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Quantitative and qualitative evaluation of forest plantations by four species and suggestion the appropriate species in the Hyrcanian forest

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ABSTRACT

Due to the process of deforestation and Increasing human population and growing demands for forests, afforestation and the development of forest is and will be of paramount importance. To detection the suitable species to plantation and reforestation in Hyrcanian forest, plantation in 1990 in Berenjestanak region, Mazandaran province, Hyrcanian forests, and northern of Iran was selected. The plantation by species Populus nigra L. Acer velotinum Boiss, Fraaxinus excelsior L, Pinus brutia L in the 42 hectare area was selected. Inventory 66 circle plots 200 m^2 by randomized-systematic in a net of 100 m × 75 m were collected. In each sample plot quantitative and qualitative characters of tree include the kind of species, diameter at breath height (cm), height (m), stem form, crown asymmetry, health and Survival were recorded. The species has a higher means of quantitative, qualitative characters and DBH distribution was suitable to plantation in the Hyrcanian forest. To study of different between qualities characters in the species used the ANOVA test. To analysis data, used the Excel and SPSS18 software's. . Result indicated the differences between means of quantity of tree parameter in the four species were significant. Duncan test showed that the two Populus nigra L. and Pinus brutia L. were higher the other species. Overall results showed that the two Populus nigra L. and Pinus brutia L. have a higher quantitative and qualitative characteristic were suitable to plantation in Hyrcanian forest. Authors suggested to plantation and afforestation in the Hyrcanian forest used the two species.

Key words: Quantitative and Qualitative character, Plantations, Afforestation, Hyrcanian forest, Berenjestanak.

INTRODUCTION

Commonly, two terms are used relative to establishing plantations of forest trees. The term reforestation involves planting trees to replace those in areas that have been recently harvested. The other term used is afforestation, which involves planting trees on areas such as brush fields, grasslands, severely burned stands and forest stands where useful trees are not now present. Afforestation relates to a conversion of land from other uses to forest plantations [17]. Plantation forestry at a global or semi-global scale has been the subject of a number of recent reviews [14]. These Forests cover about 12 million ha in Iran [1,2,3,4,5,6, 9, 36,37,38,39,40]. Hyrcanian (Caspian) forest in northern Iran has a richness of biological diversity, with endemic and endangered species, and a diverse range of economic and social conditions [7,9]. In the Caspian region, with a forest surface area of about 1500000 ha, oriental beech (*Fagus orientalis* Lipsky) is an important climax species [8]. About 45% of the Hyrcanian forests are located in mountainous areas, where forest lands are not readily accessible with ground-based logging equipment's [10]. These forests cover 1.8 million hectares of land area and are none commercial forests of Iran. Approximately 60 percent of these forests are used for commercial purposes and the rest of them have been degraded. The Hyrcanian forests are extended at a maximum altitude of 2800 meters from sea level and have an uneven topography and very

steep slopes. These forests are known as one of the most basic resources for wood production contributing an important role in supplying wood to the related industries [10]. Road development in forest has some negative and positive effects on environment [11]. Wood utilization of forest areas is increased that is due to destroy of forests in extensive areas, now days [12]. Due to the process of deforestation and Increasing human population and growing demands for forests, afforestation and the development of forest is and will be of paramount importance [18]. The several study on the plantation and afforestation in the Iran and others country include: The study of evaluation of native tree species for the rehabilitation of deforested areas in a Mexican cloud forest showed that on-farm plantations had good establishment of planted trees (5–10 species planted), and facilitated the recruitment of 9–11 woody species. *Carpinus* and *Liquidambar* appear to be suitable species for reforestation in all these areas. *Podocarpus* grew relatively slowly, although it performed well in two experimental sites. *Juglans* had high survival (76%) under the stressful conditions of the most adverse site, and therefore may be useful for rehabilitation of degraded sites. Differences among species and sites strongly suggest that species success depends on plantation site quality [31]. The study rehabilitation of the native tree species in the forest plantations and denuded hills of Namlau commune in Sonla province, Vietnam showed that a total of 22 regenerated native tree species were found in the plantation of *Acacia auriculiformis* with a density of 860 trees per ha. In this plantation, the best planting density was 1,660 trees per ha. The lowest density was 467 trees per ha for a plantation of *Eucalyptus camaldulensis* with 12 regenerated native tree species. The number of regenerated native tree species and their density abundance in plantations at 300 m away from the natural forest were half of those at a distance of 50 m away [29]. The researcher studied the Land-use history, forest conversion, and soil organic carbon in pine plantations and native forests of south eastern Australia and results showed that Variable effect between locations of this novel land-use change on soil C could be due to differences in potential productivity, conifer species, and plantation age [30]. The researcher studied the afforestation in Khalkhal area and present adaptable species, and results show that Austrian pine & palse, acacia& larch and Arizona cypress are very appropriate in this forest [26]. The evaluation of native broadleaved forest plantations in east of Guilan province (hyrcanian forest) showed that the *Alnus subcordata* with 3.2 percent in 5 cm diameter class and 38.5 percent in 20 cm diameter class had the highest values in survival, while *Fraxinus excelsior* with 31.7 percent in 5 cm diameter class and 19.7 percent in 20 cm. diameter class had the lowest values in survival. Data analysis for stem quality showed that *Fraxinus excelsior* with 31.6 percent forked trees had the lowest value; while *Alnus subcordata* with 18.5 percent forked trees had the highest value in stem quality [25]. The Comparative study of soil properties, quantitative and qualitative characteristics of mixed and pure afforestation of Poplar and Alder in Mazandaran ((hyrcanian forest) showed that he plantation spacing was 4×4m. Results after 7 years showed the survival rate of poplar were greater than alder, in general [24]. Study of afforestation trial for five almond (*Amygdalus communis* L.) genotypes and a wild pistachio (*Pistacia atlantica* Desf.) genotype in Zanjan province (center of Iran) and results showed that planting of two almonds genotypes (3 and 6) on western aspects considering their higher survival rate and growth attributes is recommended. Concerning the height survival rate and growth and the possibility of providing partial irrigation during summer periods, planting on southern aspects could also be recommended [21]. Study of elimination trial on some of important conifers in Asalem forests (hyrcanian forest) and results showed that the *Pseudotsuga menziesii* (prov. California) showed the highest height (10.2 m) and *Pinus nigra* var. *calabrica* the highest diameter (16.1 cm) after 16 years of study period [22]. The researcher Comparative study of Qualitative and quantitative investigation on plantations of lime tree (*Tilia platyphyllos*) and Cappadocian maple (*Acer cappadocicum*) in the northern Iran, Generally, this study indicates that both *Tilia platyphyllos* and *Acer cappadocicum* are suitable species for restoration of degraded areas in the plateau of Chamestan region [23]. Study of Adaptation Analysis of *Elaeagnus angustifolia* L. and *Fraxinus rotundifolia* Mill afforestation and Their Edaphic Effects in Northwest of Tabriz, and results showed that Results indicated that there was not significant difference between the diameter growth, height growth and mean basal area per hectare for *Fraxinus rotundifolia* Mill and *Elaeagnus angustifolia* L [27]. The researcher studied the quantitative and qualitative evaluation of plantations and natural forest at Darabkola, east of Mazandaran (hyrcanian forest) and results showed that the analysis of quantitative characteristics showed that natural forest and plantation of Alder were the most promising followed by Maple and Chestnut leaved Oak. From the qualitative point of view, alder and maple plantations were the most promising stands, while the Cypress plantation showed the worst results [20]. Final results (2008) indicated that: i) *Sequoia sempervirens* (origin of California- Nowshahr), *Cryptomeria japonica* (origin of Japan- Kelardasht) and *Pinus nigra* var. *calabrica* (origin of south France) were the promising species in the lower altitude, ii) *Picea abies* (origin of former Yugoslavia- Kelardasht), *Abies nordmaniana* (origin of Turkey) and *Abies alba* (origin of Bulgaria) were the promising species in the middle altitude and iii) *Pseudotsuga menziensii* (origin of Washington), *Abies alba* (origin of Bulgaria), *Abies nordmaniana* (origin of Turkey) and *Abies bormulleriana* (origin of Turkey) were the promising species in the higher elevation [19]. The researcher studied and suggestion the Appropriate Species for Afforestation in South Hillside of Alborz Mountain by Using GIS, and Several species suggest for afforestation in every ecosystem unit such as *Juniperus polycarpos*, *Amygdalus scoparia*, *Celtis caucasica*, *Elaeagnus angustifolia*, *Berberis crataegina*, *Pinus eldarica*, *Amygdalus lyciodes* and *Morus Alba*. Then, the best species suggests for afforestation in every ecosystem [18]. The aim of this research was

evaluation of Quantitative and qualitative plantations by four species) *Populus nigra* L. *Acer velotinum* Boiss, *Fraxinus excelsior* L, *Pinus brutia* L and suggestion the appropriate species in the Hyrcanian forests.

MATERIALS AND METHODS

Site description

Study areas are located in Berenjestanak lowland forest in the Southern of Ghaemshahr city (36° 23′ 30" N and 52° 54′ 30" E, respectively) (Figure 1). This study was carried out in four tree plantations 22 years of age and cover 42ha and in the surrounding degraded mixed hardwood natural forest. The plantations composed of *Pinus brutia, Populus nigra* L., *Acer velutinum Boiss* and *Fraaxinus excelsior* L. species. These plantations were planted in 1987. The altitude at the plantation site ranges from 180 to 220 m, and the slope varies between 0 and 30% (Table 1). Mean annual precipitation and temperature are 1043.6 mm and 14ºC, respectively. Edaphically, soil consists of semi heavy (Clay Loam) to heavy texture (Clay and Silty Clay) with weak drainage and pH ranges from 5.9 to 7.7 in the studied compartments [46].

Table 1. Site characteristic features and physiographic factors of study plots in the plantations and natural forest at Berenjestanak lowland forest in the north of Iran

Forets type	Elevation (m)	Aspect	Slope (%)	Canopy (%)
Acer velutinum Boiss	210	Western	15	80
Populus nigra L.	194	South western	7	75
Fraaxinus excelsior L.	200	Southern	10	85
Pinus brutia	200	South western	15	80
Natural forest	210	Southern	10	70

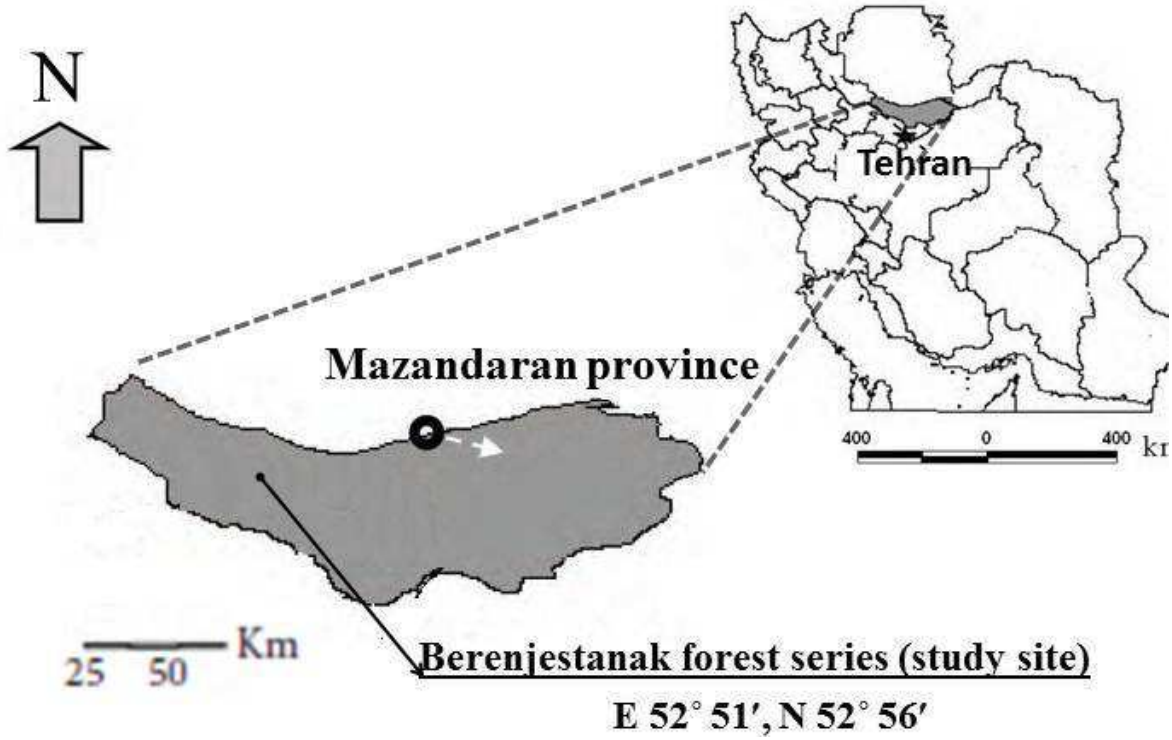

Figure 1. Study site location within the Berenjestanak forest, Mazandaran province, and north of Iran

Field measurements

To this study plantation by species *Populus nigra* L. *Acer velotinum* Boiss, *Fraaxinus excelsior* L, *Pinus brutia* L in the 42 hectare area (planted in the 1990-1991 year). At first, a map of the study areas with scale 1:25000 was provided and then Inventory 66 circle plots 200 m^2 by randomized-systematic in a net of 100 m × 75 m were collected. In each sample plot quantitative and qualitative characters of tree include the kind of species, diameter at breath height (cm), height (m), stem form, crown asymmetry, health and Survival. To determination of suitable of four species used the means of quantitative and qualitative characters and species has a higher the quantitative and a qualitative character was suitable to plantation in the Hyrcanian forest. Study of distribution of tree in the diameter and height classes. The means of different between quantities of tree characters in the four species used the ANOVA test. To analysis data, used the Excel and SPSS18 software's.

Table 2: Quantitative and qualitative characters of tree in this study

qualitative tree characters					
Survival	Health	crown symmetric	stem form	Quality of stem	Classes code
succulent	Health tree	symmetric	Vertical	appropriate	1
Non-succulent	Ill tree	Non- symmetric	Crooked	Non- appropriate	2

RESULTS AND DISCUSSION

Vegetative Enrichment of watersheds is one of the important objectives along with long term policies of the state for natural resources. Therefore, afforestation development needs the participation of people [21]. Depletion of natural forest due to different reasons has made the forest plantation important for extending forest area and wood production [25].

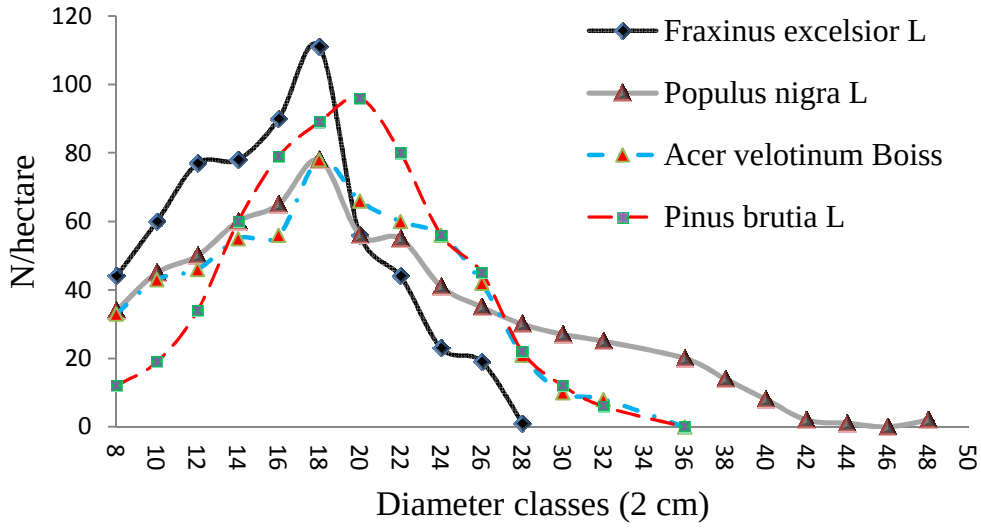

Figure 2: Distribution of tree in the diameter classes (2cm) in the four species

Figure 2 showed that the Populus nigra L. and Pinus brutia L have a higher of the diameter distribution and density (N/hectare).

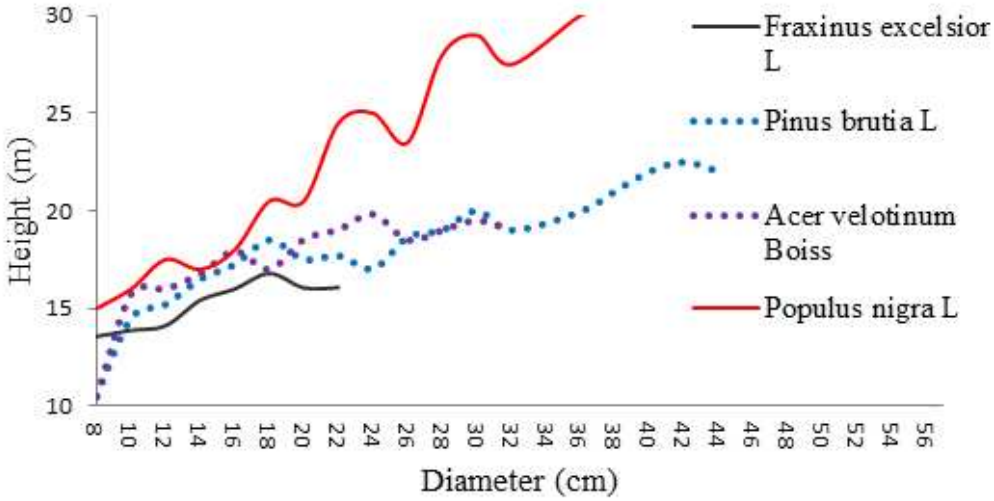

Figure 3: The growth curve (diameter and height)of four species

Results showed that the growth in the *Populus nigra* L. and Pinus *brutia* L have a higher the other species.

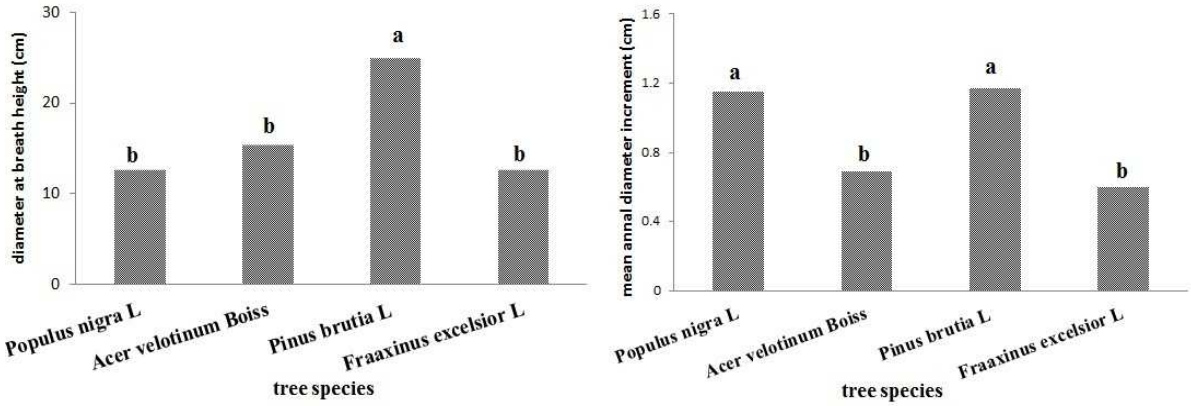

Figure 4. Mean annual diameter at breath height and mean annual diameter increment (cm) in the four species

Results of figure 4 showed that the *Populus nigra* L. and Pinus *brutia* L have a higher of the diameter at breast height (cm) and annual diameter increment (cm), this species have a more increment in compere of other species.

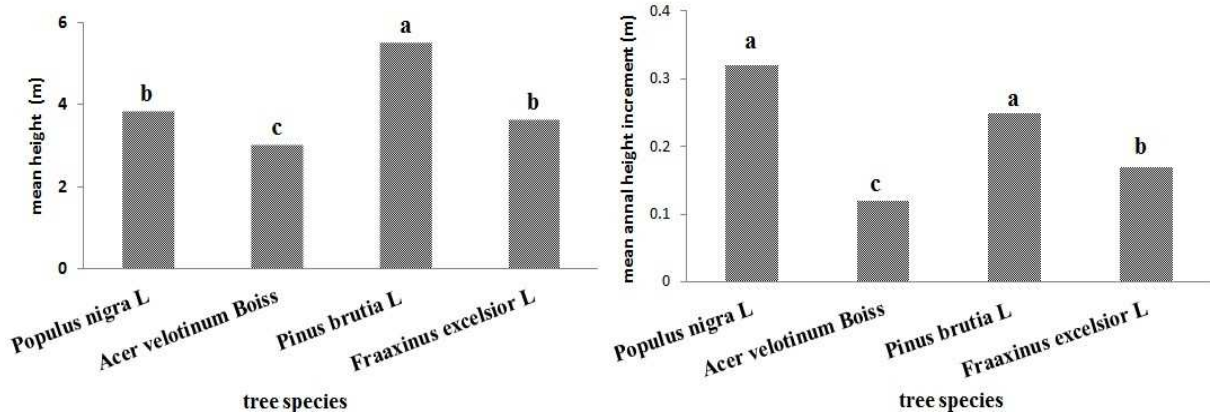

Figure 5. Mean height (m) and mean annual mean increment height (m) in the four species

Results of figure 5 showed that the *Populus nigra* L. and Pinus *brutia* L have a higher of the height (m) and annual height increment (m), this species have a more increment in compere of other species.

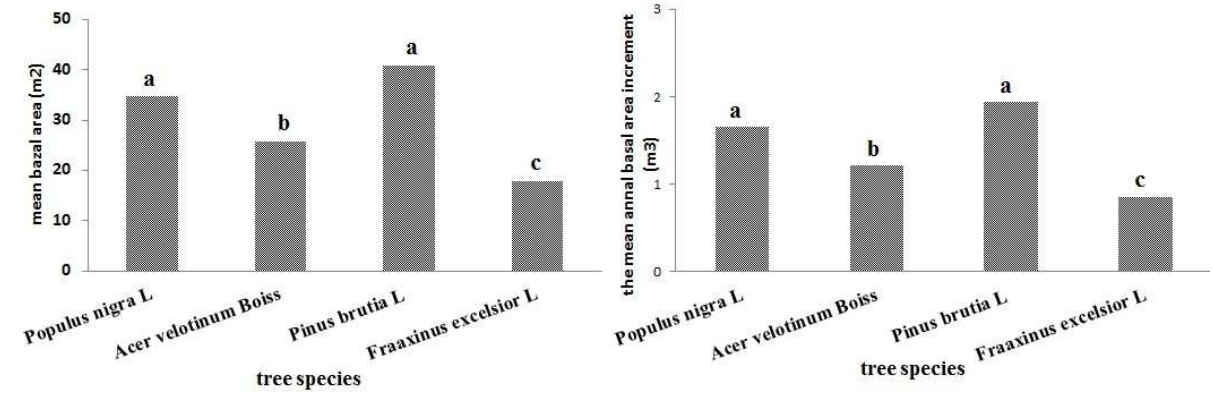

Figure 6. Mean of basal area (m2) and mean annual basal area increment (m2) in the four species

Results of figure 6 showed that the *Populus nigra* L. and Pinus *brutia* L have a higher of the mean basal area (m^2) and mean of annual basal area increment (m^2), this species have a more increment in compere of other species.

Table 3.The results Kolmogorov-Smirnov analysis to detection of normality of data.

Tree parameters	DBH	height	Basal area
Sig.	0.086	0.12	0.099

Table 3 showed that the distribution of data was normal, so that used the parametric methods for analysis of data (ANOVA test).

Table 4.The results of ANOVA analysis to compere the quantitative characters means in the four species.

Tree characters	Diversity index	DF	Mean Square	F	Sig.
DBH	Between Groups	3	2.408	2.819	0.022*
	Within Groups	838	0.854		
Annual DBH increment	Between Groups	3	1.406	1.737	0.000**
	Within Groups	838	0.809		
Height	Between Groups	3	1.997	2.013	0.006**
	Within Groups	838	0.992		
Annual DBH Increment	Between Groups	3	1.043	2.997	0.034*
	Within Groups	838	0.348		
Basal area	Total	3	2.504	2.763	0.021*
	Between Groups	838	0.906		
Annual Basal area Increment	Within Groups	3	1.805	3.023	0.045**
	Total	838	0.597		

* *Different letters indicate significant differences in 5% level, ** Different letters indicate significant differences in 1% level.*

Result table 4 indicated the differences between means of quantity of tree parameter in the four species were significant and Duncan test showed that the two *Populus nigra* L. and Pinus *brutia* L. were higher the other species. This species have a more increment in compere of other species.

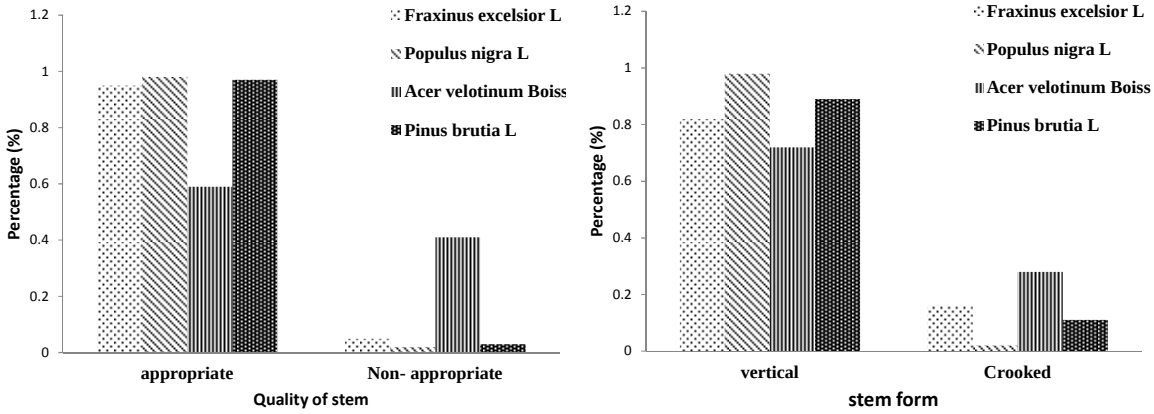

Figure 7. The percentage of quality of stem and stem form code in the four species

Figure 7 showed that the two *Populus nigra* L. and Pinus *brutia* L. were higher stem quality and stem forms. This species have a better qualitative characters and suitable to plantations.

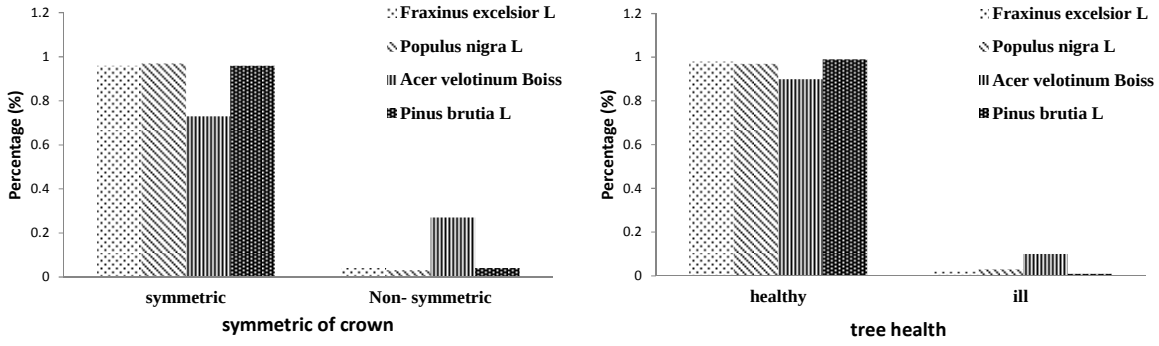

Figure 8. The percentage of symmetric of crown and tree health code in the four species

Figure 8 showed that the two *Populus nigra* L. and Pinus *brutia* L. were more symmetric crown and health. This species have a better qualitative characters and suitable to plantations. Total results showed that the *Acer velotinum* Boiss species have lowest qualitative characters.

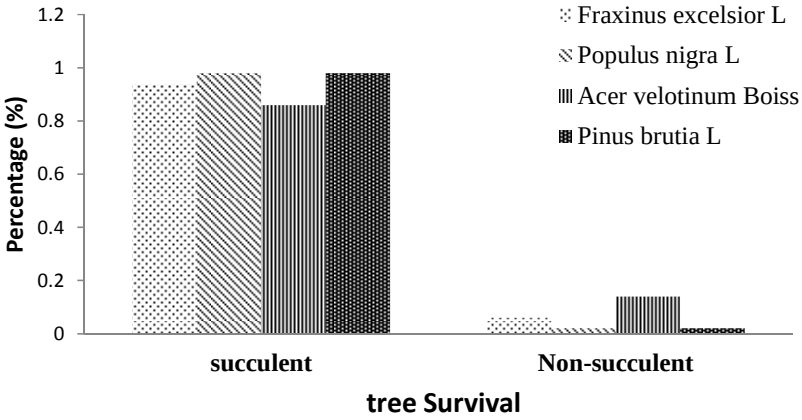

Figure 9. The percentage of tree survival classes code in the four species

Figure 9 showed that the two *Populus nigra* L. and Pinus *brutia* L. was more succulent tree. This species have a better qualitative characters and suitable to plantations.

Restoration of degraded forest areas in the Caspian region with appropriate species is very important [23]. Species can vary a great deal with source and environment under which they have developed. The environment where planting is to be done must be suitable for the species chosen [17].Depletion of natural forest due to different reasons has made the forest plantation important for extending forest area and wood production [25]. In this study plantation by species *Populus nigra* L. *Acer velotinum* Boiss, *Fraaxinus excelsior* L, *Pinus brutia* L was selected. Used the quantitative and qualitative characters criteria. The species has a higher quantitative and qualitative characteristic was suitable to plantation in Hyrcanian forest. The distribution of tree in diameter classes showed that the two *Populus nigra* L. and Pinus *brutia* L have more distribution and density (N/ha). Growth curve showed that the *Populus nigra* L. and Pinus *brutia* L have a higher the growth (diameter and height) and suitable species for plantations (figure 3). The compere of the DBH and DBH increment in the four species showed that the *Populus nigra* L. and Pinus *brutia* L have a higher of the diameter at breast height (cm) and annual diameter increment (cm), this species have a more increment in compere of other species (figure 4). The compere of the mean height (m) and mean of annual height increment (m^2) in four species showed that the *Populus nigra* L. and Pinus *brutia* L have a higher quantity (figure 5). The compere of the mean basal area (m^2) and mean of annual basal area increment (m^2) showed that the *Populus nigra* L. and Pinus *brutia* L have a higher quantity (figure 6). This species have a more increment in compere of other species. Result indicated the differences between means of quantity of tree parameter in the four species were significant (table 4). Duncan test showed that the two *Populus nigra* L. and Pinus *brutia* L. were higher the other species. This species was suitable for plantation and afforestation in the Hyrcanian forest. Qualities characters indicated that the forest and tree health has a higher qualities was suitable to afforestation and plantations. Results showed that the two *Populus nigra* L. and Pinus *brutia* L. were higher stem quality and stem forms. This species have a better qualitative characters and suitable to plantations (figure 7). Results showed that the two *Populus nigra* L. and Pinus *brutia* L. were more symmetric crown, health and survival condition. This species have a better qualitative characters and suitable to plantations (figure 8 and 9). Total results showed that the *Acer velotinum* Boiss species have lowest qualitative characters. Overall results showed that the two *Populus nigra* L. and Pinus *brutia* L. have a higher quantitative and qualitative characteristic were suitable to plantation in Hyrcanian forest. This researcher showed that this species was suitable to plantation in the Hyrcanian forest includes: (Khademi et al, 2004), (Neghad et al, 2007[25]), (Mokhtari et al, 2008[24]), (Hematti et al, 2009 [22]), (Sadati and Mostafanejad, 2009 [23]), (Gholizadeh et al, 2011), (Zare et al, 2011). This researcher rejected our results (Pourmajidian et al, 2009 [27]), (Mohammadnejad Kiasari et al, 2010 [20]). In the base of this results authors suggested to plantation and afforestation in the Hyrcanian forest used the two *Populus nigra* L. and Pinus *brutia* L. species.

DISCUSSION

Restoration of degraded forest areas in the Caspian region with appropriate species is very important, and selected the suitable species is necessary. Overall results showed that the two *Populus nigra* L. and Pinus *brutia* L. have a higher quantitative, qualitative characteristic and growths were suitable for plantation in Hyrcanian forest.

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