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Interaction between cone production and growth traits and its effect on fertility variation in Turkish Aleppo pine (*pinus halepensis mill.*) populations

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ABSTRACT

Cone production and growth characteristics (height, diameter at breast height, and crown diameter) were related, and also some genetics parameters were estimated to contribute for silvicultural and genetic-breeding practices of Aleppo Pine (*Pinus halepensis Mill.*) in this study. The data was collected 50 mother trees sampled randomly, from each three plantation areas/populations in Osmaniye district at southern part of Turkey in April-May of 2013.

Average of number of cones per tree was 98, while there were large differences among populations ($p \leq 0.05$) and within population. However, cone production was 50% higher in lowest population than that of highest population.

The fertility variations and coancestry were 1.49 and 0.005, respectively in polled populations. Effective number of parents and relative effective number of parents (67.2%, 69.7%, and 74.6%) were similar in the populations.

Age, diameter at breast height and crown diameter have positive and significant ($p \leq 0.05$) effect on cone production. Results of the study were discussed for forestry practice and genetic-breeding of the species.

KEYWORDS

Pinus halepensis;
Reproductive;
Sibling coefficient;
Status number.

INTRODUCTION

Aleppo Pine (*Pinus halepensis Mill.*) has lowest distribution by about 3000 ha in five natural Turkish pines. It occupies 3.5 million ha in Mediterranean countries[1]. Aleppo Pine grows at poor soil such as sandy area. It is very resistance to aridity. The species is used widely because of these advantages in plantation forestry. Estimation of interaction between reproductive and growth characters, and fertility variation have important roles in economical and biological success of plantation forestry. However, while many studies were conducted on the interaction and fertility variation in different forest tree species[2-8], genetical studies included fertility data are very limited in Turkish Aleppo Pine.

This study was conducted to examine the correlation between reproductive and growth characters in Turkish Aleppo Pine populations and to estimate fertility and related genetic parameters.

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MATERIAL AND METHODS

The study was carried out in three plantation populations of *P. halepensis* TABLE 1.

Number of mature cones (Con) and growth (Three height, H; Diameter at breast height, DBH; Crown diameter, CD) data were collected on fifty trees randomly chosen randomly in each three populations in April-May of 2013.

TABLE 1: Location of studied populations

Population code	Latitude (N)	Longitude (E)	Altitude (m)	Aspect
P1	36°20′	36°08′	286	West
P2	37°06′	36°09′	306	East
P3	37°17′	36°10′	352	South

Fertility variation was also estimated based on the number of cones (Ψ_c) as[9]:

$$\Psi_c = N\sum_{i=1}^{N} con_i^{\,2} \quad (1)$$

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

The effective numbers of parent (N_p) was estimated based on census number (N) and fertility variation (Ψ_c) as[10]:

$$N_p = N/\Psi_c \quad (2)$$

Group coancestry (Θ) is the probability that two genes chosen at random from a gene pool are identical by descent[11]. Group coancestry was estimated considering fertility variation in cone production ($\Theta_{\psi c}$) as[9]:

$$\Theta_{\psi c} = 0.5\sum_{i=1}^{N} c_i^{\,2} \quad (3)$$

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

The following linear ANOVA model was used for comparison of cone production in the populations:

$$Y_{ij} = \mu + P_i + e_{ij}$$

where Y_{ij} is the observation from the j^{th} individual of the i^{th} population, μ is overall mean, P_i is the random effect of the i^{th} population, and e_{ij} is random error.

Correlations among cone production and growth characters were also calculated by Pearson’s correlation using SPSS statistical package program.

RESULTS AND DISCUSSION

Cone production

There were large differences for cone production among populations and within population TABLE 2. Average of number of cone production was 97.9, while there was 50% difference for cone production between lowest (86.3) and highest (120.8) population TABLE 2. Also, the most abundant five trees (10% of total sampled individuals) in P1, P2 and P3 populations produced 29%, 24%, and 24% of total cone production, respectively.

The differences were also well accordance with results of analysis of variance TABLE 3.

Statistically significant differences (*pd”0.05*) were found among populations for cone production based on results of analysis of variance TABLE 3. The differences could be genetic[12]. Large differences in strobili productions among clones were found in seed orchards[5], and also among years[13]. Large differences in fertility among trees were reported in natural populations[14], in plantations[15]. The differences among individuals for reproductive characters were also reported in natural or planta-

TABLE 2: Averages, standard deviation and ranges of cone production in the populations

	Populations			
	P1	P2	P3	Total
Average	86.3	120.8	86.6	97.9
Standard deviation	51.0	80.6	67.2	68.8
Range	10-400	12-335	10-250	10-400

TABLE 3: Results analysis of variance for cone productions

Source of variaton	Sum of squares	Degrees of freedom	Mean of squares	F value	*P*
Between groups	39426.013	2	19713.007	4.346	.015
Within group	666779.860	147	4535.917		
Total	706205.873	149			

tion populations of many forest tree species[4,8,16,17,18,19,20].

Fertility variation, effective number of parent and coancestry

Fertility variations were similar in the populations. It was 1.49 for polled populations. Coancestry was estimated as 0.005. Effective number of parent was 100.6 (67.1% of census number) TABLE 4.

TABLE 4 : Fertility variation (Ψ_c), coancestry ($\Theta_{\psi c}$), effective number of parents (N_p) and relative effective number of parent (N_r) in the populations

	Populations			
	P1	**P2**	**P3**	**Total**
Ψ_c	1.59	1.44	1.34	1.49
$\Theta_{\psi c}$	0.016	0.014	0.013	0.005
N_p	31.4	34.8	37.3	100.6
N_{r*}	62.7	69.7	74.6	67.1

The fertility variation was lower than 3 TABLE 4. However, it is expected to close to 1 for ideal population. Thus, Ψ=1 means that there is an equal contribution of individual to gamete gene pool in the population. When an equal amount of seed is collected from each tree, the female fertility is constant and thus $CV = 0$ (i.e., equal contribution among seed parents). Fertility variation (Ψ) could be ere related by coefficients of variation (CV) in reproductive characters as [10]: $\psi = CV^2 + 1$. It was suggested that the sibling coefficient of stands as a heuristic rule of thumb could be set to three ($\Psi = 3$) and that of seed orchards could be set to two ($\Psi = 2$)[5].

Relations among characters

Averages of studied growth characters were given in TABLE 5.

There were statistically significant differences (*pd"0.05*) were found among populations for the tree height and crown diameter by results of analysis of variance.

TABLE 5 : Averages of the growth characters

	Populations			
	P1	**P2**	**P3**	**Total**
H (m)	12.8	15.0	13.9	13.9
DBH (cm)	25.7	25.5	27.6	26.3
CD (cm)	458.3	435.4	630.3	508.0

TABLE 6 : Relations between cone production and growth characteristics

	H	DBH	CD
Con	0.233 (*p?0.05*)	0.355 (*p?0.05*)	0.408 (*p?0.05*)

Statistically significant and positive correlations were found between cone production and the growth characters TABLE 6.

Correlations changed in populations of forest tree species. The positive correlations among growth and reproductive characters were reported in *Pinus sylvestris*[21] and in *Picea abies*[22], while negative correlations were reported in *Pinus sylvestris*[3] and in *Pinus taeda*[23]. Estimation of interaction between reproductive and growth characters had play important roles in management and establishment of forest area (i.e., spacing, pruning).

CONCLUSION

In the present study cone and growth data were collected from only one year. Therefore, it is needed to collect more data on fertility variation to draw accurate conclusion. However, results of the study could be used in selection of mother tree or population for establishment of seed production areas. Higher fertility variation could be balanced by forest tending.

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