

## Interaction of cone production and growth characters in Brutian pine (*Pinus brutia* Ten.) populations

Tahir Yangin<sup>1</sup>, Nebi Bilir<sup>2\*</sup>

<sup>1</sup>Directorate of Forestry, Aydin, TR-09020, (TURKEY)

<sup>2</sup>Forestry Faculty, Suleyman Demirel University, Isparta, TR-32260, (TURKEY)

E-mail : nebibilir@sdu.edu.tr; nebilir@hotmail.com

### ABSTRACT

The study was carried out to contribute for silvicultural and genetic-breeding practices of the species based on two and three year age cone productions and growth characteristics (tree height, diameter at breast height, tree age) collected from fifty trees selected randomly from each three natural populations in beginning of 2013.

Averages of two and three years cones were 18.1 and 43.6, respectively while there were large differences among populations and within population based on analysis of variance ( $p \leq 0.05$ ).

The relations were changed for the populations and characteristics, while diameter at breast height had positive and significant ( $p \leq 0.05$ ) effective on cone production in polled populations. Results of the study were discussed for forestry practice and genetic-breeding of the species.

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### KEYWORDS

Breeding;  
Growth;  
Genetics;  
Population;  
Relation;  
Reproductive.

### INTRODUCTION

Brutian pine or also called as Turkish red pine (*Pinus brutia* Ten.) has the largest natural distribution by 3.7 million ha. in Turkish forestry. The species is also classified as one of the economically important tree species for Turkish forestry in the “National Tree Breeding and Seed Production Programme”<sup>[1]</sup> because of the largest distribution area. It is known that production of reproductive characters depend on the size and morphology of the tree. Estimation of the interaction between reproductive and growth characters is an important stage in breeding programs for future silvicultural treatments. Many studies were conducted on growth and reproductive characters; few have

considered the relation with growth characters<sup>[2-4]</sup>. However, fertility data on shrub and hermaphroditic species are very limited.

The purposes of this study were to evaluate correlations among cone productions and growth characters in natural populations of Brutian pine. The results of the study are also discussed for future silvicultural treatments in the species.

### MATERIALS AND METHODS

The study was carried out in three natural populations of *P. brutia*. Geographic properties of the studied populations are given in TABLE 1. General views of the populations were also showed in Figure 1.

TABLE 1 : Location of studied populations

population code	latitude (N)	longitude (E)	altitude (m)	Aspect
P1	68°44'	41°04'	850	East
P2	70°62'	41°44'	1000	North
P3	69°68'	41°20'	1100	South



Figure 1 : General view of the populations

Cone and growth data were collected on fifty trees randomly chosen randomly in each population in spring of 2013. The following observations were made:

- Numbers of two years cones ( $CON_2$ );
- Numbers of three years cones ( $CON_3$ );
- Three height (H, m.);
- Diameter at breast height (DBH, cm.); and
- Tree age (A).

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

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

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

Correlations among cone production and growth characters were calculated by Pearson's correlation.

## RESULTS AND DISCUSSION

### Cone production

Averages, standard deviation and ranges of cone production for the populations were given in TABLE 2. There were large differences among populations and within population for cone production. The production difference was also observed between cone ages. Averages of cone production were 18.1 in  $CON_2$  and 43.6 in  $CON_3$ . Cone production was the lowest in P1, while it was the highest in P2 for both cone ages (TABLE 2). The differences showed importance of selection of population for higher cone production.

Statistically significant differences ( $p \geq 0.05$ ) were found among populations based on results analysis of variance (TABLE 3).

The most abundant five (10% of total individuals) individuals produced 22.4% and 35.7% in P1, 6.7%

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

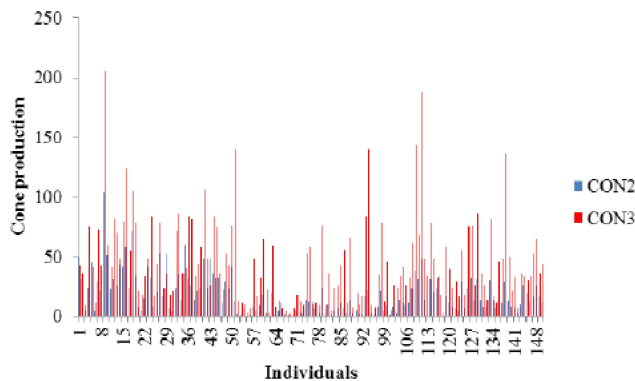
	Populations			
	P1	P2	P3	General
<b><math>CON_2</math></b>				
Average	30.9	6.8	29.2	18.1
standard deviation	19.2	6.3	32.3	16.5
Range	4-104	0-24	2-140	0-104
<b><math>CON_3</math></b>				
Average	56.4	16.5	45.2	43.6
standard deviation	34.5	10.6	35.4	35.6
Range	9-205	1-48	0-188	0-205

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**TABLE 3 : Results analysis of variance for cone productions**

Source of variaton	Sum of squares	Degrees of freedom	Mean of squares	F value	P
<b>CON<sub>2</sub></b>					
Between groups	14730.013	2	7365.007	42.074	.000
Within group	25732.180	147	175.049		
Total	40462.193	149			
<b>CON<sub>3</sub></b>					
Between groups	18694.453	2	9347.227	8.054	.000
Within group	170597.120	147	1160.525		
Total	189291.573	149			

and 33.5% in P2, and 11.8% and 41.1% in P3 of total CON<sub>2</sub> and CON<sub>3</sub>, respectively. The most abundant fifteen (10% of total individuals) individuals produced 30% and 27.5% of total CON<sub>2</sub> and CON<sub>3</sub> productions in polled populations, respectively (Figure 2). The individual differences emphasized importance of individual selection instead of mass selection in higher cone production of the species.



**Figure 2 : Individual cone production in polled populations**

The present study was carried out by one year data. It was known that trees used their energy for growth or reproductive characters in some periods<sup>[5]</sup>. There could be many environmental or genetically effects in variation

on amount of polen, strobili, cone and seed production<sup>[6-11]</sup>.

**TABLE 4 : Averages of the growth characters for the populations**

	Populations			
	P1	P2	P3	Genel
H (m)	15.3	16.3	14.1	15.2
DBH (cm)	26.7	25.4	24.8	25.6
A	57.8	77.5	92.5	75.9

### Growth characters

Averages of studied growth characters were given in TABLE 4 for the populations. The populations were also compared for the growth characters by analysis of variance (TABLE 5).

There were statistically significant differences ( $p \leq 0.05$ ) were found among populations for the tree height and tree age, while it was opposite for diameter at breast height (TABLE 5).

### Relations among characters

The relations among cone production and growth characters showed differences for the populations (TABLE 6).

**TABLE 5 : Results analysis of variance for growth characters.**

Characters	Source of variaton	Sum of squares	Degrees of freedom	Mean of squares	F value	P
H	Between groups	121.853	2	60.927	18.155	.000
	Within group	493.320	147	3.356		
	Total	615.173	149			
DBH	Between groups	95.093	2	47.547	2.706	.070
	Within group	2582.480	147	17.568		
	Total	2677.573	149			
A	Between groups	30253.213	2	15126.607	516.521	.000
	Within group	4304.980	147	29.286		
	Total	34558.193	149			

**TABLE 6 : Relations between cone production and growth characteristics**

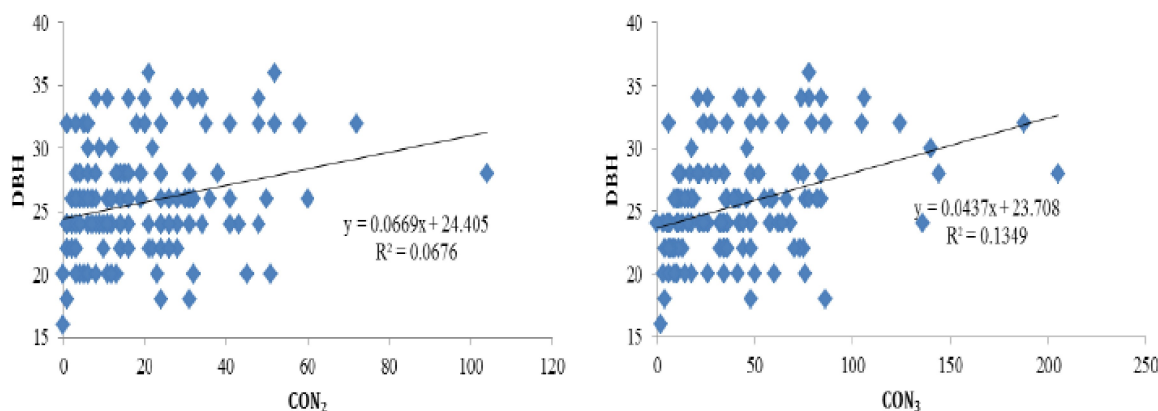
Populations	Cone	Growth characters		
		H	DBH	A
P1	CON2	-0.080NS	0.224 NS	0.071( $p \leq 0.05$ )
	CON3	0.039 NS	0.303( $p \leq 0.05$ )	0.115( $p \leq 0.05$ )
P2	CON2	0.387( $p \leq 0.05$ )	0.540( $p \leq 0.05$ )	0.003 NS
	CON3	0.375( $p \leq 0.05$ )	0.589( $p \leq 0.05$ )	0.086 NS
P3	CON2	-0.182NS	0.013 NS	-0.020 NS
	CON3	-0.205 NS	0.157 NS	0.024 NS
Polled	CON2	-0.106 NS	0.260( $p \leq 0.05$ )	-0.357( $p \leq 0.05$ )
	CON3	-0.013 NS	0.367( $p \leq 0.05$ )	-0.113( $p \leq 0.05$ )

Diameter at breast height had positive and significant ( $p \leq 0.05$ ) effective on cone production, while effects of age were significant ( $p \geq 0.05$ ) and negative in polled

populations (TABLE 6). Relations between cone production and diameter at breast height were showed in Figure 3. The positive effect of diameter at breast height on cone production was also reported in *Pinus sylvestris*<sup>[8,12]</sup> and in *P. brutia*<sup>[13]</sup>.

Age of tree had negative and significant ( $p \geq 0.05$ ) effects on cone production (TABLE 6). Significant effect of age on reproductive characters were also reported in different forest tree species<sup>[6,8,10,14-17]</sup>, while negative relations were reported between reproductive and growth characters in different forest tree species<sup>[3,18]</sup>.

Results of the present study showed that importance of growth characters in cone production and silvicultural treatments such as selection and establishment of seed collection areas.

**Figure 3 : Relations between cone production and diameter at breast height**

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