

BROAD-SENSE HERITABILITY FOR SEEDLING CHARACTERS AND ITS IMPORTANCE FOR BREEDING IN SCOTS PINE

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Abstract: Number of cotyledons, lengths of hypocotyl and epicotyl, and height of three-month seedlings, and height and root collar diameter of one year seedlings grown from sixteen clones of a Scots pine (*Pinus sylvestris* L.) seed orchard were investigated in the study. Correlations among the characters and broad-sense heritability were estimated. Averages of number of cotyledons, lengths of hypocotyl and epicotyl, and height of three-month seedlings, and height and root collar diameter of one year seedlings were 7.1, 12.4 mm, 17.7 mm, 30.3 mm, 42.9 mm and 2.1 mm, respectively. There were large differences among and within clones for the studied characters. All the seedlings characters of three-month seedlings were significantly effective on seedling height and root collar diameter of one year. Broad-sense heritability was more than 0.9 for all the characters.

Key words: *Pinus sylvestris*, heritability, cotyledon, height, root collar diameter

SARIÇAM'DA FİDAN ÖZELLİKLERİ İÇİN GENİŞ ANLAMLI KALITIM DERESESİ VE BUNUN ISLAH ÇALIŞMALARINDAKİ ÖNEMİ

Özet: Bu çalışmada, 16 Sarıçam (*Pinus sylvestris* L.) klonundan yetiştirilen üç aylık fideciklerin kotiledon sayısı, hipokotil, epikotil ve fidecik boyları ile bir yaşlı fidanların fidan boyu ve kök boğazı çapı özellikleri araştırılmış; özellikler arası ilişkiler ve geniş anlamlı kalıtım derecesi tahmin edilmiştir. Ortalama kotiledon sayısı, hipokotil, epikotil ve fidecik boyları ile fidan boyu ve kök boğazı çapı değerleri sırasıyla 7.1, 12.4 mm, 17.7 mm, 30.3 mm, 42.9 mm ve 2.1 mm bulunmuştur. Çalışmaya konu özellikler bakımından klon içi ve klonlar arası geniş farklılıklar belirlenmiştir. Çalışmaya konu fidecik özellikleri, fidan özellikleri üzerinde istatistiksel bakımdan anlamlı etki yapmıştır. Kalıtım derecesi çalışmaya konu özelliklerin tamamında 0.9'dan yüksek bulunmuştur.

Anahtar kelimeler: *Pinus sylvestris*, kalıtım derecesi, kotiledon, boy, kök boğazı çapı

INTRODUCTION

Scots pine (*Pinus sylvestris* L.) is one of the most economically and ecologically important forest tree species for both Europe and Asia. For instance, In Finland, 140 seed orchards in 1700 ha had been established by 1970, and 63 clonal seed orchards were established in Great Britain between 1953 and 1965 in the species (WRIGHT 1976). It has also an interesting growing as an introduced exotic species such as Korea, China, Mexico and New Zealand, where provenance and cultivation trials have been

established (BORATYŃSKI 1991). The species occupies between 37°-70° N latitude and 7°-137° E longitude in the world (ANONYMOUS 2001). Scots pine is one of the economically important species for Turkish forestry and the “National Tree Breeding and Seed Production Programme” (KOSKI & ANTOLA 1993). Scots pine grows from sea level up to 3125 meters (mainly 1000-2500 m) in Turkey. Pure stands of the species occupy roughly 750 000 ha in mostly Black Sea Coastal mountains at northern part of Turkey (38°41'-41°48' N latitude, 28°00'-43°05' E longitude) where the climate is humid, of which roughly 475 000 ha (65%) are considered to be productive forests. But, there are very restrict number of studies on genetic and breeding of Turkish Scots pine (e.g., BILIR 2002, BILIR et al. 2002, TURNA 2003, BILIR et al. 2006a, BILIR et al. 2006b). While Turkey has 21 Scots pine seed orchards on 114 ha was established by the Directorate (ANONYMOUS 2006), only 9.2% of annual seed demand for plantations in the species was covered from the orchards (CENGİZ 2003). Therefore, seed orchards are becoming gradually more important to produce superior seed crop. Estimation of heritability for seedling characters is important for breeding, nursery practice and economical and biological success of plantation forestry, and also for forestry of breeding programmes.

The purposes of this study were to evaluate averages, variation, broad-sense heritability and correlations for seedling characters in a Scots pine seed orchard. The results of the study are discussed based on breeding, nursery practice and plantation forestry of the species.

MATERIAL AND METHODS

Seed Source

Cones were collected from 16 clones of a seed orchard in September of 2005. The cone seed orchard of *Pinus sylvestris* had established at Taskopru, Kastamonu (41°36'N, 35°05'E, 1500 m) at 6x6 m consisting of 30 clones and 1987 grafts in 1995. Seeds were extracted from the cones in December of 2005.

Sowing of Seeds

The seeds were sown at Suleyman Demirel University Nursery (37°45'N, 30°35'E, 1060 m) in Isparta, southern part of Turkey at polyethylene boxes (5x9) at a depth of 3-5 mm as three replicates, in March of 2006. The seeds were covered with organic matter mulch.

Data Collection

Data were collected on fifteen seedlings (five seedlings per replicate), chosen at random, each of sixteen clones chosen at random in July and September of 2006. The following characters were studied:

- number of cotyledons (CN)
- hypocotyl length (HL, mm)
- epicotyl length (EL, mm)
- height of three-month seedling (Sh, mm)
- height of one year seedling (SH, mm)
- root collar diameter of one year seedlings (RCD, mm).

Genetic Parameters

Differences among clones for the studied characters were determined by following model of one way-analysis of variance:

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

where Y_{ij} is the observation from the j^{th} individual of the i^{th} clone, μ is overall mean, C_i is the random effect of the i^{th} clone, and e_{ij} is random error includes environmental variation.

Broad-sense heritability (the fraction of the variance which is genetic among clones, H^2) was estimated as:

$$H^2 = \frac{\sigma_c^2}{\sigma_c^2 + \sigma_e^2}$$

where σ_c^2 is the variance among clones, σ_e^2 is the variance within clone.

Variance components, expressed as coefficient of variation among clones (CV_c) and within clone (CV_e), were estimated as:

$$CV_c = 100\sigma_c / \bar{x} \quad \text{and} \quad CV_e = 100\sigma_e / \bar{x}$$

where \bar{x} is overall character mean. Correlations among characters were calculated at the levels of individually and clonal means.

RESULTS AND DISCUSSION

Characters

As seen in Table 1, there was a large difference for the characters among and within the clones. For instance, SH varied between 20 and 97 mm individually; between 31.7 and 61.6 mm clonally (Table 1). It showed large genetic diversity in base population of the seed orchard and parental importance (e.g. selection of parent trees from base population/natural stands). The estimation of gene diversity in seed orchard crop based on fertility was more than 0.9 in Turkish Scots pine seed orchards (BILIR 2002, BILIR et al. 2006-b).

Parental effect is also well accordance with differences within clone. For instance, the height (SH) and root collar diameter (RCD) of one year seedlings had to have at least 5 cm and 2 mm for plantations, respectively (ANONYMOUS 1988). But, only 24% of the seedlings for SH, 55% for RCD had the criteria. They were 16.7% for SH, 58.3% for RCD in grafts; 6.0% for SH and 68.8% in clones. This showed the importance of selection of parent trees from base population/natural stands and parental effect. Because, there were also differences for the characters among grafts of the same clone and among seedlings belong to the same graft.

Table 1. Average (\bar{x}); ranges; coefficient of variation among (CV_C , %) and within clones (CV_e , %), and broad-sense heritability (H^2)

Characters	\bar{x}	Ranges		CV_C	CV_e	H^2
		Individual	Clonal			
CN	7.1	5-9	6.4-7.7	55.7	7.4	0.983
HL	12.4	5-29	10.7-14.0	79.0	15.1	0.965
EL	17.7	4-35	15.1-20.3	80.9	15.1	0.966
Sh	30.3	11-52	25.8-33.7	82.2	22.7	0.929
SH	42.9	20-97	31.7-61.6	85.4	16.4	0.964
RCD	2.1	1.0-4.1	1.65-2.42	60.7	12.0	0.962

Averages of number of cotyledons and hypocotyl length were found 6.5 and 26 mm in natural populations, respectively, by TURNA (2003).

Heritability

Broad-sense heritability was more than 0.9 for all the characters (Table 1). All the properties, especially, number of cotyledons as a criterion should be used in comparison of populations. Because, the number of cotyledons is not effected by nursery and environmental conditions and also age. For instance, number of cotyledons estimated by TURNA (2003) and in the present study was similar (Table 1). Parental trees were initially selected according to their phenotype for traits such as vigour, form, wood quality or other desired characteristics, which include general adaptability (ZOBEL & TALBERT 1984). But, estimation heritability for seedling characters can play important role in economical (such as survival, seedling cost) and biological (such as adaptation) success for plantation forestry especially in its first few years. It is also important for nursery practice (e.g. seedling quality, seedling cost). Therefore, seedling characters can also use as criterion during establishment and selection of seed sources. It was also reported for hypocotyl length in *Pinus caribea* seedlings by VENATOR (1974).

Relations among Characters

All the characters of three-month seedlings were significantly effective on height and root collar diameter of one year seedlings while number of cotyledons and seedling height of three months was also effective significantly on that at clone level (Table 2).

Table 2. Correlations between grafts (below diagonal) and clones (above diagonal)

	CN	HL	EL	Sh	SH	RCD
CN	-	0.419 ^{ns}	0.375 ^{ns}	0.558*	0.814**	0.603*
HL	0.086 ^{ns}	-	-0.017 ^{ns}	0.605*	0.322 ^{ns}	0.262 ^{ns}
EL	0.205**	0.149*	-	0.786**	0.426 ^{ns}	0.485 ^{ns}
Sh	0.209**	0.562**	0.901**	-	0.538*	0.548*
SH	0.391**	0.314**	0.572**	0.615**	-	0.685**
RCD	0.331**	0.130*	0.393**	0.385**	0.546**	-

**; statistically significant at 0.01 probability level.

*; statistically significant at 0.05 probability level.

^{ns}; non significant.

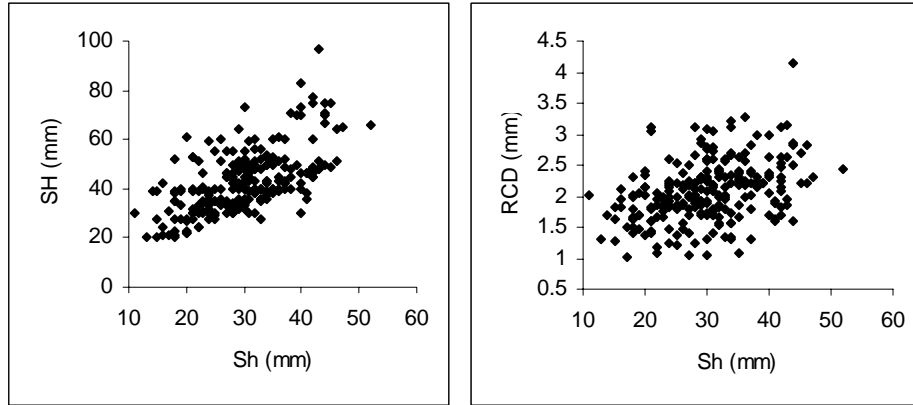


Figure 1. Relationships between heights of three-month (Sh) and one year (SH) seedlings and between height of three months and root collar diameter of one year old (RCD) seedlings

Therefore, when one of the characters is used a criterion, other characters will also be high. For instance, the height of three-month seedlings (Sh) correlated significantly on seedling height and root collar diameter of one year seedling (Table 2, Figure 1).

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