considerable decrease from 151 to 77. There was also a significant difference in standing volume among the spacing levels the highest of which was 111.8 m^3 in 1×1 layout and the lowest was 52.5 m^3 in 4×4 layout (P< 0.05) (Table 2).

Table 1. Analysis of variances

Variables	DF	SS	MS	F	Sig.
Tree diameter (m)	4	0.779	0.195	58.088	*
Tree height (m)	4	0.013	0.003	0.894	ns
Natural pruning height (m)	4	7.998	1.999	4.483	ns
basal area (m^2 ha^{-1})	4	288.421	72.105	59.704	*
Survival (%)	4	2652.6	656.4	37.295	*
H/D ratio	4	11499.733	2874.933	76.87	*
Standing volume	4	7128.744	1782.186	1.782	*

* indicates the significant difference and ns indicates non significant different

Table 2. The effect of spacing on growth parameters (Different letters indicate significant differences between treatments).

Spacing (m)	Tree diameter (cm)	Tree height (m)	Natural pruning height (m)	basal area (m^2 ha^{-1})	Survival (%)	H/D ratio	Standing volume (m^3)
1×1	6.93 c	10.56 a	5.36 a	19.98 a	53 b	151 a	111.8 a
1.5×1.5	7.74 c	10.32 a	4.92 a	12.54 b	60 b	133 b	77.65 b
2×2.5	9.27 b	10.08 a	3.72 a	10.93 b	81 a	109 c	89.2 b
2×3	11.16 a	9.72 a	3.67 a	13.52 b	83 a	86 d	109 a
4×4	12.42 a	9.6 a	3.63 a	6.43 c	85 a	77 d	52.5 c

Discussion

The relationships between spacing layout and allometric characteristics in *Quercus castaneifolia* at the age of 12 years were in agreement with patterns frequently reported in trees of temperate forests. In this study spacing slightly and insignificantly affected the height growth of trees. The

result is in consistent with most of other observations of no or little effect of spacing on the tree height growth (Cochran *et al*. 1991; Nielsen and Gerrand 1999; Henskens *et al*. 2001; Hegazy *et al*. 2008)

But tree diameter (at breast height) significantly increased in wider spacing which is a response to more resources availability. According to size-density theory, diameter growth decreases with increasing tree density (Drew & Flewelling 1979; Willcocks & Bell 1995).

Despite low average diameter at breast height of trees in lower spacing levels, due to high density, spacing layout of 1×1 m had the greatest tree basal area per ha.

Wider spacing reduced mortality rate and H/D ratio. Lower tree density, and as a result, greater availability of resources such as soil water, and nutrient reduced competition among trees and consequently declined mortality. More resources availability also resulted in greater diameters of trees in wider spacing plots and consequently lower H/D ratios. H/D ratio is one of the most important factors in tree stability against natural disturbances specially wind and snow. Mayer (1984) proved that an H/D ratio of more than 100 increases vulnerability of trees against natural disturbances. He also suggested that an H/D ratio of 80 to 100 is ideal. The natural pruning height of trees significantly increased by decreasing spacing, which is due to less light availability in plots with high density that causes in natural pruning. The standing volume was the highest in 1×1 spacing layout which is due to high tree density and basal area in 1×1 layout. Regarding the standing volume, H/D ratio and survival, the spacing layout of 2×3 m is the most suitable layout for *Q. qastanifolia* in the study area, while in Iran the common spacing layouts for the mentioned species are 1.5×1.5 and 1.5×2 m. Planting in a too dense spacing layout causes more competition and less survival among the trees.

REFERENCES

Bonyad, A.E., Sima, A., Bakhshandeh, A. and Dadras, H. (2012) Evaluation of non-destructive Meyer method for determination of bark volume of beech (Fagus orientalis Lipsky) in different geographical aspects. Caspian Journal of Environmental Sciences. 10 (1): 67-73.

Cochran, P.H., Newman R.P. and Barrett, J.W. (1991) Fertilization and spacing effects on growth of planted ponderosa pine. Research Note PNW-RN-500, Pacific Northwest Research station, US .Department of Agriculture. pp. 13.

Deans, J.D. and Milne, R. (1999) Effects of respacing on young sitka spruce crops. Forestry. 72: 47-57.

Drew, T.J. and Flewelling, J.W. (1979) Stand density management: an alternative approach and its application to Douglas-fir plantations. Forest Sciences. 25: 518-532.

Ehsanpour, A.A. and Zahedi, S. (2006) Induction of somatic embryogenesis from cotyledon of Oak (Quercus castaneifolia). Journal of Science. 32(1): 47-50

Gerrand, A.M., Nielsen, W.A. and Med horst J.L. (1997) Thinning and pruning Eucalypt plantation for sawlog production in Tasmania. Tasforests. 9: 15-34.

Hegazy, s.s., Aref, I.M., AL-Mefarrej, H. and EL-Juhany, L.I. (2008) Effect of spacing on the biomass production and allocation in Concarpus erectus L. Trees grown in Riyadh, Saudi Arabia. Saudi Journal of Biological Sciences. 15(2): 315-322.

Henskens, F.L., Battaglia M., cherry, M.L. and Beadle, C.L. (2001) Physiological basis of spacing effect on tree growth and from in Eucalyptus globulus. Trees. 15: 365-377.

Malimbwib, R.E., Pesson, A., Iddi, S., Chashama, S.A.O., and Mwihomeke, S.T. (1992) Effects of spacing on yield and some wood properties of Cupressus lusitanica at Rongai, Northern, Tanzania. Forestry. 65(1): 73-82.

Mamedova, M.E., Aslanov, S.M. and Mirzoev, O.G. (1993) Chemical composition of the acorns of Quercus Castneifolia. Chemistry of Natural Compounds. 29(4): 609-610.

Mayer, H. (1984) Wald bau auf sizologich-oekologischer Grundl-age. 3 Auflay. Gustav ficher verlag, Stugart. 514 P.

Mohammadnezhad Kiasari, Sh., Sagheb-Talebi, Kh., Rahmani R. and Ghasemi Chapi, O. (2009) Seasonal Variation of Earthworm Abundances and Biomass in Natural Forests and Plantations

(North of Iran). Caspian Journal of Environmental Sciences. 7 (2): 87-98.

Neilsen, W.A. and Gerrand, A.M. (1999) Growth and branching habit of Eucalyptus nitens at different spacing and the effect on final crop selection. Forest Ecology and Management. 123: 217-229.

Panahi P., Jamzad Z., Pourmajidian M.R., Fallah A. and Pourhashemi M. (2011) A revision of chestnut-leaved oak (Quercus castaneifolia C. A. Mey.; Fagaceae) in Hyrcanian Forests of Iran. Caspian Journal of Environmental Sciences. 9 (2): 145-158.

Rix, M. and Kirkham, T. (2009) Quercus castaniflora, Fagaceae. Curtis's Botanical Magazine. 26 (182): 54-63.

Willcocks, A.J. and Bell, W. (1994) Effect of stand density on the growth and timing of harvest and establishment costs of coniferous stands. OMNR, Northeast science & technology TN-007. pp 12.

Williams, D.R., Dotts, B.M., Neilsen, W.A. and Joyce, K. (2006) the effect of tree spacing on the production of flowers in Eucalyptus nitens. Australian Forestry. 69(4): 299-304.

تأثیر تراکم اولیه بر روی برخی خصوصیات الومتری جنگلکاری ۱۲ ساله بلوط در مرکز مازندران، جنگلهای خزری ایران

ع. ابراهیمی، م. ر. پورمجیدیان، ح. جلیلوند، ا. فلاح، س. م. واعظ موسوی*

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چکیده

در این مطالعه، ما اثر طرح فاصله بندی اولیه را بر روی برخی خصوصیات آلومتری درخت *Quercus castaneifolia*، ۱۲ساله در بخش های مرکزی استان مازندران در شمال ایران، مورد آزمایش قرار گرفت. درختان در ۵ فاصله مختلف ۱×۱، ۱/۵×۱/۵، ۲/۵×۲ ، ۳×۲ و ۴×۴ متر کاشته شدند. ارتفاع درخت، قطر درخت در فاصله ۱/۴ متری از زمین ، ارتفاع هرس طبیعی و ماندگاری درختان در هر قطعه نمونه ثبت گردید. سطح مقطع و نسبت H/D و حجم سرپا برای تمامی درختان محاسبه شد. نتایج حاصل از تجزیه و تحلیل آماری نشان داد که افزایش در سطح فاصله از ۱×۱ تا ۴×۴ متر به طور معنی داری سبب افزایش میانگین قطر درخت در فاصله ۱/۴ متری از زمین از ۶/۹۳ تا ۱۲/۴۲ سانتی متر می شود و همچنین ماندگاری درخت از ۵۳ ٪ به ۸۵٪ افزایش می یابد. با افزایش فاصله بین درختان از ۱×۱ تا ۴×۴ متر ، میانگین سطح مقطع درخت به ازای هر هکتار از ۱۹/۹۸ مترمربع در هکتار به ۶/۴۳ مترمربع در هکتار و نسبت H/D از ۱۵۱ به ۷۷ کاهش یافته است. ولی رژیم فاصله هیچ اثر معنی داری روی ارتفاع درخت و ارتفاع هرس طبیعی نداشت. می توان نتیجه گرفت که با توجه به حجم سرپا، نسبت H/D و نرخ ماندگاری، بهترین فاصله کاشت درخت در این ایستگاه ۲ متر در ۳ متر است.

*مولف مسئول