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PROVENANCE VARIATIONS OF SCOTS PINE (*PINUS SYLVESTRIS* L.) IN THE SOUTHERN PART OF TURKEY

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Abstract

Tree height, basal diameter, stem form, number, angle and diameter of branches were assessed in eight-year-old provenance test established by 30 seed sources of Scots pine (*Pinus sylvestris* L.) at Aydogmus and Kemer experimental sites of Southern part of Turkey. Growth of the provenances was also compared to two native species (Taurus cedar- *Cedrus libani* A. Rich., and Black pine-*Pinus nigra* Arnold.) of the region. Variations within provenance and among provenances, and relations among the traits were estimated. There were large differences ($p \leq 0.05$) within provenance and among provenances for the traits, while sites showed similar ($0.05 \leq p$) performance for tree height and stem form. For instance, average of tree height was 181 cm and varied between 138.3 cm and 229.8 cm in provenances of Aydogmus site, it was 184 cm and ranged from 130 cm to 246.1 cm in that of Kemer site. Averages of tree height of a provenance were 144.4 cm in Aydogmus and 194.5 cm in Kemer. Individual tree height of the provenance varied between 69 cm and 267 cm, and ranged from 51 cm to 280 cm in sites. Averages of tree height were 143.2 cm in Black pine 145.6 cm in Taurus cedar which were natural species of the region. There were mostly positive and significant ($p \leq 0.05$) correlations among the traits. Results of the study were discussed for new plantations and breeding of the species.

Key words: Provenance variation, Scotch pine, Origin, *Pinus sylvestris* L., Afforestation.

Introduction

Scots pine (*Pinus sylvestris* L.) is classified as one of the most economically important tree species for Turkish forestry. The species is also an important timber species in European and Asian Forestry. Besides, it is interesting as an introduced exotic species in Korea, China, Mexico and New Zealand, where provenance and cultivation trials have been established (Boratynski, 1991). Scots pine is one of the main species in the "National Tree Breeding and Seed Production Programme" (Koski & Antola, 1993). Estimation of provenance variation is an important stage in tree breeding programme because of valuable contribution in economical and biological success of future plantation.

Scots pine forests cover about 757 000 ha of which about 475 000 ha are considered to be productive forests, which is nearly 4% of the total forest area in Turkey (Anonymous, 2013). The species occupy mainly northern part of Turkey (Fig. 1, Anon., 2013). It is also reported that suitable plantation area of the species is about 500 000 ha in Turkey (Anonymous, 2001).

Provenance test is getting importance for these unproductive and potential areas of the species. While many national and international studies were conducted on provenance test for different purposes in the species in many countries (e.g., Saatcioglu, 1967; Giertych, 1979 & 1991; Stephan & Liesebach, 1996; Dagdas *et al.*, 1997; Shutyaev & Giertych, 1997), the present study is carried out as firstly for Southern part of Turkey in the species. The first forest provenance experiment was established by Scots pine in 1820. At the end of the 19th and at the beginning of 20th centuries several similar studies were conducted. Trice, in 1907, 1938 and 1939, IUFRO (International Union of Forest Research Organizations) organized international provenance experiments on Scots pine (Giertych, 1991). The first Turkish forest provenance experiment was also established by 16 provenances of Scots pine in 1940 (Saatcioglu, 1967).

The purposes of this study were to estimate variations of growth performance within provenance and among provenances, to evaluate relations among the traits, and to compare to native forest tree species of the region based on eight-year-old performances of provenances. The results of the study were also discussed for future plantation of the species.

Materials and Methods

Experimental areas and establishment: This study was carried out in two experimental areas in Aydogmus (latitude 38°36'N, longitude 30°24'E, altitude 1100 m) and Kemer (latitude 37°35'N, longitude 30°06'E, altitude 1180 m), at Southern part of Turkey, established by 30 Scotch Pine provenances (Table 1) and included native Taurus Cedar (*Cedrus libani* A. Rich.) and Anatolian Black Pine (*Pinus nigra* Arn.) provenances as a comparison.

The experiments were laid out in the fields as to "Randomized Blocks Method" with three replications 2.5x2 m spacing in 2000. Each provenance was represented by thirty containerized seedlings (2+0 years old) in each replication.

Data collection: Data were collected on eight-year-old provenance test of 30 Scotch Pine, one Taurus Cedar and Black Pine provenances the end of 2008. The following observations were made:

- Tree height (**H**, cm)
- Basal diameter (**D_0**, mm)
- Stem form (**SF,** stems was classified by scale in Fig. 2)
- Number of branches (**BN**)
- angle of branches (**BA**, °)
- diameter of branches (**BD**, mm)

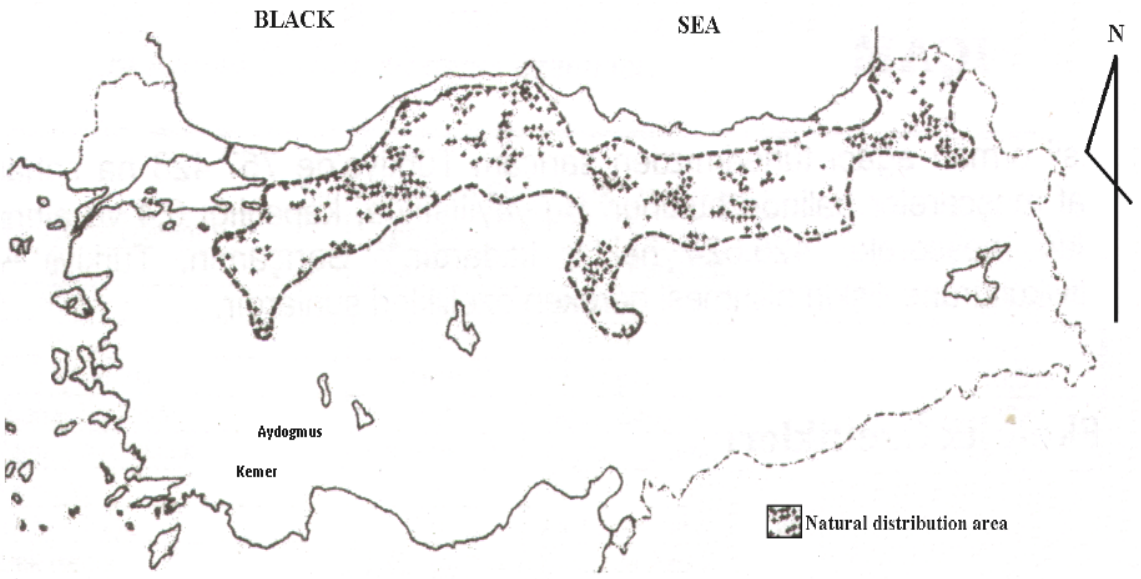

Fig. 1. Natural distribution of Scots pine in Turkey, and experimental sites.

Table 1. Some details of the provenances.

Provenance No.	Provenance	Country	Latitude (N)	Altitude (m)	Harvesting year
1	Eskipazar-Ulupinar	Turkey	40º53′	1550	1990
2*	02 Hanau Versant	France	49º02′	300	1994
3	Senkaya-Aydere	Turkey	40º38′	2050	1990
4	Greece-1	Greece	41º17′	1600	1996
5	V.Kopru-Ovacik-Kunduz	Turkey	41º10′	1200	1997
6*	Haguena Fransa-2	France	48º51′	140	1980
7	Camlidere-Benliyayla	Turkey	40º31′	1550	1996
8**	Catacik-Gumelidere	Turkey	39º58′	1550	1988
9**	Camlidere-Benliyayla	Turkey	40º32′	1575	1992
10	Daday-Kolanderesi	Turkey	41º22′	1250	1995
11	Sarikamis-Ciplakdag	Turkey	40º15′	2300	1996
12**	Akdagmadeni-Aktas	Turkey	39º41′	910	1996
13**	Catacik -Degirmendere	Turkey	39º51′	1320	1996
14	Usak-Catak	Turkey	38º54′	1675	1997
15	Akdagmadeni-Aktas	Turkey	39º34′	1750	1990
16	Senkaya-Karincaduzu	Turkey	40º45′	2250	1997
17	Daday-Bolayca-Ballıdag	Turkey	41º34′	1300	1996
18	Koyulhisar-Ortakent	Turkey	40º23′	1950	1994
19	Bolu-Aladag	Turkey	40º37′	1350	1997
20	Kargi-Kosedag	Turkey	41º01′	1600	1991
21	Catacik -Degirmendere	Turkey	39º58′	1550	1994
22	Vezirkopru-Golkoy	Turkey	41º10′	1300	1994
23	Mesudiye-Arpaalan	Turkey	40º22′	1650	1995
24	Ilgaz-Gokdere	Turkey	41º02′	1500	1990
25	Akdagmadeni-Sirikli	Turkey	39º34′	1800	1997
26	Greece-2	Greece	-	-	1996
27	Sarikamis-Merkez	Turkey	40º18′	2350	1996
28	Sarikamis -Boyali	Turkey	40º26′	2250	1996
29	Akyazi-Dokurcun	Turkey	40º37′	1450	1995
30**	Eskisehir-Catacik	Turkey	39º45′	1350	1997
31	06 Pique. Oisea. Fransa-3	France	45º18′	860	1985
32*	05 Faite. Fransa-4	France	48º13′	500	1983
33*	10 palau de Cer. Fransa-5	France	42º21′	1600	1984
34**	Erzurum	Turkey	39º54′	1570	1998
40	Black Pine	Turkey	37°29′	1000	1999
41	Taurus Cedar	Turkey	37°44′	1567	1999

*; Not enough seedlings for plantation, **; Seed Orchards

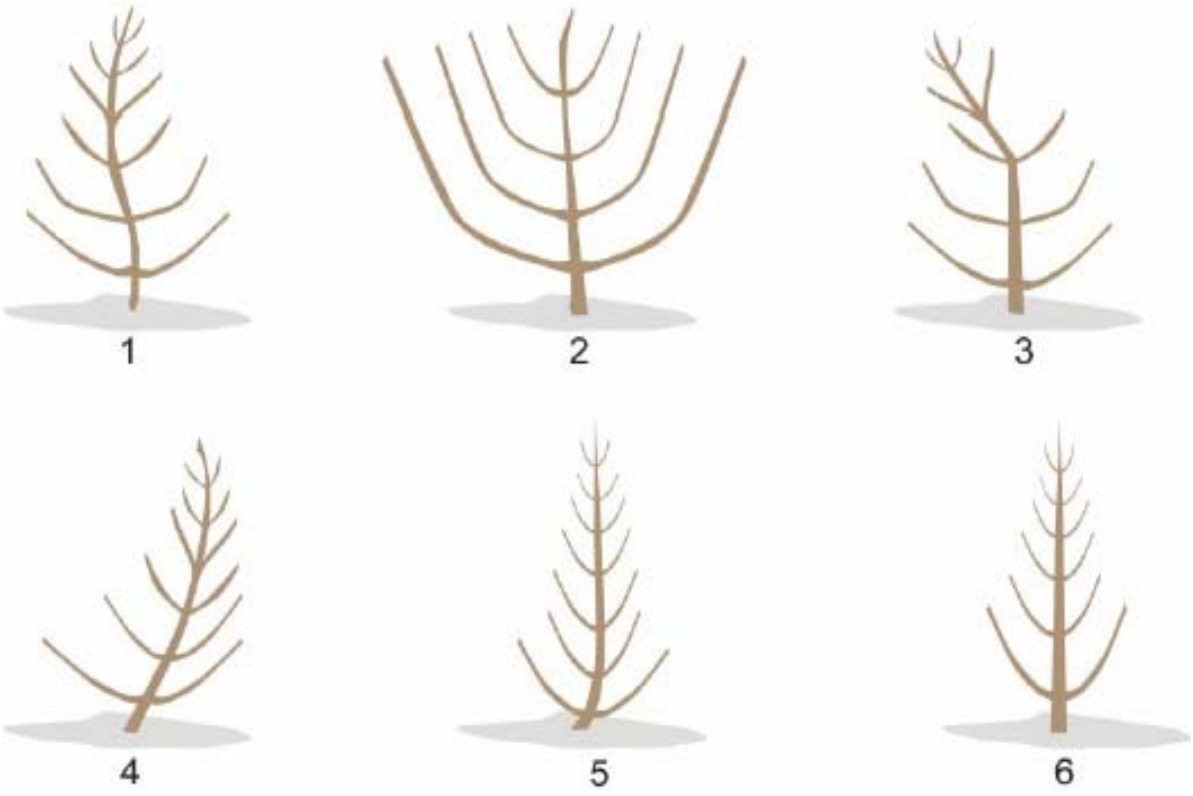

Fig. 2. The scale of stem form (Işık *et al.*, 2001).

Data analyses

The statistical analysis was carried out by SPSS statistical program according to following model of ANOVA was used for the analysis:

$$Y_{ijk} = \mu + P_i + S_j + P(S)_{i(j)} + e_{ijk}$$

where Y_{ijk} is the observation from the k^{th} tree of the i^{th} provenance in the j^{th} site, μ is overall mean, P_i is the effect of the i^{th} provenance in the j^{th} site, $P(S)_{i(j)}$ interaction between i^{th} provenance and j^{th} site, e_{ijk} is random error.

Correlations among traits were also calculated.

Results and Discussion

Tree height and basal diameter: Provenances showed similar performances for averages of tree height and basal diameter in the sites. Averages of tree height were 181.2 cm in Aydogmus site, 182.0 in Kemer site, and 181.5 in polled sites. They were 40.2 mm, 38.7 mm and 39.6 mm for basal diameter (Table 2). However, there were large differences for the traits among provenances within site. For instance, averages of tree height were ranged from 138.3 cm (provenance 3) to 229.8 cm (provenance 30) in Aydogmus site, and between 130 cm (provenance 11) and 246.1 cm (provenance 22) in Kemer site. The averages of basal diameter were between 31.2-49.1 mm (provenances 3 and 29 respectively) in Aydogmus site however they changed between 33.3-48.0 mm (provenances 18 and 22 respectively) in Kemer site (Table 2, Figs. 3a and 3b).

The differences were also observed within provenance within site. For instance, individual tree height was changed from 69.0 cm to 267.0 cm of first provenance in Aydogmus site. It was between 16 mm and 62 mm for the basal diameter in the provenance and in the site.

Scots pine which was an exotic plant for the region generally showed higher performances for height, basal diameter, number and diameter of branches than Taurus cedar and Black pine in sites (Table 2).

Stem form: Individual trees were classified according to the scale. Averages of the stem form for provenances and sites were presented in Table 2. They were also showed in Fig. 4. Stem form was one of the most important traits in wood quality. Provenances of Scots pine had generally quality stems. But stem form was the better in Taurus cedar than Scots pine and Black pine. It was related to biology of the Taurus cedar which was grown pyramidal.

Averages of the stem form was 5.5 in both site, while some differences were observed among Scots pine provenances within site. Averages of the stem forms were 5.9 in Taurus cedar and 5.4 in Black pine (Table 2). Individual stems of the provenances had generally good quality (Table 3). More than 70% of the stems were in six^{th} class, while about 1% was in 1^{st} class (Table 3). Beside, Taurus cedar showed the highest performances for stem quality (97%) than that of Scots pine (76%) and Black pine (70%) (Table 3).

Table 2. Averages of the provenances in the Aydogmus, Kemer and polled sites.

Provenance No.	Aydogmus						Kemer						Polled					
	H*	D_0	SF	BN	BA	BD	H	D_0	SF	BN	BA	BD	H	D_0	SF	BN	BA	BD
1	144.4	37.3	5.1	8.7	19.2	10.7	194.5	41.9	5.3	9.9	40.7	12.8	165.4	39.2	5.2	9.2	28.2	11.6
3	138.3	31.2	5.4	9.2	16.9	9.5	161.7	34.0	5.6	10.0	40.0	10.4	151.0	32:7	5.5	9.6	28.9	10.0
4	188.7	38.6	5.3	9.7	16.6	10.3	179.5	37.3	5.4	9.6	43.6	9.6	184.6	38.0	5.4	9.7	28.7	10.0
5	184.1	42.5	5.2	9.7	17.1	12.1	157.4	35.7	5.1	9.4	35.5	11.2	174.0	39.9	5.1	9.6	24.1	11.8
7	145.5	36.0	5.0	9.2	19.6	10.5	173.6	36.1	5.6	10.1	42.4	10.2	160.2	36.1	5.3	9.6	31.5	10.4
8	169.2	40.1	4.9	9.1	20.4	11.9	216.7	44.4	5.6	9.9	40.0	13.4	190.5	42.0	5.2	9.4	29.0	12.5
9	167.1	39.6	4.9	9.0	18.3	11.8	212.3	41.7	6.0	9.9	44.5	10.7	178.8	40.1	5.2	9.2	25.1	11.5
10	167.3	39.5	5.0	9.4	17.0	11.9	202.9	41.0	5.8	10.0	40.1	11.8	183.4	40.1	5.4	9.8	27.4	11.8
11	152.3	34.1	5.7	9.5	14.1	9.3	130.0	32.7	5.4	9.6	36.0	9.0	143.1	33.6	5.6	9.5	2.31	9.1
12	177.0	41.8	5.0	9.2	22.8	11.9	168.5	36.0	5.7	9.9	46.3	10.9	173.4	39.3	5.3	9.5	32.8	11.4
13	179.2	40.8	5.6	8.8	20.2	11.6	235.9	46.7	5.9	10.5	45.1	11.7	208.5	43.9	5.7	9.7	33.1	11.7
14	168.6	40.2	5.7	8.9	22.6	12.0	222.9	46.1	5.9	9.8	44.3	12.3	190.6	42.6	5.8	9.3	31.5	12.1
15	174.4	37.8	5.6	9.1	19.2	11.0	179.0	38.8	5.3	10.1	42.8	12.3	176.1	38.2	5.5	9.4	27.6	11.5
16	167.4	38.0	5.6	9.4	15.8	10.9	195.2	40.8	5.6	10.2	41.5	11.4	180.2	39.2	5.6	9.8	27.6	11.1
17	202.5	43.8	5.7	10.1	19.8	12.5	196.0	43.4	5.3	9.7	40.0	12.2	200.0	43.6	5.5	9.9	27.7	12.4
18	188.3	38.6	5.3	9.2	20.4	12.5	145.5	33.3	4.7	9.6	41.1	10.7	168.2	36.1	5.0	9.4	30.1	11.7
19	161.2	31.5	5.7	9.4	19.9	9.8	190.3	41.2	5.6	10.4	43.8	12.1	170.7	34.7	5.6	9.8	27.8	10.6
20	196.1	41.9	5.9	9.8	20.0	11.6	169.4	36.9	5.6	10.3	42.8	11.0	186.6	40.1	5.8	10.0	28.1	11.4
21	222.6	48.0	6.0	10.5	20.3	13.9	177.7	39.4	5.6	10.4	46.3	10.3	207.7	45.2	5.8	10.4	28.9	12.7
22	222.3	46.5	5.8	10.0	19.7	13.1	246.1	48.0	5.8	10.8	39.2	11.7	230.0	47.0	5.8	10.3	25.7	12.7
23	180.7	40.5	5.3	9.2	19.1	11.3	163.6	36.0	5.1	9.7	43.3	10.7	173.1	38.5	5.2	9.4	29.8	11.1
24	187.6	42.2	5.9	9.4	17.8	11.8	160.6	35.4	5.4	10.0	29.3	9.9	180.6	40.4	5.8	9.6	20.8	11.3
25	185.0	41.3	5.5	9.4	23.3	13.4	158.6	37.9	5.0	8.8	43.5	12.2	177.5	40.3	5.4	9.2	29.0	13.1
26	199.0	37.5	5.8	10.1	20.4	11.0	214.1	41.8	5.6	10.4	37.7	11.4	202.8	38.6	5.7	9.2	24.8	11.1
27	182.6	40.9	5.8	10.0	16.3	11.6	169.7	37.3	5.3	10.2	35.3	9.9	177.8	39.6	5.6	1.02	23.4	11.0
28	169.2	39.4	5.8	10.1	17.7	11.3	165.4	37.1	5.6	10.3	34.0	10.7	168.2	38.8	5.7	10.1	21.9	11.2
29	229.1	49.1	5.7	9.5	18.4	13.9	224.8	43.6	5.8	10.5	37.4	11.3	228.1	47.8	5.7	9.7	23.0	13.2
30	229.8	47.8	5.8	10.8	20.2	13.4	177.4	39.5	5.4	10.1	42.8	10.7	215.6	45.6	5.7	10.6	26.1	12.7
31	182.0	34.4	5.4	10.1	16.5	11.3	190.8	37.8	5.6	10.4	33.8	10.6	185.1	35.6	5.7	10.2	22.5	11.0
34	173.5	42.5	5.7	9.7	19.2	11.3	140.4	33.7	5.1	8.6	34.5	10.7	162.6	39.4	5.5	9.3	24.2	11.1
Mean	181.2	40.2	5.5	9.4	19.7	11.7	182.0	38.7	5.5	9.7	40.4	11.1	181.5	39.6	5.5	9.5	27.5	11.5
40 (Black Pine)	127.0	34.1	5.4	6.8	19.6	11.3	159.5	36.6	5.6	8.2	39.0	10.0	131.4	34.4	5.4	7.0	22.2	11.1
41 (Taurus Cedar)	149.0	30.4	6.0	5.5	39.3	10.2	142.1	30.1	5.8	5.2	35.8	9.7	145.6	30.2	5.9	5.4	37.6	10.0

*; tree height (H, cm); basal diameter (D_0, mm); stem form (SF); number of branches (BN); angle of branches (BA); diameter of branches (BD, mm)

Table 3. Distribution (%) of stem forms in the provenances and experimental sites.

Provenance No.	Aydogmus						Kemer						Polled					
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
1	0	10	6	8	16	60	0	6	8	11	6	69	0	8	7	9	12	64
3	0	3	11	13	3	71	0	4	1	0	13	78	0	4	7	1	13	75
4	5	3	3	3	8	76	0	13	3	0	0	84	3	7	4	1	4	80
5	4	2	14	4	6	71	3	3	10	0	32	52	4	2	12	2	16	63
7	3	6	13	3	10	65	0	3	0	3	21	74	2	5	6	3	15	69
8	4	4	15	6	13	58	3	3	5	0	0	90	3	3	10	3	7	72
9	2	12	7	9	7	63	0	0	0	0	0	100	2	9	5	7	5	72
10	2	8	10	2	7	57	0	0	0	0	24	76	1	5	6	1	14	65
11	0	0	2	0	12	37	0	4	9	4	4	78	0	1	3	1	10	48
12	2	2	26	0	28	64	2	0	0	0	17	81	2	1	13	0	22	72
13	0	0	6	6	10	65	0	0	2	2	2	94	0	0	4	4	6	79
14	0	0	3	0	14	76	0	0	0	3	3	95	0	0	2	1	9	83
15	0	0	7	0	7	52	0	0	4	12	32	52	0	0	7	3	14	52
16	0	0	4	1	12	44	0	0	0	8	21	72	0	0	3	4	15	54
17	0	0	5	3	10	82	0	8	3	5	21	64	0	3	4	4	14	65
18	0	6	8	10	10	67	0	9	15	9	30	37	0	7	11	9	19	53
19	0	0	8	2	8	82	0	4	0	4	12	80	0	1	5	3	9	82
20	0	0	2	2	5	92	0	6	0	0	15	79	0	2	1	1	9	87
21	0	0	0	0	5	95	0	3	3	0	17	77	0	1	1	0	9	87
22	0	0	0	7	7	86	0	3	0	0	6	90	0	1	0	5	7	87
23	0	2	12	4	18	65	0	7	0	9	14	36	0	4	7	6	31	52
24	0	0	0	3	3	93	0	5	5	0	19	71	0	1	1	2	7	88
25	0	2	2	15	9	72	0	12	8	4	23	54	0	4	3	12	13	67
26	2	0	2	2	2	91	0	6	0	0	19	75	2	2	2	2	6	87
27	0	0	0	10	6	85	0	6	3	6	26	58	0	2	1	8	13	75
28	2	0	0	5	5	88	0	5	0	5	15	75	1	1	0	5	8	85
29	1	0	4	3	6	85	0	0	0	5	14	81	1	0	3	3	8	84
30	0	0	8	0	0	92	4	4	0	4	22	67	1	1	6	1	6	85
31	4	2	4	7	14	70	0	3	0	0	23	73	2	2	2	5	17	71
34	2	4	0	4	4	87	0	11	0	4	41	44	1	6	0	4	16	73
Mean	1	2	6	4	9	79	0	4	3	4	18	77	1	3	5	4	12	76
40 (Black Pine)	0	3	8	8	14	68	0	0	0	20	0	80	0	3	7	9	12	70
41 (Taurus Cedar)	0	0	0	0	0	100	0	4	0	0	2	94	0	2	0	0	1	97

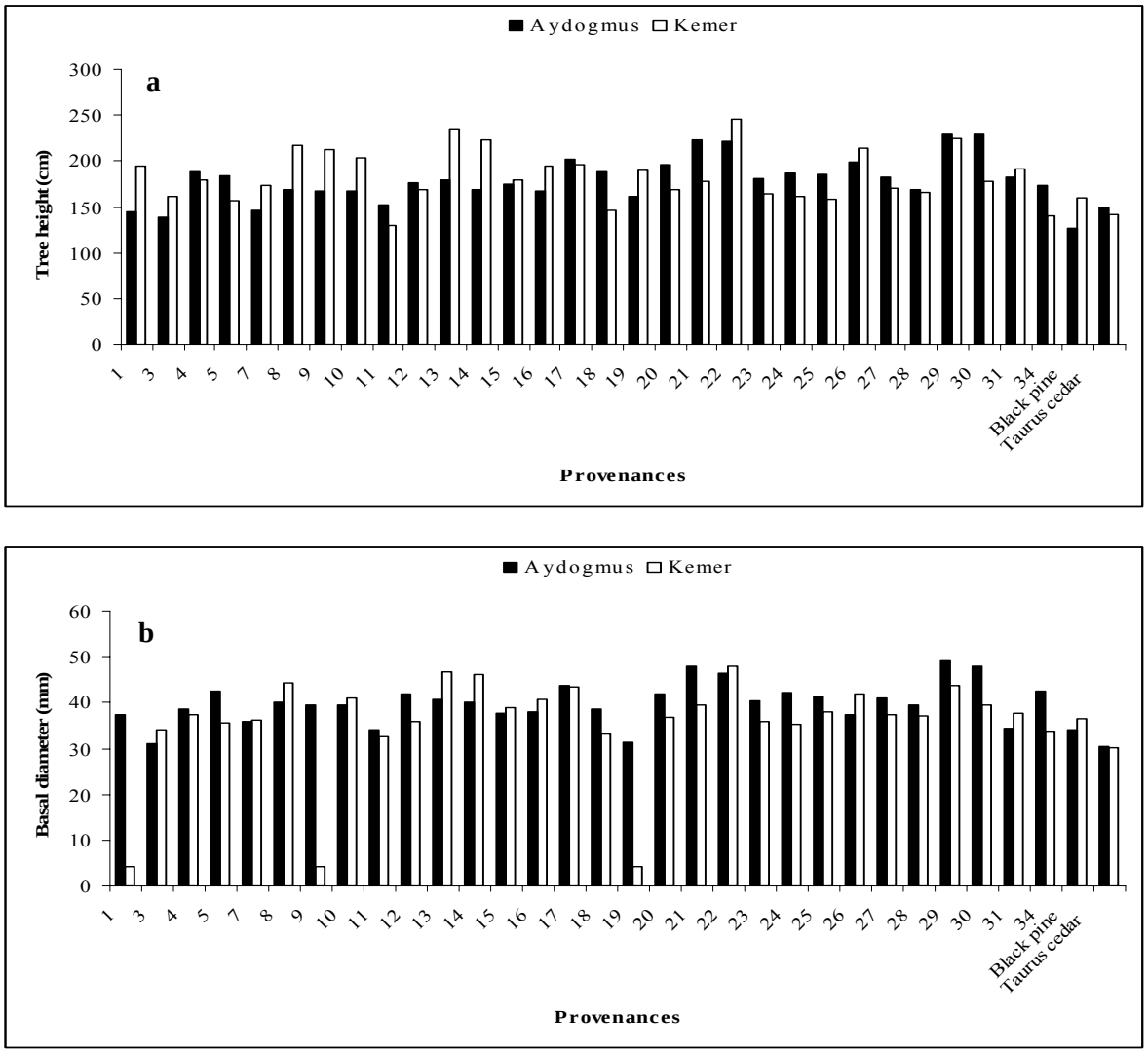

Fig. 3. Averages of the tree height (**a**) and basal diameter (**b**) for provenances.

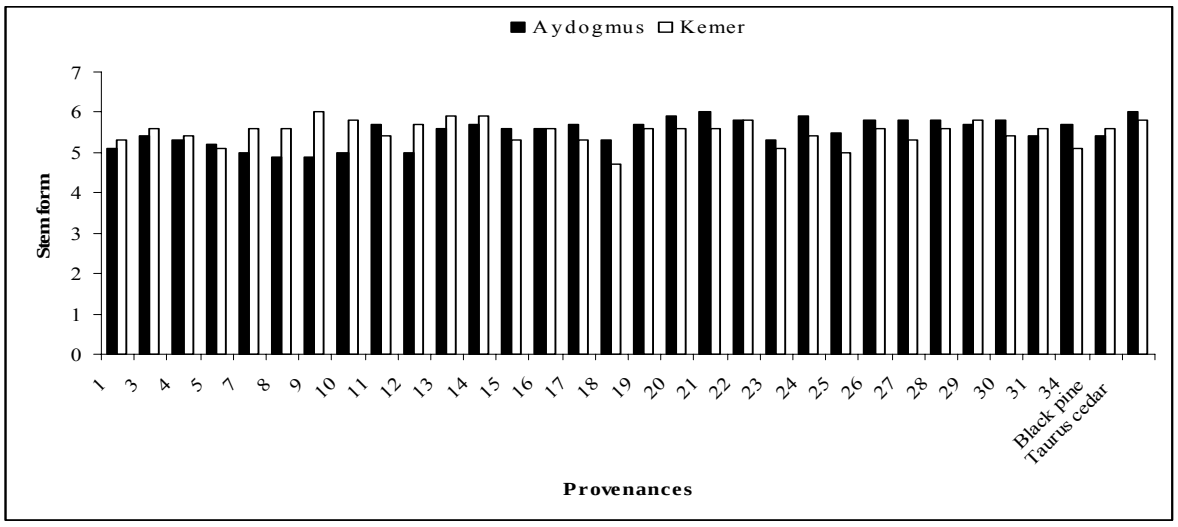

Fig. 4. Averages of the stem form for provenances.

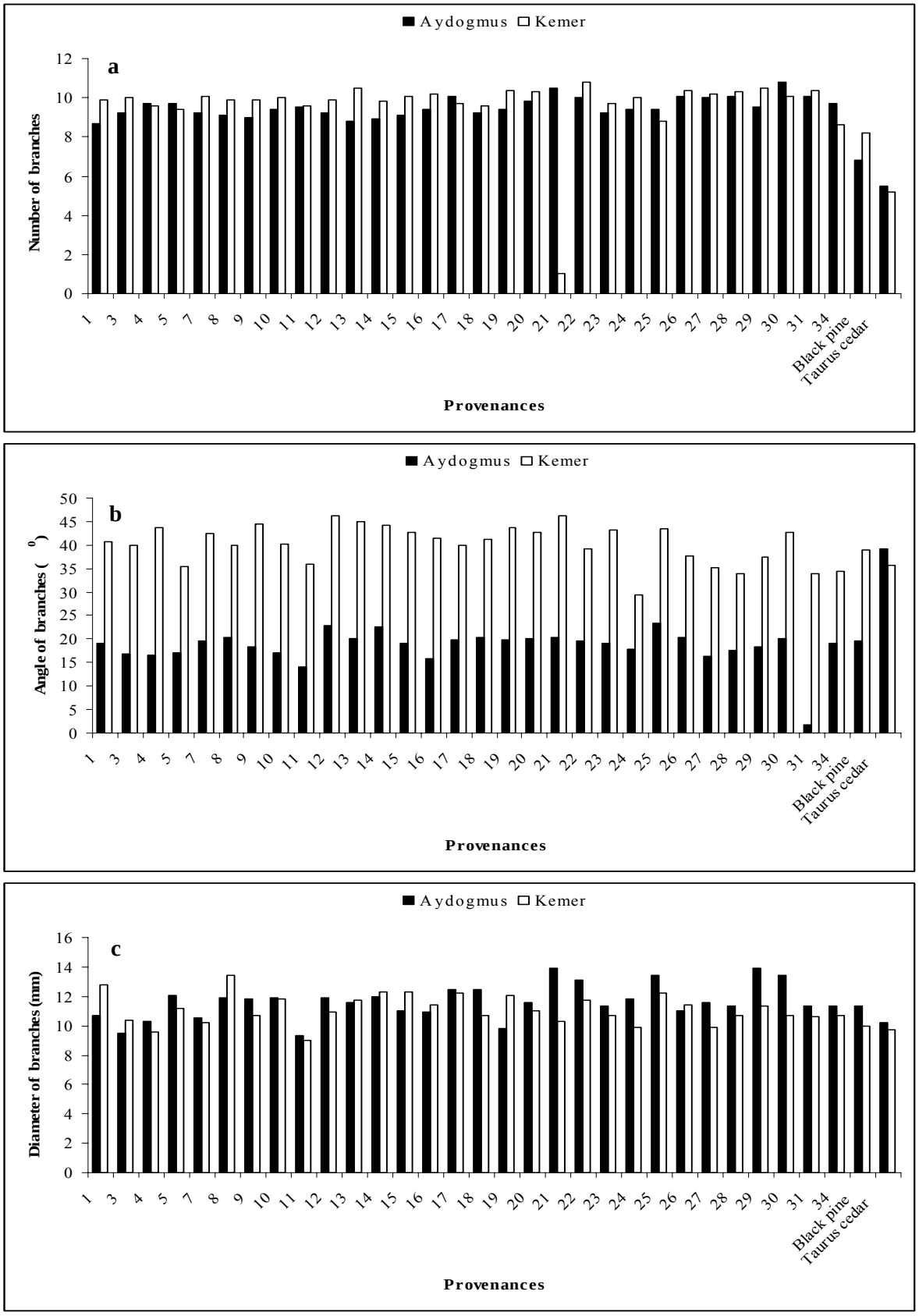

Fig. 5. Number (**a**), angle (**b**) and diameter (**c**) of branches for provenances.

Table 4. Homogenous groups of Duncans multiple range tests.

H		D_0		SF		BN		BA		BD	
Provenance No.	Homogenous groups*	Provenance No.	Homogenous groups	Provenance No.	Homogenous groups	Provenance No.	Homogenous groups	Provenance No.	Homogenous groups	Provenance No.	Homogenous groups
40	a	41	a	18	a	41	a	24	a	11	a
11	ab	3	ab	5	ab	40	b	28	a	41	ab
41	abc	11	abc	1	abc	25	c	40	ab	3	ab
3	bcd	40	abcd	23	abcd	9	c	31	abc	4	ab
7	bcde	19	bcde	9	abcde	1	c	29	abcd	7	bc
34	cdef	31	bcdef	8	abcde	14	cd	11	abcd	19	bcd
1	defg	7	bcdef	12	abcdef	34	cde	27	abcde	27	bcde
18	defg	18	bcdef	7	abcdefg	18	cde	5	abcdef	31	bcde
28	defg	4	cdefg	25	abcdefg	23	cdef	34	abcdef	23	bcde
19	defgh	15	defg	4	abcdefg	15	cdef	26	abcdefg	26	bcde
23	efgh	23	defg	10	abcdefg	8	cdef	9	abcdefg	40	bcdef
12	efgh	26	defg	40	bcdefgh	11	cdefg	22	abcdefg	16	bcdef
5	efgh	28	dedfgh	31	bcdefghi	12	cdefg	30	abcdefg	34	bcdef
15	efgh	1	efghi	34	bcdefghi	24	cdefgh	10	abcdefgh	28	bcdef
25	efgh	16	efghi	15	bcdefghi	5	cdefgh	15	abcdefghi	24	cdefg
27	efgh	12	efghi	3	bcdefghi	3	cdefghi	16	bcdefghij	20	cdefgh
9	efgh	34	efghi	17	cdefghij	7	cdefghi	17	bcdefghij	12	cdefghi
16	efghi	27	efghi	27	defghij	13	cdefghi	19	cdefghij	15	cdefghi
24	efghi	5	fghi	11	defghij	4	cdefghi	20	cdefghij	9	cdefghi
10	fghij	20	fghi	16	efghij	29	cdefghi	1	defghij	1	cdefghi
4	ghij	9	fghi	19	fghij	19	cdefghi	4	defghij	13	defghi
31	ghij	10	fghi	30	fghij	16	cdefghij	3	efghij	18	defghi
20	ghij	25	fghi	29	ghij	10	cdefghij	21	efghij	5	defghi
8	hijk	24	fghi	28	ghij	17	defghij	8	efghij	10	defghij
14	hijk	8	ghij	26	ghij	20	defghijk	25	fghij	14	efghijk
17	ijkl	14	ghijk	13	ghij	27	efghij	23	fghij	17	fghijk
26	jkl	17	hijkl	20	hij	28	fghij	18	ghij	8	ghijk
21	kl	13	ijkl	24	ij	31	fghij	14	ghij	22	hjik
13	kl	21	jkl	22	ij	26	ghij	7	hij	30	hijk
30	lm	30	jkl	14	ij	22	hij	12	hij	21	ijk
29	m	22	kl	21	ij	21	ij	13	ij	25	jk
22	m	29	l	41	j	30	j	41	j	29	k

*; the same letter do not significantly differ ($p \leq 0.05$)

Table 5. Correlations among the traits in the polled sites.

		H	D_0	SF	BN	BA
Scots pine	**D_0**	0.667**	-			
Black pine		0.390**	-			
Taurus cedar		0.640**	-			
Scots pine	**SF**	0.381**	0.201**	-		
Black pine		0.322**	0.020 ns	-		
Taurus cedar		0.313**	0.277**	-		
Scots pine	**BN**	0.493**	0.352**	0.318**	-	
Black pine		0.602**	0.361**	0.322**	-	
Taurus cedar		0.393**	0.314**	0.228*	-	
Scots pine	**BA**	0.109**	0.100**	0.031 ns	0.132**	-
Black pine		0.207ns	0.200 ns	0.068 ns	0.199 ns	-
Taurus cedar		0.463 ns	0.090 ns	0.148 ns	-0.032 ns	-
Scots pine	**BD**	0.509**	0.699**	0.109**	0.223**	0.066**
Black pine		0.344**	0.465**	0.097 ns	0.229*	-0.045 ns
Taurus cedar		0.314**	0.412**	0.204*	0.091 ns	-0.052 ns

****;** Significant at the 0.01 level; ***;** Significant at the 0.05 level; ns; correlations not significant

Branch traits: Averages of the number, angle and diameter of branches for provenances and sites were presented in Table 2. They were also showed in Figures 5a, 5b and 5c. Branch traits had more effective on wood quality and forest tending such as pruning, and also resistance to snow damage. Scots pine had more branches than Taurus cedar and Black pine and also it had thicker branches than the others.

Scots pine had more branches than Taurus cedar and Black pine in each site and polled site (Table 2). Averages of branch number were 9.4 for Scots pine, 6.8 for Black pine and 5.5 for Taurus cedar in Aydogmus experimental site (Fig. 5a). They were 9.7, 8.2 and 5.2, respectively in Kemer experimental site as presented in table 2 and in figure 5a. Branch angle was the highest in Taurus cedar (37.6° in polled site) (Fig. 5b), while it was the lowest in Black pine (22.2°) (Table 2). Provenances of Scots pine had the thickest branches. It was 11.7 mm in Aydogmus site, 11.1 mm in Kemer site and 11.5 mm in polled sites (Table 2, Fig. 5c).

Variations of traits: There were large differences within provenance and among provenances for the traits within site, while sites showed similar ($0.05 \leq p$) performance for tree height and stem form according to results of Analysis of variance. For instance, average of tree height varied between 138.3 cm (Provenance 2) and 229.8 (Provenance 30) cm in provenances of Aydogmus site, it ranged from 130 cm (Provenance 11) to 246.1 cm (Provenance 21) in that of Kemer site. Averages of tree height of first provenance were 144.4 cm in first site and 194.5 cm in second site (Table 2). Individual tree height of the provenance varied between 69 cm and 267 cm, and ranged from 51 cm to 280 cm in sites. Averages of basal diameter were 40.2 mm in Aydogmus site, and 38.7 mm in Kemer site. They were between 31.2 mm and 49.1 mm, and between 33.3 mm and 48.0 mm in Aydogmus and Kemer sites, respectively (Table 2). The differences were also observed within provenance for all the traits. For instance, individual tree of first provenance was 10% in second, 6% in third, 8% in fourth, 16% in fifth and 60% sixth group for stem form in Aydogmus site (Table 3).

The provenances showed larger variations for tree height and basal diameter than that of the other traits according to results of Duncan's multiple range test (Table 4). There were 13 and 12 homogenous groups for tree height and basal diameter, respectively (Table 4) while it was 9 for stem form, 11 for branch diameter, and 10 for number and angle of branches (Table 4). There were large differences within provenance and among provenances for the traits within site, while sites showed similar ($0.05 \leq p$) performance for tree height and stem form. The provenances showed larger variations for tree height and basal diameter than that of the other traits. The differences were also reported for some seedling traits of the provenance by Gulcu & Bilir (2000). Fries (1999) reported significant differences for diameter and height in Swedish provenances of Scots pine. Perks & Ennos (1999) reported significant variations among populations for growth traits in provenance and progeny test in Scotland. Stephan & Liesebach (1996) reported large variations for branch number, branch diameter and stem form among populations of Scots pine populations. Large height growth differences were reported in provenances of Scots pine by Giertych (1979), Shutyaev & Giertych (1997). Alia *et al*. (2001) studied height, diameter, number of twigs at the fourth year whorl and survival on 16 Spanish and 6 German provenances of Scots pine (*Pinus sylvestris* L.*)* at age 5 after planting. Provenance by site interaction was very significant ($p<0.01$) for most traits. Dagdas *et al.* (1997) reported large differences among sites and among populations within site for height growth performance of 35 Scots pine provenances test established in 16 sites at age 7. Large differences were also reported for breast height diameter in Scots pine provenances at age 25 by Saatcioğlu (1967).

There could be from genetic, environmental effects or both in these variations such as site x provenance interaction. Beside, Scots pine is the pine species with the largest natural distribution area. It is not surprising therefore that variation among provenances.

Correlations among the traits: There were generally positive and significant ($p \leq 0.05$) correlations among the traits in the species for polled sites (Table 5). Tree height and basal diameter were more effective on the traits than that of the others. There were generally positive and significant ($p \leq 0.05$) correlations among the traits in the species. Tree height and basal diameter were more effective on the traits than that of the others. Stephan & Liesebach (1996) reported good and positive correlation between height and growth traits in Scots pine populations.

Significant relation was reported between stem straightness and severity index in the species (Eriksson, 2008). Oleksyn *et al.* (1992) found that elevation of the provenance had very effective on growth traits. For instance, Schneck & Hertel (1999) presented strong relationship between temperature and tree height at age 20.

It was known that height and diameter had very important roles in wood quantity. Averages of tree height were 181.2 cm in Aydogmus site, 182.0 in Kemer site, and 181.5 in polled sites. They were 40.2 mm, 38.7 mm and 39.6 mm for basal diameter in eight-year-old results of the provenance test. The average highest tree height of a provenance was 229.8 cm (provenance 30) in Aydogmus site and 246.1 cm (provenance 22) in Kemer site. It was 49. 1 mm (provenance 29) in Aydogmus site and 48.0 mm (provenance 22) in Kemer site. Stephan & Liesebach (1996) reported 242 cm tree height ranged from 159 cm to 317 cm of 26 Scots pine populations at age 9. They were also reported that average of diameter at breast height was 27.6 mm ranged from 14.5 mm to 37.2 mm. Dagdas *et al*. (1997) reported average height growth was generally lower than 200 cm in 35 Scots pine provenances at age7. Averages of tree height and breast height diameter were between 11.05 meters and 3.81 meters for height, and between 6.4 cm and 16.1 cm in 16 exotic and 1 native provenances of Scots pine at age 25 (Saatcioglu, 1967). Oleksyn *et al*. (1992) found ecotipic differences in growth traits in Scots pine populations. It was also known that Scots pine had different geographic races because of its large natural distribution (Saatcioglu, 1967). Natural distribution area of Turkish Scots pine was grouped into 5 main regions and 11 sub-regions for seed transfer (Atalay, 1977). The differences among provenances could be genetic or environmental.

Gezer *et al.* (2000) reported the highest average seedling height and root-collar diameter were 15.7 cm (provenance 13) and 3.87 mm (provenance 22) in 2+0 years old containerized seedlings of the provenances, respectively. They were also reported that provenance 13 had the highest quality seedling for height, while it was provenance 7 for root-collar diameter.

Provenances 22, 13, 23 and 29 of Scots pine showed better performances for height and diameter according to results of second growing season at the experiment (Gezer *et al.*, 2002). Provenance of Taurus Cedar had higher performances than Scots pine provenances at the end of second growing season of the experiment (Gezer *et al.*, 2002). Scots pine generally showed higher performances for height, basal diameter, number and diameter of branches than Taurus cedar and Black pine in eight-year-old results in the present study. It could be longer growth period in the experimental sites than natural distribution area of the species. These results emphasized that performances of the species and provenances were very changeable in first year. There was difference for height among provenances of 17 Scots pine provenances at the beginning. This difference has become more obvious when the trees reached their 25th years (Saatcioglu, 1967).

Averages of tree height and basal diameter of seed stand provenances showed generally higher performance than that of seed orchard provenances. It emphasized importance of adaptation capability than seed quality. It could be related to higher genetic diversity in seed stands than seed orchards. The results were also showed potential plantation of the species.

Conclusion

Large variations within provenance emphasized more importance of individual selection than mass selection in Scots pine. The provenances showed different performances for the traits in sites. It showed importance of local seed sources for biological and economical success of plantations. Local seed sources should be selected. Height was significant effective on the traits so, new studies should be conducted mainly on height as a growth trait. It was also supported by mostly positive and significant correlations among the characters. The present study conducted on growth traits. Future studies should be taken into consideration on resistance of global warming in provenances. Vegetative propagation should be considered for plantation because of the large variation within provenance. International scale should be prepared for stem form/quality in the species.

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