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Fertility variation and effective number of parent in Taurus fir (*Abies cilicica* Carr.) populations

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ABSTRACT

The paper was carried out to contribute for silvicultural and genetic-breeding practices of Taurus fir (Abies cilicica Carr.) based on cone production, growth characteristics (height, diameter at breast height, crown diameter and age) and also altitude. The data was collected 90 mother trees sampled phenotypically, from three natural populations selected attitudinally (1500 m >; 1500 m ≤ - 1750 m ≥; 1750 m<) in Seydisehir district in 2012.

Average of number of cones was 6.7 while there were large differences among populations and within population. However, cone production was three times higher in low altitude than that of high altitude. The fertility variation was the highest (1.471) in the low population.

Effective number of parents (17) and relative effective number of parents (68%) was the highest in the high population. It was 41.5 (47.2%) in polled population.

Age, diameter at breast height and crown diameter have positive and significant (≤0.05) effective on cone production, while tree height has no effect (≥0.05) on the production. Besides, there was negative correlation between cone production and altitude (r=-0.350; ≤0.05). Results of the study were discussed for forestry practice and genetic-breeding of the species.

KEYWORDS

Population;
Breeding;
Taurus fir;
Coancestry;
Cone.

INTRODUCTION

Turkish firs are important forest trees both taxa richness and distribution area. Taurus fir (*Abies cilicica* Carr.) is one of these taxa by pure fir forests of 213652 hectares[1] account for 30% of the pure forests of Turkish firs[2]. However, the Taurus fir is present around 10% in the gene conservation forest (69/680 ha) and seed stands (385/3772 ha) of the Turkish firs. Beside, Turkey has no any fir seed orchard yet[3]. In this case, estimation of basic genetic parameters and selection/establishment of seed source is getting importance in the species. Fertility variation and its related to effective number or parent and relative effective number of parent are one of the basic genetic parameters used widely in plant genetics.

Estimation of fertility variation, cheap and short-term studies, is widely used in forestry and other biological sciences, for conservation, selection and management of seed sources[4-9]. It is expected close to zero for genetic-improvement studies, while it is

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acceptable up to 3 for the ideal of natural populations and up to 2 for artificial populations such as seed orchards[9]. Estimation of this parameter, cone, flower, pollen, fruit and seed yield are used[4,7,10,11], although studies have generally focused on flower production[12-19]. However, the issue of fertility variation has not been studied in Turkish firs yet. This emphasizes clearly originality of the study.

The purposes of this study were to estimate fertility variation and effective number of parent based on mature cone production of three natural populations, compare the populations for the cone production and to estimate the correlations between cone production and growth characteristics to make contribution in genetic-breeding studies such as establishment and selection of seed sources, and silvicultural treatments and future studies in the Turkish firs such as establishment of seed orchards.

MATERIALS AND METHODS

Studied populations and data collection

Natural distribution areas of *Abies cilicica* in Seydisehir district at the southern part of Turkey were divided into three altitudinal ranges as low zone (1500 meters ≤), middle zone (1500 m < altitude ≤ 1750 m) and high zone (1750 m < altitude). The zones mean that altitudinal ranges in the present study. Numbers of mature cone production were counted in three natural populations and thirty trees randomly chosen in the each population in September of 2012. Growth characteristics (height, diameter at breast height, crown diameter and age) were also measured in the populations. Geographic properties of the studied populations are given in TABLE 1.

TABLE 1 : Location of studied populations.

Altitudinal ranges	Population code	Latitude (n)	Longitude (e)	Average altitude (m)
1500 >	Low	38°06′	31°53′	1384
1750 ≥ x ≥ 1500	Middle	37°18′	31°50′	1576
>1750	High	37°15′	31°53′	1772

Fertility variation

Fertility was defined as the relative proportion of fertile individuals (i.e., contribution) to the entire population[20]. Cones, flowers, pollen, fruits and seeds have been used to estimate fertility in plants[6,11,21]. The fertility variation (Ψ_c) was estimated based on cone production as[21].

$$\Psi_c = N\sum_{i=1}^{N} c_i^{\,2}$$

where N is the census number, c_i is the fertility for cone production of the individual i.

Effective number of parent

The effective numbers of parent ($N_{p(c)}$) was estimated based on census number (N) and fertility variation of cone production (Ψ_c) for total gametic gene pool as[22].

$$N_{p(c)} = N / \Psi_c$$

The populations were compared for cone production by one-way analysis of variance (ANOVA) by SPSS statistical package[23]. Cone production was also correlated by Pearson's correlation.

RESULTS AND DISCUSSION

Cone production

Averages and ranges of cone for the populations were given in TABLE 2. Amount of cone production varied within population and among populations (TABLE 2). Two individuals in low populations had no cones while it was five individuals in middle and high populations.

Average of cone production of low population (9.7) was about three times higher than that of high population (3.4) as seen in TABLE 2. The differences could be also seen within population (Figure 1).

TABLE 2 : Average and ranges of cone for the populations.

	Populations			
	Low (28)*	Middle (25)	High (25)	Total
Average	9.7	7.0	3.4	6.7
Ranges	0-30	0-40	0-12	0-40

***; Number or cone producer individuals in parentheses.**

Significantly differences ($p<0.05$) among populations for cone production was also found by analysis of variance.

Large differences in fertility among individuals were reported in clonal seed orchards of *Tectona grandis*[24]. The results of the present study were included one year data and a restricted area. Differences in gamete

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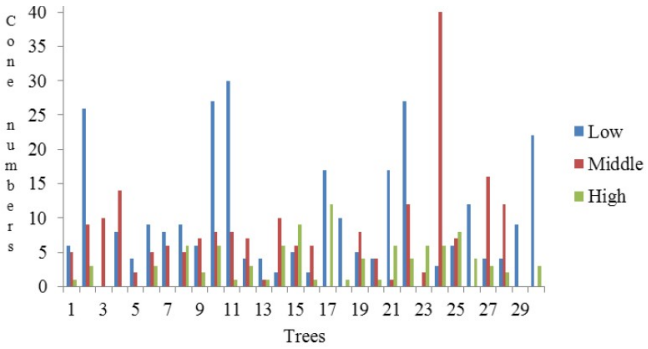

Figure 1 : Individual cone production in the populations.

contribution among clones could be genetic[25], environmental[26], forest management[27], locations and years[28]. Large differences in the production of female and male strobili among clones were reported in two seed orchards of *Pinus brutia*[29] and in a seed orchard of *Pinus brutia* among clones and years[30]. These results showed importance of individual selection instead of mass selection.

Fertility variation and effective number of parent

Fertility variation, effective number of parent and relative effective number of parent were given for the populations in TABLE 3.

Fertility variation of polled populations was 2.12, it was varied between 1.47 in high population and 1.78 in middle population (TABLE 3). Large differences in fertility among trees were reported in natural populations[5,31,32]. It was concluded based on a considerable survey that Ψ of a magnitude up to 3 could be typical in natural populations[31]. Much lower values observed in this investigation suggest that the natural *A.cilicica* populations have considerable less fertility variation than found in many other forest objects. The results were also showed selection importance of local population for seed sources.

Relations among characters

Correlations between cone production and the growth characters were presented in Table 4. According to results of correlation analysis, while there was no relation between cone production and tree height, diameter at breast height, crown diameter and age had positive and significant (≤*0.05*) effective on cone production (TABLE 4).

Positive correlation between number of strobili and size of the graft were reported for *Pinus contorta*[33]. It was found that age, elevation and crown closure were important factors in seed yield in *Pinus brutia*[34]. Age

TABLE 3 : Fertility variation (Ψ_c) and effective number of parent ($N_{p(c)}$) relative effective number of parent ($N_{r(c)}$) for the populations.

	Populations			
	Low (28)*	Middle (25)	High (25)	Total
(Ψ_c)	1.66	1.78	1.47	2.12
($N_{p(c)}$)	16.9	14.05	17.0	41.5
($N_{r(c)}$)=N/($N_{p(c)}$)	60.2	56.2	68.0	47.2

***; census number (*N*) in parentheses.**

TABLE 4 : Relations between cone production and growth characteristics.

	Tree height	Diameter at breast height	Age	Crown diameter
Cone production	-0.066 (p≥0.05)	0.418 (p≤0.05)	0.416 (p≤0.05)	0.273 (p≤0.05)

was also positive effective on cone production in natural populations of *Pinus sylvestris*[35]. Low correlation was reported between strobili production and tree height in *Picea abies*[15] and in *Pinus contorta*[17]. Differences in age and environmental variation, mainly in soil properties, may have influenced the observed variation in fruiting and seed set within each population in the natural forest[32].

These results emphasized that relations could be change among species and populations within species.

CONCLUSIONS

The trees, were not cone producer, should be removed from the populations because of improved seed products especially in seed sources of the species.

Estimated fertility variation was acceptable level. However it could be balanced by genetical or traditional forest tending. Estimated fertility variation was showed that seeds could be harvested genetically in poor seed year.

Effective number of parent and relative effective number of parent could have been higher by silvicultural treatments.

Cone production could be balanced by silvicultural treatments such as pruning, tending based on results of correlation analysis.

Results of the study emphasized importance of altitude in selection and establishment of seed sources.

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