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Fertility variation in two populations of Brutian pine (*Pinus brutia* Ten.)

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ABSTRACT

Fertility variation, measured as "sibling coefficient", based on number of two and three year cones were investigated in a plantation population (PP), and a natural population (NP) of Brutian pine (*Pinus brutia* Ten.) sampled from western part of Turkey. The cone production was also correlated by tree height, tree age, and diameter at breast height. The averages of two and three year cones were 21 and 42 in PP, while they were 13 and 36 in NP population, respectively. Fertility variations were 2.04 and 1.98 for two and three year cones in PP and 1.81 and 1.62 in NP, respectively. Coefficients of variations among trees in cone productions were 1.02 and 0.98 for two and three year cones in PP, and 0.90 and 0.79 in NP. The effective number of parents estimated based on the fertility were 24.6 (49.1 % of census number) for two year cones, and 25.2 (50.3 % of census number) for three year cones in PP. They were 27.6 (55.1 %) and 30.9 (61.8 %) in NP. Diameter at breast height had positive and significant ($p \leq 0.05$) effective on cone production, while effects of tree height and age were not significant ($p \geq 0.05$) on that. Results of the study were discussed for silvicultural practices of the species.

KEYWORDS

Coancestry;
Cone;
Effective number;
Population;
Status number.

INTRODUCTION

Brutian pine or also called as Turkish red pine (*Pinus brutia* Ten.) is classified as one of the economically important tree species for Turkish forestry in the "National Tree Breeding and Seed Production Programme"[1] because of the largest distribution area among forest tree species in Turkey, and occupies about 3.7 million ha of the total 13.8 million ha of high forest area in Turkey[2]. It occurs from sea level up to 1200 meters at this area[1]. The main natural range of the species is low and mid altitude of Mediterranean countries such as Greeks, Cyprus, Turkey, Georgia, Iran, Russia and Ukraine. Of these countries Turkey has the main part of the *P. brutia* stands. The species grows up to 25-30 meters in natural stands. It is the fastest growing (15 m^3/ha/year in the best forest soil) within main conifer species by 50-60 years rotation age in Turkish forestry. It is known that estimation of genetic parameters have important role in quality and quantity of forest products such as short rotation age, fast growing. Fertility variation and its related to effective number of parent and relative effective number of parent are one of the basic genetic parameters used widely in plant genetics.

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Fertility variation, cheap and short-term studies, is widely used in forestry and other biological sciences, for conservation, selection and management of seed sources[3-6], estimated by cone, flower, pollen, fruit and seed yield[7,8]. However, while there were many studies on Brutian pine, studies on fertility variation is very limited. The purpose of this study is to evaluate fertility variation and effective number of parent in a plantation population and in a natural population of the species and to compare, and to provide genetic information to guide the "National Tree Breeding and Seed Production Programme for Turkey".

MATERIALS AND METHODS

The numbers of two (Con_2) and three (Con_3) years cones (Figure 1) were assessed from 50 trees chosen phenotypically in a plantation population (PP) and a natural population (NP) at spring of 2013.

Figure 1 : Two and three years cones.

Height (H), tree age (A), and diameter at breast height (DBH) were also measured at the sampled trees. The PP at Denizli district is located at latitude 69°29′ N, longitude 41°07′ E, and average elevation 1150 m, while NP is located at latitude 68°53′ N, longitude 41°14′ E, and average elevation 950 m. Averages of tree age were 40 in PP and 75 in NP.

Fertility variation

Fertility was defined as the relative proportion of fertile individuals (i.e., contribution) to the entire population[9]. The fertility variation (Ψ_c) was estimated based on cone production as[10]:

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

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[11]:

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

The cone production was also correlated by tree height, tree age, and diameter at breast height by Pearson's correlation.

RESULTS AND DISCUSSION

Cone production

Averages of cone production varied between years of cones within population and among populations (TABLE 1).

TABLE 1 : Average, coefficient of variation (*CV*), and range in cone production in the populations.

	PP		NP	
	Con_2	Con_3	Con_2	Con_3
Average	21	42	13	36
CV	1.02	0.98	0.90	0.79
Range	4-113	3-254	2-58	5-120

For instance there were two times differences in PP (21 & 42) and about three times differences in NP (13 & 36) between averages of cone years. The differences could be also seen among trees within population (Figure 2).

Large differences in the production of reproductive characteristics were reported in seed orchards, plantations and natural populations of many forest tree species[12,13]. It is known that individual differences for amount of reproductive characteristics could be genetic, environmental or years[14,15].

These results showed importance of individual selection instead of mass selection. The differences could be also balanced mix seeds, genetic or traditional forest tending such as removing of unproductive trees.

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 2.

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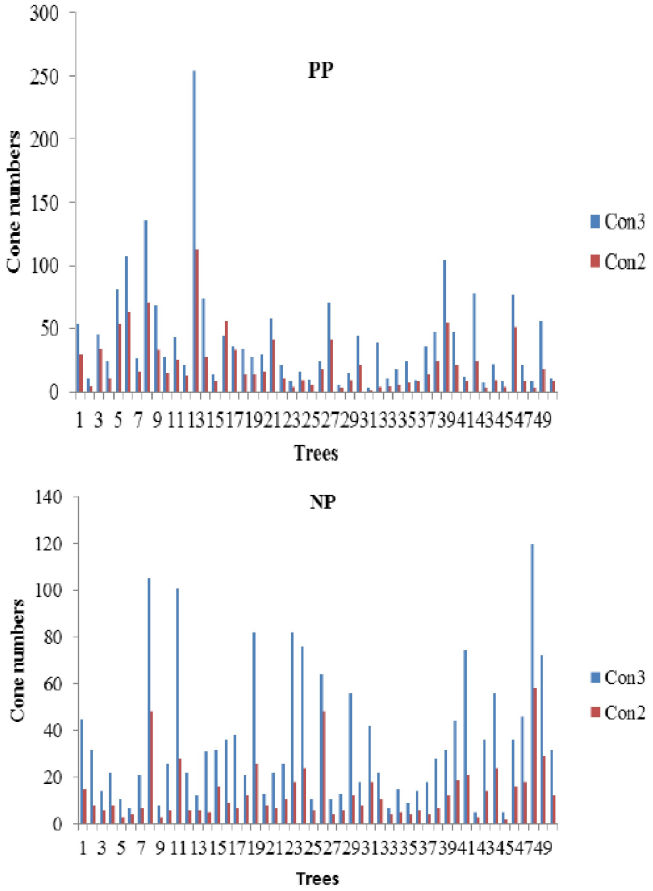

Figure 2 : Individual cone production in PP and in NP.

TABLE 2 : Fertility variation for two (ψ_{CON2}) and three (ψ_{CON3}) years cones, and effective number of parent for two ($N_{p(CON2)}$) and three ($N_{p(CON3)}$) years cones, and relative effective number of parent for two ($N_{r(CON2)}$) and three ($N_{r(CON3)}$) years cones in the populations.

	ψ_{CON2}	ψ_{CON3}	$N_{p(CON2)}$	$N_{p(CON3)}$	$N_{r(CON2)*}$	$N_{r(CON3)}$
PP	2.04	1.98	24.6	25.2	49.1	50.3
NP	1.81	1.62	27.6	30.9	55.1	61.8

***; ($N_{r(c)}$)=N/($N_{p(c)}$)**

Fertility variation was higher in PP than NP for two cone years. It was the highest in PP for two year cones (2.04), while it was lowest in NP for three year cones (1.62) as shown in TABLE 3. It was expected close to 1, while it was acceptable based on a considerable survey that Ψ of a magnitude up to 3 could be typical in natural populations[16]. The effective number of parents were 24.6 (49.1 % of census number) for two year cones, and 25.2 (50.3 % of census number) for three year cones in PP. They were 27.6 (55.1 %) and 30.9 (61.8 %) in NP. The results showed importance of local population for seed sources and year of seed yield.

Large differences in fertility among trees were reported in natural populations[16,17].

TABLE 3 : Relations between cone production and growth characteristics.

		H	DBH	A	Con_3
PP	Con_2	0.202^{NS*}	0.541 *(p≤0.05)*	0.201^{NS}	0.934 *(p≤0.05)*
	Con_3	0.230^{NS}	0.651 *(p≤0.05)*	0.200^{NS}	-
NP	Con_2	0.047^{NS}	0.548 *(p≤0.05)*	0.072^{NS}	0.887 *(p≤0.05)*
	Con_3	0.041^{NS}	0.560 *(p≤0.05)*	0.162^{NS}	-

NS; correlation was not significant.

Relations among characters

Diameter at breast height had positive and significant ($p \leq 0.05$) effective on cone production, while effects of tree height and age were not significant ($p \geq 0.05$) on that (TABLE 3). There were also positive and significant ($p \leq 0.05$) correlation between years in cone production.

The correlations changed for the species, populations and characters. Positive correlation between number of strobili and size of the graft were reported for *Pinus contorta*[18], while low correlations were reported between strobili production and tree height in *Picea abies*[19] and in *Pinus contorta*[20]. It was reported that age, elevation and crown closure were important factors in seed yield in *Pinus brutia*[21]. These results emphasized local forest tending practice such as pruning to harvest higher cone/seed productions.

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