

Performance of *Pinus contorta* Dougl. Ex. Loud. Provenances at Three Sites in Eastern Turkey

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Abstract: *Pinus contorta* provenance trial with eight seed sources of lodgepole pine and a native provenance of scots pine was conducted in randomized complete block design at three locations to identify the seed sources best suited in the east of Turkey above 1500 m. The twelve-year performance of seed sources in three plantations was analyzed, and it was found that provenance and site were statistically significant for all parameters. Site differences in total height varied from 125.2 cm to 226.8 cm. At each trial seed sources showed significant differences in survival and height. Native scots pine grew taller and had more survival at all three locations compared to lodgepole pine seed sources. All seed sources of lodgepole pine would not be a good choice for plantation in Erzurum and Erzincan. The results of this provenance study also show that some seed sources of lodgepole pine is well suited for planting in Sarikamis which in the highest elevation (2220 m) if planting stock from the proper seed source is used.

Key words: Height • provenance test • scots pine • survival

INTRODUCTION

Pinus contorta Dougl. Ex. Loud. (lodgepole pine) is an ubiquitous species with a wide ecological amplitude. Although its coastal form grows mainly between sea level and 610 m, the inland form is found from 490 to 3660 m. The species was divided geographically into four varieties: *Pinus contorta* var. *contorta*, *P. contorta* var. *bolanderi*, *P. contorta* var. *murrayana*, *P. contorta* var. *latifolia* [1]. It grows under a wide variety of climatic conditions [2] and grows on soils that vary widely but are usually moist [3].

The performance of lodgepole pine in Turkey was first reported in northeastern Turkey by Simsek *et al.* [4]. The 4-year results of that provenance study with 34 lodgepole pine provenances at four locations of the north of Turkey showed that some provenances could be used for planting above 1000 m. And in another study provenances from British Columbia gave a promising result in the northeast of Turkey ranging from 1200-2000 m after 13 year results [5]. The performance of lodgepole pine in high elevations in northeastern Turkey was also reported by Eyupoglu [6] and nine seed sources showed significant differences in survival and height growth.

In high elevations regeneration of *Pinus sylvestris* L. (scots pine) has some difficulties in eastern Turkey, and

thus a study was established to find suitable provenances for planting above timberlines in eastern Turkey by Guven *et al.* [7] since the scots pine plantations above timberlines in eastern Turkey grew poor. Scots pine occupies about 715000 ha as productive forest in Turkey [8]. The southernmost occurrences of *Pinus sylvestris* are situated at about 37° N in Spain and 38° N in Turkey [9, 10]. It is generally found in areas with annual precipitation ranging from 600 to 1000 mm. Its altitudinal range in Turkey is from sea level on the coastal belt of the Black Sea to about 2700 m in northeastern Turkey (Sarikamis) [9].

This study was based on the provenance test of lodgepole pine done by Guven *et al.* [7] in eastern Turkey, and it was reported that after 5 years seed sources of lodgepole pine showed significant differences in survival and height growth in three trials. This paper reports the 12-year performance of the lodgepole pine seed sources in three plantations in eastern Turkey.

MATERIALS AND METHODS

Lodgepole pine seed collection, planting stock production and plantation establishment were previously documented [7]. Briefly, 8 seed sources of lodgepole pine were obtained from the Forest Tree Seed Centre, USDA

Table 1: Seed source data of *Pinus contorta* and *P. sylvestris*

Seed					
lot No.	Species	Sources	Lat.N	Long.W	Alt.m
1	<i>P. contorta</i>	Florence, Oregon	44°	120°	750
2	<i>P. contorta</i> var. <i>murrayana</i>	Oregon	-	-	-
3	<i>P. contorta</i> var. <i>latifolia</i>	Centurion Creek Canada	55° 35'	121° 40'	700-1000
4	<i>P. contorta</i> var. <i>latifolia</i>	Colorado	-	-	-
5	<i>P. contorta</i>	Tillamook-Oregon	-	-	1600
6	<i>P. contorta</i>	Valets-Oregon	-	-	-
7	<i>P. contorta</i>	Oregon-Deschutes	43° 30'	121° 30'	1200
8	<i>P. sylvestris</i>	Sarikamis, Turkey	-	-	-
9	<i>P. contorta</i>	Montana	45° 30'	111° 10'	2400

Table 2: Geographical and climatic features of the trial sites

Geographical and climatic features	Trial sites		
	Erzurum	Erzincan	Sarikamis
Lat. N	39° 53'	39° 55'	40° 18'
Longt. E	41° 19'	38° 41'	42° 34'
Elev., m	2110	1560	2220
Average high temperature, °C	12.6	18.5	10.6
Average low temperature, °C	-11.5	-1.3	-8.5
Average relative humidity, %	60.0	64	70.8
The lowest relative humidity, %	10	26	20
Average precipitation, mm	400.7	392.7	611.4
Average snowy days	61	25.5	58.3

Table 3: Soil properties of the study sites

Soil property	Trial sites		
	Erzurum	Erzincan	Sarikamis
Clay %	30.41	33.9	21.77
Silt %	26.1	19.04	28.78
Sand %	43.49	47.02	49.45
Textural class	CL	SCL	SCL
CaCO ₃ %	0.68	0.57	0.67
pH	6.67	7.45	5.95
N %	0.1	0.07	0.12
Organic matter	2.10	1.38	2.41

CL: clay/loam. SCL: Sandy clay/loam

Forest Service by Forest Tree Seeds and Tree Breeding Research Centre, Ankara (Table 1). 2+0 containerized seedlings were produced in nursery and were hand planted in the field in April 1994.

Containerized seedlings were out-planted at 2 years of age in three blocks with three replications in each trial site [7]. Seedling planting spacing was 1.5 x 3 m. A provenance of *Pinus sylvestris* from Sarikamis seed source was added to trial to compare its the potential with lodgepole pine. The geographical and climatic features of the trials site were given in Table 2. Soil characteristics at 0-30 cm in each study site were determined by Guven *et al.* [7] (Table 3).

The experimental design was a randomized complete block design. In the present study seed source differences in height and survival percentage after 12-year results of provenance test were analyzed using SPSS. All means were compared using Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

Site and provenance significantly affected survival and total height. Site differences in total height varied from 125.2 cm to 226.8 cm and site differences in survival varied from 54.8% and 67.1%. Average survival and height growth were the lowest in Erzincan. Survival and height were the highest at Erzurum (67.1%) and Sarikamis (226.8 cm), respectively when averaged over all provenances (Table 4).

At each trial seed sources showed significant differences in survival after 12 years. The provenances doing best at all locations were seed sources 2, 8 and 9. Most seed sources did poorly at all locations as a result of frost kill and snow breakage (Table 4).

Although seed source 5 showed the highest survival at Erzurum trial, there were not significant differences among seed sources 1, 2, 3, 5, 8 and 9. Seed source 6 showed the lowest survival percentage (39.6%). Seed sources 2, 7, 8 and 9 at Erzincan trial and seed sources 2, 3 and 4 at Sarikamis trial showed the highest survival. The lowest survival percentage was 25% (seed source 4) and 39.6% (seed source 5) at Erzincan and Sarikamis trials, respectively.

Height growth showed significant differences among locations and seed sources (Table 5). Height growth of seed sources was the highest (226.8 cm) at Sarikamis trial averaged for 9 seed sources. Seed source 8 was the fastest growing seed source in both Erzurum (187.4 cm) and Erzincan trials (219.3 cm). Seed sources 1, 3 and 9 had the lowest height growth at Erzurum (<150 cm) and seed sources 1, 3, 4, 6 and 9 at Erzincan trial (<120 cm). Best mean height (>300 cm) growth at 12 years were achieved by seed sources 3 and 8 at Sarikamis trial, and this

Table 4: Survival (%) of nine seed sources at the trial sites

Trial sites			
Seed sources	Erzurum	Erzincan	Sarikamis
1	60.4a	31.2bc	45.8c
2	79.2a	68.7ab	97.9a
3	68.7a	29.2bc	79.2ab
4	x	25.0c	83.3a
5	75.0a	47.9bc	39.6d
6	39.6b	41.7bc	43.7bc
7	x	87.5a	16.7d
8	77.9a	89.6a	62.5b
9	68.7a	72.9ab	66.7b
Mean	67.1	54.8	59.5

Means in column followed by the same letter are not significantly different at $p < 0.05$. x: no data.

Table 5: Height (cm) of nine seed sources at the trial sites

Trial sites			
Seed sources	Erzurum	Erzincan	Sarikamis
1	130.6c	110.4c	147.0cd
2	156.3b	139.4b	288.4ab
3	136.7c	102.2c	322.2a
4	x	65.9c	196.0bc
5	154.4b	117.4c	243.2ab
6	158.2b	103.7c	210.8ab
7	x	116.8c	69.6d
8	187.4a	219.3a	319.8a
9	145.3bc	152.0b	244.5ab
Mean	152.7	125.2	226.8

Means in column followed by the same letter are not significantly different at $p < 0.05$. x: no data.

location was in the highest elevation. At Sarikamis trial pH was the lowest (5.95) and organic matter was the highest compare to the other two trials. Seed source 7 had the lowest height growth (69.6 cm).

Five-year results of this provenance test were evaluated by Guven *et al.* [7] and seed sources showed significant differences in survival and height at all three trials after 5 years. At Erzurum trial although *P. sylvestris* had the tallest height (50.9 cm) as found in the present study, there were not significant differences among seed sources 1, 2, 5, 7 and 8 after 5 years, and seed sources 2, 3, 5, 8 and 9 had significantly higher survival than others. In this study, seed source 6 had the lowest survival percentage after 12 years and there were not significant

differences among other provenances. It was found that seed sources 1, 3 and 9 had the lowest height growth (<150 cm) at Erzurum trial.

Three seed sources, 1, 7 and 8 were the fastest growing seed sources (>57 cm) at Erzincan trial after 5 years [7]. Although seed source, 2, had the lowest height growth, the 6 slowest growing seed sources (2, 3, 4, 5, 6 and 9) didn't differ significantly. But in the present study it was found seed sources 1, 3, 4, 5, 6 and 7 had the lowest height growth (<120 cm) after 12 years at Erzincan trial. Seed sources 2, 4, 7, 8 and 9 had significantly higher survival than others at Erzincan trial. Seed source 4 had the lowest survival percentage (25%).

Seed sources 2, 3, 6, 7, 8 and 9 were significantly greater growing than others at Sarikamis trial after 5 years [7]. In the present study the best height growth (>300 cm) at 12 years was achieved by seed sources 3 and 8 at Sarikamis trial. Seed sources 2, 3, 4, 5, 6, 8 and 9 had significantly higher survival than others at Sarikamis trial. Seed source 7 had the lowest survival percentage (69.6%).

The performance of lodgepole pine in high elevations in northeastern Turkey was also reported by Eyupoglu [6], and nine seed sources showed significant differences in survival and height growth. One seed source showed significant performance above 2500 m.

In general, native *P. sylvestris* grew taller and had more survival at all locations compared to *Pinus contorta* seed sources in the present study. *Pinus contorta* seed sources of 2, 3 and 9 in Sarikamis performed nearly as well. All seed sources of *P. contorta* would not be a good choice for plantation in Erzurum and Erzincan. But according to the results some seed sources of *P. contorta* is well suited for planting in Sarikamis which in the highest elevation (2220 m) if planting stock from the proper seed source is used.

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