

Interaction between cone production and growth traits in taurus cedar (*Cedrus libani* A. Rich.) populations

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ABSTRACT

Relation between cone production and growth characteristics (height, diameter at breast height, and crown diameter), and also fertility variation and effective number of parents were estimated in three natural populations of Taurus cedar (*Cedrus libani* A. Rich.) in this study.

Average of number of cones per tree was 41, while there were large differences among populations ($P < 0.05$) and within population. Averages of number of cones were 19, 39 and 63 in the populations.

The fertility variation was 1.85 in pooled populations. Relative effective number of parents were 61.8%, 70.8%, and 71.5% in the populations sampled the same number of individual.

Three height and diameter at breast height have positive and significant ($P < 0.05$) effective on cone production according to results of correlation analysis.

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KEYWORDS

Breeding;
Cedar;
Genetic;
Growth;
Population;
Reproduction.

INTRODUCTION

Taurus cedar (*Cedrus libani* A. Rich.), is classified as one of the most economically important species for Turkish forestry and the "National Tree Breeding and Seed Production Programme"^[1] because of the largest natural distribution mainly on the Taurus Mountains in southern Turkey (Figure 1)^[2]. It is known that estimation of interaction between reproductive and growth characters, and fertility variation have important roles in economical and biological success of plantation forestry and breeding programme.

The purposes of this study are to estimate the fertility variation and effective number of parent, and to examine the interactions between cone production and growth characters in a natural population of Taurus cedar to provide genetic information to guide the breeding

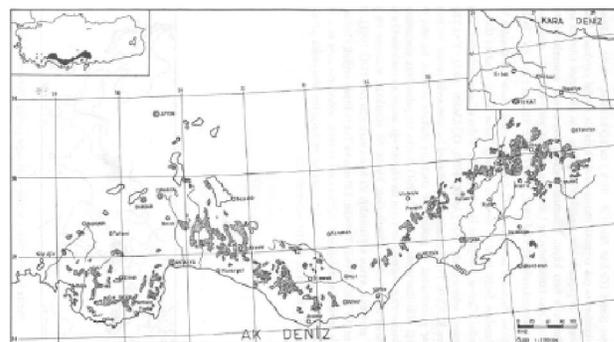


Figure 1 : Natural distribution of the species in Turkey
programme and forestry practices of the species.

MATERIAL AND METHODS

Studied populations and data collection

The cone and growth data was collected 30 mother

TABLE 1 : Location of studied populations

Population	Latitude (N)	Longitude (E)	Altitude (m)
Egirdir (P1)	37°50'	30°50'	1528
Barla (P2)	38°05'	30°45'	1622
Senirkent (P3)	38°10'	38°30'	1494

trees sampled randomly, from each three natural populations (Figure 2) in end of 2015. Geographic properties of the studied populations are given in TABLE 1.

Number of mature cones (Con, Figure 3), and tree height (H); diameter at breast height, (DBH) and crown diameter (CD) data were collected on the mother trees.

**Figure 2 : Views from the populations****Figure 3 : Mature cones of the species**

Fertility variation and effective number of parent

Fertility was defined as the relative proportion of fertile individuals (i.e., contribution) to the entire population^[3]. Fertility variation (Ψ) was estimated based on the cone number as^[4]:

$$\Psi = N \sum_{i=1}^N \text{Con}_i^2$$

Where N is the census number, Con_i is the fertility for cone production of i^{th} tree.

The effective numbers of parent (N_p) was estimated based on census number (N) and fertility variation (Ψ) as^[5]:

$$N_p = N / \Psi$$

The following linear ANOVA model was used for comparison of the populations for number of mature cone numbers and growth characteristics:

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

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

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

RESULTS AND DISCUSSION

Cone production

The averages, range and coefficient of variation for the characters were presented for the populations in TABLE 2. There were large differences among populations and within population for cone production and growth characters (TABLE 2). Average of number of cones per tree was 41, while there were large differences among populations ($p \leq 0.05$) and within population. Averages of number of cones were 19, 39 and 63 in the populations. The most abundant six individual trees (20% of total sampled trees) produced 39%, 44%, 39% of total cone production in the populations. Statistically significant ($p < 0.05$) difference was found for cone production and tree height based of result of analysis of variance (TABLE 3). The results emphasized importance of selection to produce higher cone in seed collection areas. Large reproductive differences among populations and within population were reported in forest tree species^[6-9]. The differences could be genetic^[10] or environmental^[11].

Fertility variation and effective number of parent

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TABLE 2 : Averages, ranges and coefficient of variation (CV%) of the characters in the populations

Characters	Populations	Average	Minimum	Maksimum	CV%
Con	P1	39.1	1.0	85.0	65.3
	P2	62.9	10.0	250.0	80
	P3	19.4	6.0	67.0	64.2
	General	40.5	1.0	250.0	92.8
H (m)	P1	14.5	10.0	24.0	22.1
	P2	16.5	10.5	26.0	24.8
	P3	13.4	9.5	18.5	15.7
	General	14.8	9.5	26.0	23.6
DBH (cm)	P1	31.1	18.0	56.0	29.3
	P2	28.4	16.0	38.0	19.4
	P3	27.3	16.0	68.0	44.0
	General	29.0	16.0	68.0	32.1
CD (cm)	P1	668.0	370.0	960.0	25.5
	P2	592.7	400.0	950.0	25.0
	P3	625.0	340.0	1060.0	30.0
	General	628.6	340.0	1060.0	27.1

TABLE 3 : Results analysis of variance for cone productions

Characters	Source of variaton	Sum of squares	Degrees of freedom	Mean of squares	F value	P
Con	Between groups	28554.867	2	14277.433	12.829	0.000
	Within group	96821.533	87	1112.891		
	Total	125376.400	89			
H	Between groups	147.117	2	73.558	7.006	0.002
	Within group	913.483	87	10.500		
	Total	1060.600	89			
DBH	Between groups	230.489	2	115.244	1.347	0.265
	Within group	7445.333	87	85.579		
	Total	7675.822	89			
CD	Between groups	85235.556	2	42617.778	1.476	0.234
	Within group	2512496.667	87	28879.272		
	Total	2597732.222	89			

and relative effective number of parent were given for the populations in TABLE 4. Fertility variation was 1.85 for polled populations, while it was 1.41, 1.62 and 1.40 in the populations (TABLE 4). Large differences in

TABLE 4 : Fertility variation (Ψ), effective number of parent (N_p) and relative effective number of parent (N_r) in the populations

	Populations			
	P1	P2	P3	Total
Ψ	1.41	1.62	1.40	1.85
N_p	21.2	18.5	21.4	48.6
$N_r (=N/N_p)$	70.8	61.8	71.5	54.0

fertility among trees were also reported in natural populations of different forest tree species^[12,13]. Sibling coefficient of natural stands is acceptable up to 3 for ideal populations^[14] (TABLE 4). The results showed the studied populations were ideal populations. However, data on reproductive characters were collected from only one year. Therefore, it is needed to collect more data on fertility variation to draw accurate conclusion.

Relations among characters

Statistically significant and positive correlations were found between cone production and tree height (H) and

TABLE 5 : Relations between cone production and growth characteristics

	Con	H	DBH	CD
Con	-			
H	0.226	-		
DBH	0.219	0.481	-	
CD	NS	0.300	0.792	-

diameter at breast height (DBH) (TABLE 5).

Positive correlations between number of strobili an tree size were reported in different forest tree species^[7,15,16], while negative genetic correlations between flowering and growth were reported in a natural forests^[17]. These results could play important role in forestry practices.

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