smaller plots and the same number of replications, the triple lattice structure could permit smaller experiments with no loss of precision.

10) Optimum plot size for precision of ranking at 1.5 years is probably from three to five trees; these small plots allow more replication and greater precision.

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Short Note: Winter Injury in a Scotch Pine (Pinus sylvestris L.) Clonal Seed Orchard

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Summary

Scotch pine clonal seed orchard trees, 3 to 6 years old, sustained varying amaunts of crown damage following prolonged drought stress and severe winter conditions in eastern Nebraska, U.S.A. Damage was greatest in the northwestern portion of the orchard, direction af prevailing winter winds. Primary branch tips and secondary branchlets of trees were killed by desiccation in the north and northwest portions of the crowns. Significant differences in injury were detected among clones and provenances, with greater variation between provenances than among clones within provenances. Provenances from most northerly and southerly regions incurred most damage. Age of trees was not significant.

Key words: Seed orchard, winter injury, Pinus sylvestris

Zusammenfassung

Drei bis sechs Jahre alte *Pinus sylvestris* in einer Klon-Samenplantage im östlichen Teil Nebraskas, U.S.A. erlitten nach längerer Einwirkung von Trockenheit und strengen winterlichen Bedingungen Schädigungen im Kronenbereich. Am schlimmsten waren die Schäden im nordwestlichen Teil der Samenplantage in der vorherrschenden Richtung der Winterwinde. Durch Austrocknung waren die Spitzen von Haupt- und Nebenästen der Bäume abgestorben. Signifikante Unterschiede in den Schäden wurden zwischen Klonen und Herkünften entdeckt. Die Unterschiede zwischen den Herkünften waren größer, als die zwischen Klonen innerhalb der Herkünfte. Die Herkünfte der nördlichsten und südlichsten Regionen wiesen die meisten Schäden auf. Das Alter der Bäume war nicht entscheidend.

Introduction

Young Scotch pine (*Pinus sylvestris* L.) trees in an eastern Nebraska, U.S.A. clonal seed orchard were observed with varying amounts of crown damage in the early spring of 1977. Damage was confined to the north and northwest portions of the crowns and was restricted to the killing of primary branch tips and secondary branchlets. The grafted trees ranged in height from 1.2 to 3.0 m. Evaluations were made early spring 1977 to determine the cause of the damage, and whether or not it was related to location within the orchard, age, clone, or provenance.

Study Site and Methods

The orchard, located about 50 km northeast of Lincoln, Nebraska, was established during 1971—74 from trees selected within a range-wide Scotch pine provenance test planted in Nebraska in 1962 (READ 1971, VAN HAVERBEKE 1974) (*Table 1*). The orchard is on a Sharpsburg silty clay loam with a zero to 2 percent slope to the southeast. It is ex-

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posed to prevailing winds with very little protection from topographic features or vegetation.

Scions from the selected provenance ortets were greenhouse-grafted onto a random mixture of 2 + 1 potted Scotch pine stock seedlings (race Noble-d'Auvergne, France; and Nelson King Strain, Raymond Nelson Nursery, Dubois, Pa.)[2]).

The orchard contains nearly 1,000 grafted ramets and covers about 4 ha. Forty-one clones are represented at random within each of 20 blocks. Spacing is 6- by 6-m.

Each tree was rated according to percent of crown damaged. Seven classes were recognized: no damage = 0; 1 to 5% damage = 1; 6 to 25% damage = 2; 26 to 50% damage = 3; 51 to 75% damage = 4; 76 to 99% damage = 5; and 100% damage = 6.

Results and Discussion

Source of Variation	df	MS	EMS	Comp. Var.	% Var.
Blocks	19	3.05**			
Clones	40	9.90**			
Provenances	17	19.63**	E + 20C + 45.56P	.3723	34.6
Clones w/in Prov.	23	2.67**	E + 20C	.1035	9.6
Error (B × C)	760	0.60	E	.6000	55.8
Total	819	1.07		1.0758	100.0

Table 1. — Origins and identities of Scotch pine clones in eastern Nebraska seed orchard.

Provenance	Country of origin	Latitude (degrees)	Longitude (degrees)	Elevation (meters)	Geographic variety[1]
		Northern			
265	Scotland	57.1	4.9W	195	*scotica*
		Central European			
527	E. Germany	50.9N	13.7E	518	*hercynica*
318	Belgium	51.2N	5.0E	-	*haguenensis*
235	N.E. France	48.2N	7.2E	701	*haguenensis*
203	S. Germany	48.2N	8.3E	-	*hercynica*
554	N. Italy	46.0N	11.2E	732	*"Italy"*
556	N. Italy	46.3N	11.3E	976	*"Italy"*
557	N. Italy	46.3N	11.0E	793	*"Italy"*
		Southern			
261	U.S.S.R. Georgia	41.7N	42.7E	1,098	*armena*
264	U.S.S.R. Georgia	41.8N	43.5E	1,585	*armena*
220	W. Turkey	40.0N	31.3E	1.433	*armena*
243	N. Greece	41.5N	24.3E	1,768	*rhodopaea*
551	N. Greece	41.3N	23.4E	1,494	*rhodopaea*
242	Yugoslavia	43.9N	19.4E	1,220	*illyrica*
239	S. France	45.3N	3.7E	1,006	*aquitana*
240	S. France	42.6N	2.1E	1,524	*aquitana*
245	Cen. Spain	40.7N	4.2W	1,463	*iberica*
218	Cen. Spain	40.3N	5.2W	1,128	*iberica*

[1]) WRIGHT *et al.* 1966.

Position Effect

Crowns of trees in blocks situated in north and northwest portions of the orchard incurred significantly more damage than trees in south and southeast blocks ($P < 0.01$). Prevailing winter winds are from the northwest; thus, these trees were more exposed to the desiccating effects of cold, dry wind. Trees in the southern portions of the orchard were protected by trees to the north and were, thus, somewhat sheltered.

Age Effect

Using year of planting, as the covariate, age of tree contributed nothing to the precision of the analysis. Correlation of crown damage rating to year was almost zero ($r = 0.01$); and the slope of the residual regression was also nearly zero ($b = 0.05$). Thus, the year of planting, or age of the trees, had no effect on the amount of crown damage.

Clonal Effects

Differences attributable to clones were highly significant ($P < 0.01$). Mean clone damage ratings ranged from 0.05 (almost no damage) to 3.81 (over 50 percent damage) *(Table 2).* Because of the high degree of precision in the analysis, a considerable amount of variation among clones is suggested. Actual differences in percent crown damage, however, except for clones from provenances 527 (E. Germany), 318 (Belgium), 218 (C. Spain) and 265 (Scotland), are not great *(Table 2).* For example, the percent difference in crown damage between clone M-551-2 (N. Greece; ranked #1) and clone G-556-1 (N. Italy; ranked #35) is only 6 percent). The number of clones per provenance varied from 1 to 6.

Clone within provenance variation was also highly significant, ($P < 0.01$), but accounted for only about 10 percent of the variation. Except for provenance 527, differences in percent damage among intra-provenance clones were relatively small *(Table 2).* The 6 clones within provenance 245 (C. Spain) differed by only 3 percent. Other clones within provenance groups, with similar or less variation, include 4 clones from provenance 240 (S. France; 2%) 3 from 551 (3%), and 3 from 242 (Yugoslavia; 1%).

Provenance Effects

Variation attributable to provenance was highly significant ($P < 0.01$), and accounted for about 35 percent of the variation in crown damage. Provenances 527 (E. Germany), 218 (C. Spain), 318 (Belgium) and 265 (Scotland) were the most severely damaged. Each of these provenances incurred mean damage ranging from about 10 to more than 40 percent; suggesting they are less well-adapted to the central Great Plains environment *(Table 2).* The situation with provenance 527 may be even more serious than these data suggest since each block contained one or more trees of the two 527 clones with damage exceeding 25 percent. In addition, a disproportionate number of previous ramet failures within the orchard have involved one or the other 527 clones. All other provenances, however, incurred only 6 percent or less crown damage.

Of interest is the contrast in performances between provenances from the same general geographic region; for

[2]) Trade names are used for the benefit of the reader, and do not imply endorsement or preferential treatment by the U. S. Department of Agriculture.

Table 2. — Crown damage among Scotch pine seed orchard clones and provenances.

Clone ranking	Prov. clone I.D.	Clones average rating	Clones crown damage	Provenances[1] average rating	Provenances[1] crown damage		
		(no.)	(percent)	(no.)	(percent)		
2	I-240-1	0.15	1				
5	I-240-4	0.32	2				
10	A-240-4	0.65	2				
14	N-240-4	0.76	3	0.47	2	a	
1	M-551-2	0.05	0				
11	H-551-3	0.68	3				
15	B-551-3	0.79	3	0.51	2	a	
3	M-557-2	0.20	1				
26	G-557-1	1.08	4	0.64	2	a	
4	E-261-3	0.30	2				
22	L-261-3	0.98	4	0.64	3	a	
6	B-554-4	0.45	2				
27	F-554-4	1.10	4	0.78	3	a	
9	G-243-4	0.62	2				
20	I-243-1	0.94	3	0.78	3	a	
12	B-220-3	0.70	3				
21	M-220-4	0.95	3	0.82	3	a	
7	N-245-3	0.58	2				
8	J-245-4	0.60	2				
13	F-245-1	0.70	3				
16	G-245-1	0.85	3				
24	J-245-1	1.00	4				
33	K-245-2	1.48	5	0.87	3	a	
18	I-203-2	0.90	3				
25	K-203-2	1.05	4	1.00	4	a	
23	D-235-4	1.00	4	1.00	4	a	
19	N-264-2	0.90	3				
28	F-264-1	1.12	4				
31	J-264-1	1.40	4	1.16	4	a	
17	E-239-2	0.90	3				
34	K-239-1	1.52	5	1.21	4	a	
29	G-242-3	1.28	4				
30	G-242-1	1.40	5				
32	L-242-1	1.45	5	1.36	5	a	
35	G-556-1	1.55	6	1.55	6	a	
36	G-265-2	1.75	9	1.75	9	a	b
37	L-218-3	1.80	10				
38	H-218-3	1.84	11	1.82	10		b
39	D-318-3	2.25	19	2.25	19		b
40	L-527-4	2.65	27				
41	B-527-3	3.81	56	3.23	42		b

[1]) SCHEFFE's Test: Any two means not within the same letter differ at 1% level.

instance, provenances 245 (3% damage) and 218 (10% damage) from central Spain. This intra-regional genetic variation can best be explained on the basis of varying levels of selection pressure within a relatively large geographic region. Genetic sampling within local populations would account for the usually smaller amount of variation among clones within a provenance. Being grafted trees, however, one cannot discount the possible influence of varying scion-stock interrelationships. Lacking comparison of seedling progenies of similar age and origin, one can only speculate as to the exact nature of this variation.

Interpretation

Drought, preceding severe winters, can have a profound influence on tree survival. EICHE (1966), in Sweden, reported no injury to Scotch pine during the severe winter of 1954—55, following a normal summer 1954. He reported high death rates, however, in the winter of 1956—57, following a protracted drought in summer 1955.

Abnormally cold, dry, windy winters with below normal snowcover characterized the years 1975—77 at the seed orchard site. Severe drought, with hot, windy summers also prevailed during this period, with precipitation deficits of 280 mm for each of the years 1975 and 1976. Average annual rainfall is 760 mm. These conditions apparently placed severe physiological stress on the young Scotch pine trees during the winter of 1976—77.

Locales from which provenances 527, 318 and 265 originate are somewhat milder and wetter in winter, and cooler and more humid in summer than the seed orchard site under normal conditions. Thus, winter burn (dessication), aggravated by summer drought seems to be the probable explanation for injury of these provenances within the seed orchard.

Conversely, provenance 218 (C. Spain) was also more severely damaged; but is from a drier, less humid locale than the seed orchard. It is also one of the most southerly provenances, however; and factors other than dessication may have contributed to winter injury in these clones. EICHE (1966), in Sweden, however, found the southern Scotch pine provenances to be most susceptible to drought in a northern Sweden test. He pointed out that (mechanisms for) resistance to drought and cold are similar.

Because of natural selection and adaptation, provenances 527, 318, 218 and possibly 265 appear to lack genes which confer a high degree of winter hardiness in the Nebraska seed orchard environment. These data, relating to a single indicator of adaptability are, of course, not sufficiently diagnostic to base final seed orchard composition upon. They do emphasize, however, the importance of knowing as much as possible about the provenance environment and the intended planting site environment prior to seed orchard establishment.

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