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FERTILITY VARIATION IN TWO POPULATIONS OF TAURUS CEDAR (*CEDRUS LIBANI* RICH.)

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Abstract

Fertility variation, measured as "half-sib family coefficient", based on number of one, two and three years cones were investigated in plantation population (PP), and a natural population (NP) of Taurus Cedar (*Cedrus libani* Rich.) sampled from southern part of Turkey. Fertility variation was higher in PP than NP for one, two and three years. It was the highest in PP for one year cones (2.34), while it was lowest in NP for three years cones (1.73) as shown in Table 2. The effective number of parents were 21.8 (38.4% of census number) for one year cones, 25.7 (47.9% of census number) for two years cones and 29.8 (52.6% of census number) for three cones in PP. On the other hand the effective number of parents were 28.3 (43.4% of census number) for one year cones, 32.8 (51.6% of census number) for two years cones and 36.4 (58.9% of census number) for three years cones in NP. Diameter at breast height and tree crown area had positive and significant ($p<0.05$) effective on cone production, while effects of tree height and tree age were not significant (*NS*) on that (Table 3). There were also positive and significant ($p<0.05$) correlation between years in cone production.

Key words: Taurus cedar, Cone production, Fertility, Population, Seed, Parent.

Introduction

Cedrus libani Rich. (Cedar of Taurus cedar) is a significant and salient tree species in historical, cultural, aesthetic, scientific, and economic terms. Its present distribution is restricted mainly to the Taurus Mountains in southern Turkey, where the most productive populations are found, especially in the Elmali region near Antalya. Historical records indicate that extensive and magnificent forests of Taurus cedar also grew in Syria and Lebanon, where only small populations remain today (Boydak, 2003; Khuri *et al*., 2000; Kurt *et al*., 2008). Heavy human impact in the past likely caused genetic erosion, decrease in genetic variability, and eventually degradation of the gene pool of the species (Rogers & Kaya, 2006; Fady *et al*., 2008; Kurt *et al*., 2008). The elevational distribution of the species ranges between 800 and 2100m in the Taurus Mountains. Marginal small populations can also be found at lower (500m) (e.g., Babadag-Fethiye) and higher (2400 m) (e.g., Bolkar Mountains) elevations in certain localities (Kantarci, 1990; Boydak, 1996; Kurt *et al*., 2008). In its distribution area, individuals and populations of *C. libani* exhibit distinct phenotypic characteristics (Boydak, 1996; Kurt *et al*., 2008). 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 are one of the basic genetic parameters used widely in plant genetics. Fertility variation, cheap and short-term studies is widely used in forestry and other biological sciences, for conservation, selection and management of seed sources (Dutkuner *et al*., 2014), estimated by cone, flower, pollen, fruit and seed yield (Kang and Lindgren, 1999; Keskin, 1999; Bilir, 2011). The objectives 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 "National Taurus Cedar Breeding and Seed Production Programme for Turkey".

Materials and Methods

The numbers of one (Con_1),two (Con_2) and three (Con_3) years cones (Fig. 1) were assessed from 50 trees chosen phenotypically in plantation population (PP) and a natural population (NP) at spring of 2015.

Height (H), tree age (A), tree crown area (CA) and diameter at breast height (DBH) were also measured at the sampled trees. The PP at Mut-Söğütözü district is located at latitude 36º 46′ 30″ N, longitude 33º32′20″ E, and mean elevation 1650m, while NP is located at latitude 37º 30′ 32″ N, longitude 34º57′38″ E, and mean elevation 1320m in Pozantı district. Averages of tree age were 55 in PP and 78 in NP.

Fertility variation: Fertility was defined as the relative proportion of fertile individuals (i.e., contribution) to the entire population (Bila, 2000; Kang, 2001; Kang *et al*., 2003; Dutkuner *et al*., 2014). The fertility variation (ψ_c) was estimated based on cone production as (Zobel & Talbert, 1984; Almqvist *et al*., 2001; Dutkuner *et al*., 2014):

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

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 (Varghese *et al*., 2006):

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

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

Fig. 1. One, two and three years cones.

Results and Discussions

Cone production: Mean of cone production varied between years of cones within population and among populations (Table 1).

For instance there were two times differences in PP (36 & 63) and about four times differences in NP (10 & 42) between averages of cone years. The differences could be also seen among within population (Fig. 2). 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. According to the values in Table 2, fertility variation was found higher in PP than NP for one, two and three years.

Relations among characters: Diameter at breast height and tree crown area had positive and significant ($p<0.05$) effective on cone production, while effects of tree height and tree age were not significant (*NS*) on that (Table 3).

Table 1. Mean, coefficient of variation (*CV*), and range in cone production in the populations.

	PP			NP		
	Con_1	Con_2	Con_3	Con_1	Con_2	Con_3
Mean	36	48	63	10	15	42
CV	0.31	0.23	0.18	0.57	0.39	0.14
Range	4-118	3-265	2-123	4-141	3-286	5-132

Table 2. Fertility variation for one (Ψ_{con1}), two (Ψ_{con2}) and three (Ψ_{con3}) years cones, and effective number of parent for one ($N_{p(CON1)}$), two ($N_{p(CON2)}$) and three ($N_{p(CON3)}$) years cones, and relative effective number of parent for one ($N_{r(CON1)}$), two ($N_{r(CON2)}$) and three ($N_{r(CON3)}$) years cones in populations.

	Ψ_{con1}	Ψ_{con2}	Ψ_{con3}	$N_{p(CON1)}$	$N_{p(CON2)}$	$N_{p(CON3)}$	$N_{r(CON1)*}$	$N_{r(CON2)*}$	$N_{r(CON3)*}$
PP	2.34	2.12	1.96	21.8	25.7	29.8	38.4	47.9	52.6
NP	1.93	1.82	1.73	28.3	32.8	36.4	43.4	51.6	58.9

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

Table 3. Relations between cone production and growth characteristics.

Population type	Cones of years	H	DBH	CA	A	Con_3
PP	Con_1	0.208^{NS}	0.945*	0.938*	0.342^{NS}	0.956*
	Con_2	0.310^{NS}	0.951*	0.944*	0.336^{NS}	0.963*
	Con_3	0.290^{NS}	0.923*	0.957*	0.284^{NS}	0.961*
NP	Con_1	0.053^{NS}	0.932*	0.928*	0.085^{NS}	0.883*
	Con_2	0.061^{NS}	0.917*	0.937*	0.134^{NS}	0.889*
	Con_3	0.049^{NS}	0.924*	0.953*	0.147^{NS}	0.915*

NS: Correlation was not significant,*: 95% significance level

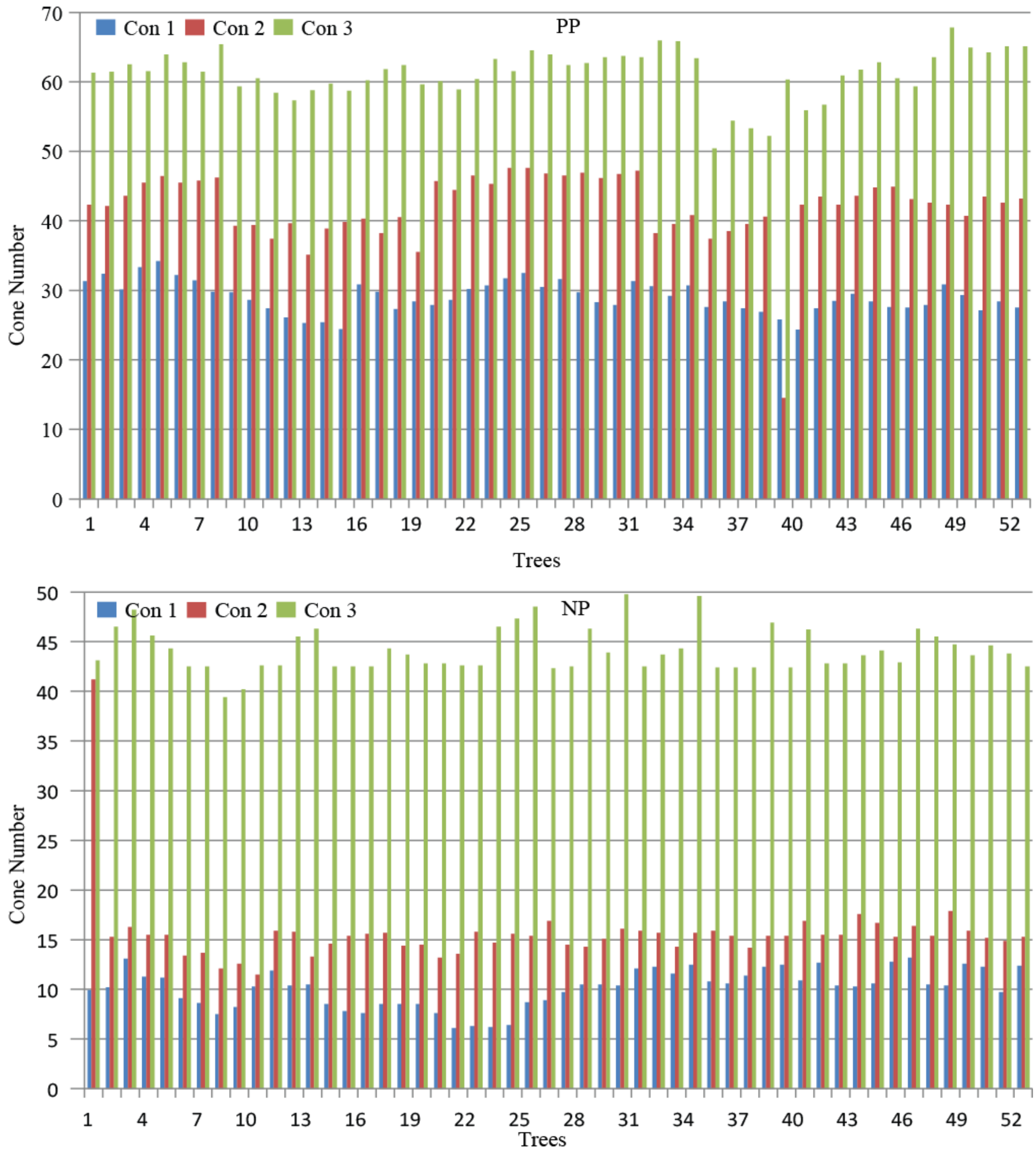

Fig. 2. Individual cone production in PP and NP.

Discussion

There were two times differences in PP (36 & 63) and about four times differences in NP (10 & 42) between averages of cone years (Table 1 and Fig. 2). Large differences in the production of reproductive characteristics were reported in seed orchards, palntations of many forest tree species (Kang *et al*., 2004; Dutkuner *et al*., 2014). It is known that individual differences for amount of reproductive characteristics could be genetic, environmental or years (Zobel & Talbert, 1984; Bilir & Temirağa, 2012).

It was the highest in PP for one year cones (2.34), while it was lowest in NP for three years cones (1.73) as shown in Table 2. 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 (Kang *et al*., 2003). The effective number of parents were 21.8 (38.4% of census number) for one year cones, 25.7 (47.9% of census number) for two years cones and 29.8 (52.6% of census number) for three cones in PP. On the other hand the effective number of parents were 28.3 (43.4% of census number) for one year cones, 32.8 (51.6% of census number) for two years cones and 36.4

(58.9% of census number) for three years cones in NP. The results showed that importance of local population for seed sources and year of seed yield. However, the similar results were obtained from a original research on Turkish Red Pine (*Pinus brutia* Ten.) from its PP and NP (Dutkuner *et al*., 2014). Furthermore, large differences in fertility among trees were reported in natural populations (Kang *et al*., 2003).

There were also positive and significant ($p<0.05$) correlation between years in cone production (Table 3). 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* (Fries, 1994), while low correlations were reported between strobili production and tree height in *Picea abies* and *Pinus contorta* (Almqvist *et al*., 2001; Hannerz *et al*., 2001). Furthermore positive correlations between diameter at breast height, tree crown area and cone production were determined of *Pinus brutia* Ten., in PP and NP (Dutkuner *et al*., 2014). Additionally it was reported that age, elevation and crown closure were important factors in seed yield in *Pinus brutia* Ten (Eler, 1990). These results emphasized local forest tending practice such as pruning and thinning to harvest higher cone and seed productions.

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