VARIATION IN COLD-HARDINESS IN BLUE PINE

Howard B. Kriebel 1/

Abstract. Among three-year-old blue pines from 54 seedlots, only those from Nepal had winter burn and mortality after the first winter in the field in Ohio. In contrast, mortality varied from zero to 100% among growing one-year-old progenies of 102 seedlots after exposure to spring frost. Most selections from Pakistan had a high survival rate, as did some from the Middle Himalayan region of India. Survival was low among most selections from Kashmir and Nepal.

INTRODUCTION

Cold-hardiness is an important consideration in the introduction of blue pine (*Pinus griffithii* McClell)2/ into North America and Europe. Some hardy introductions survive in the northern parts of the USA, but seed source records are inadequate or non-existent.

Recently, IUFRO's Working Party on Breeding White Pines obtained collections of blue pine seed from documented sampling points in the western and central parts of the species distribution. Seed was distributed to 22 cooperating institutions in 12 countries.

This paper reports early evidence of variation in cold hardiness of IUFRO material in Ohio, as measured by (1) winter foliage burn and mortality of 3-year-old trees and (2) differential reaction of growing nursery seedlings to spring frost.

MATERIALS AND METHODS

Source-documented seedlots were obtained from individual trees in Afghanistan, Pakistan, India and Nepal. Collection records are available from the author.

The first experiment contained 54 single-tree seedlots, including IUFRO accessions 6001, 6005 and 6006, 6008 to 6027, and 6029 to 6059. Origins of 45 of the seedlots are listed in Table 1. The others were from Kashmir and Uttar Pradesh in India.

Two-year old container-grown seedlings were hand-planted bare root on a previously-prepared old-field site near Coshocton, Ohio in 8 replications of 4-tree plots. The trees were under lath house protection during the two winters prior to planting. At the end of the first winter

---

1/ Professor, Department of Forestry, Ohio Agric. Research and Development Center, Wooster, OH 44691. Special acknowledgment is due to Dr. P.D. Dogra, Central Arid Zone Research Institute, Jodhpur, India and to the Pakistan Forest Institute, Peshawar, Pakistan for extensive seed collection efforts.

2/ Taxonomy according to Critchfield and Little 1966 (syn. P. *wallichiana* A. B. Jacks.).

in the field, after exposure to temperatures to -18 C, all trees were scored for the presence or absence of foliage burn, Mortality records were taken the following summer.

A subsequent blue pine experiment included 10 trees of each of 102 single-tree seedlots of 22 origins (Table 1, Fig. 1). The seeds were sown in May in plastic tubes in a greenhouse. In October, the trays of seedlings were transferred to a single cold frame for winter chilling, where they were closely arranged in an area of about 1.5 square meters.

Table 1. Spring frost survival rate of one-year-old blue pine seedlings in relation to seed origin.

		Seed origin			Percent survival of seedlots		
Map symbol	IUFRO Seedlot no.(s)	Country, district, locality	Elev. m	Clim. zone[1/]	Range	Average[2/]	
A	6070-79	Pakistan, Kurram, Parachinar	2195	Dry	90-100	99	a
B	6034-35	India, Himachal Pr., Simla	2350	Moist	80-100	90	
C	6100-09	Pakistan, Swat, Utror	2440	Dry	50-100	87	ab
D	6036-45	Pakistan, Hazara, Panjoul	2960	Moist	60-100	84	bc
E	6060-69	Pakistan, Chitral, Bamburet	2315	Dry	30-100	73	cd
F	6110-13	Pakistan, Hazara, Kalabagh	2285	Moist	60-100	72	
G	6114	Pakistan, Hazara, Murree	2285	Moist	--	70	
H	6090-99	Pakistan, Dir, Kalkot	2240	Dry	40- 80	65	d
I	6001	Afghanistan, Paktia, Kotgai	2450	Dry	--	50	
J	6031-32	India, Himachal Pr., Chamba	2530	Moist	10- 80	45	
K	6080-89	Pakistan, Azad Kashm., Kiran	2135	Moist	0- 80	42	e
L	6116-25	India, Kashm., Liddar Valley	2225	Dry	0-100	34	e
M	6019	India, Himachal Pr., Manali	2135	Moist	--	30	
N	6046-55	Pakistan, Hazara, Malkandi	2515	Moist	10- 30	25	e
O	6015	India, Kashmir, Sonamarg	3045	Dry	--	20	
P	6022	India, Kashmir, Baltal	3045	Dry	--	20	
Q	6033	India, Himachal Pr., Sanjoul	2135	Moist	--	20	
R	6006	India, Himachal Pr., Kaithu	1889	Moist	--	20	
S	6018	India, Uttar Pr., Chakrata	2135	Moist	--	10	
T	6005	India, Himachal Pr., Kaithu	2070	Moist	--	0	
U	6012	India, Kashmir, Kangan	2285	Dry	--	0	
V	6009-11	Nepal, Tistung, Makawanpur	2285	Moist	--	0	

1/ Dry zone has precipitation mainly in winter; moist (monsoon) zone mainly in summer.

2/ Average survival rates with the same letters in the superscript are not significantly different at $p < 0.05$. The analysis only included the eight 10-seedlot origins.

Insolation in late winter caused growth initiation prior to sash removal. After sash removal, a temperature drop to -6°C caused severe injury to the growing seedlings. Mortality was recorded before and after transplanting of the tube-contained seedlings into nursery beds.

RESULTS

After one winter in the field, most of the needles of every tree of seedlots 6009, 6010 and 6011 from the one Nepalese origin were brown to some degree. No other seedlots had evidence of winter burn. Subsequently, there was a 23% mortality of trees of Nepal origin attributable to winter burn but no cold-related mortality of trees of other origins.

In contrast, the effect of subfreezing temperature on the growing seedlings in tubes was much more pronounced. The survival rate of individual progenies varied from 100% to zero (Table 1). Eight of the 9 origins with 50% or higher average seedling survival were in the westernmost part of the species distribution in Pakistan and Afghanistan. Some seedlings of Indian origin from the province of Himachal Pradesh had a high survival rate, but mortality was heavy in most progenies from India. All trees from Nepal were killed.

Seed origin differences in average survival rate were significant ($p < .01$). The analysis was limited to the 8 origins represented by 10 single-tree seedlots. Significant gaps in the ranking of these 8 origins are presented in Table 1.

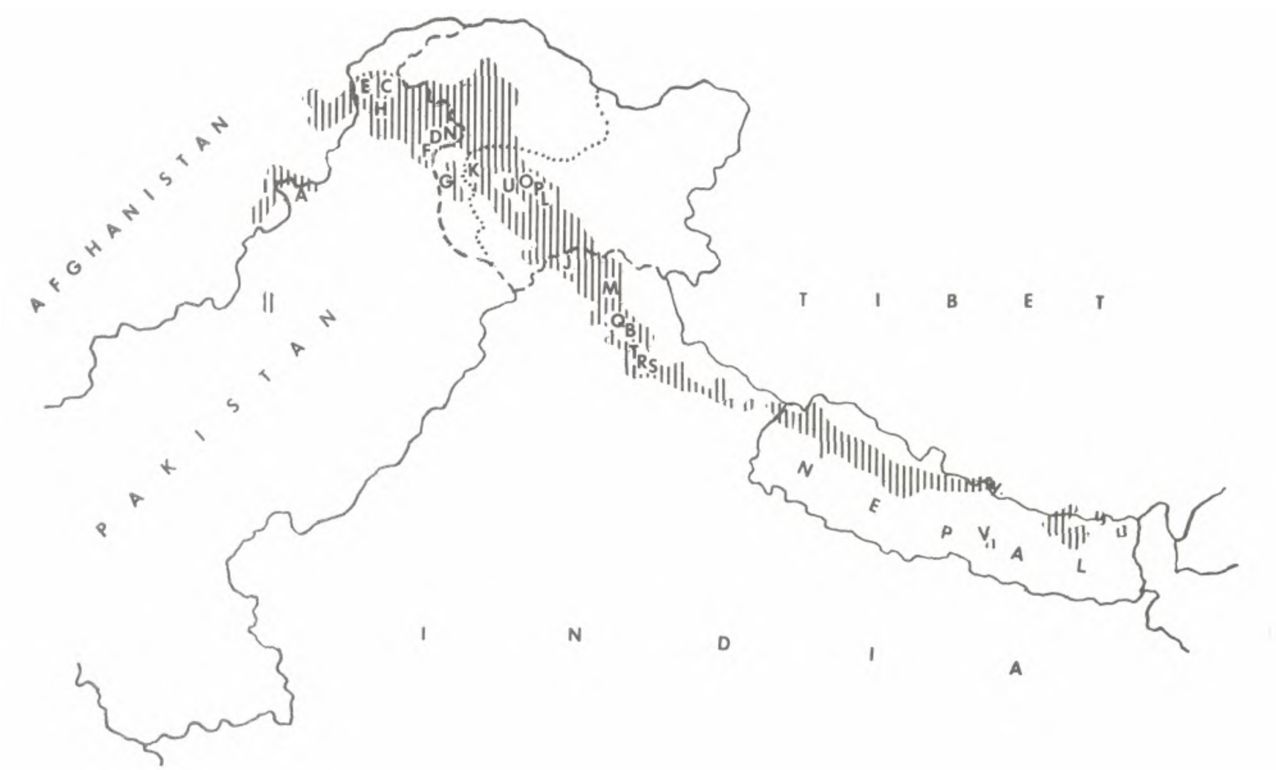

Figure 1.--Blue pine distribution, excluding areas east of Nepal, and sampling points (map symbols A to V).

DISCUSSION

Phenotypic variation in response of field-planted trees to the first winter's environment revealed little of the actual genotypic variation in cold-hardiness. Only the trees from Nepal were affected.

Evidently the Nepalese trees were more cold-sensitive than any of the others. Unlike cold-sensitive trees from India, they were affected by low dormant-season temperatures as well, as by low temperature effects on actively-growing seedlings.

Conditions imposed on the small, growing plants were artificial and unusually severe. The results might not be relevant if nursery material is provided with reasonable protection during the winter, as in the first experiment. On the other hand, the mortality may be indicative of the potential impact of an occasional severe winter or extremely late frost on trees of these genotypes after they have been planted in the field.

Seedlots low in cold-hardiness should be included in other IUFRO seed source tests, because replicated testing is necessary in a diversity of environments. Also, we have no information at present on growth rate, disease resistance, branch habit or wood quality. Surviving specimens of cold-sensitive genotypes may be useful for species hybridization if they have other valuable traits. Experiments have shown that hybrids of this species are often more cold-hardy than the blue pine parent (Kriebel 1972).

Wide variation in cold-hardiness could be expected in a species with a 3,000 kin east-west distribution, occupying sites varying in elevation from 1,200 to 3,800 m, and occurring on both the monsoon and dry sides of slopes in the Himalayas with annual precipitation varying from 250 mm to 5,000 mm (Ahmad and Khan 1972, Dogra 1972). Table 1 does not indicate a. relationship between survival rate and elevation or climatic zone, but these experiments include only 22 origins and some are represented by one single-tree progeny. Sampling was heaviest in the western part of the range, sparse in India and Nepal, and we have no material from Bhutan eastward to China.

There were indications of a geographic pattern of variation. in cold-hardiness even if it cannot be related to known habitat conditions at this time. Most selections from Pakistan had a high survival rate, whereas survival of Kashmir and Nepal selections was low.

On the other hand, samples from the Middle Himalayan regions of India (Himachal Pradesh and Uttar Pradesh) varied widely in survival rate. Cold-hardy selections from this region may be of particular interest if the good growth of native stands (Dogra 1972) is any indication of growth potential elsewhere. In contrast, winter-hardy introductions from Pakistan have been slow-growing in Canada (Heimburger, personal communication).

Additional sampling and testing of Middle and Eastern Himalayan stands is urgently needed. We now have collections from 30 additional Pakistan origins, providing a reasonably adequate basis for evaluating the adaptability and growth potential of blue pine from the western part of its natural range.

LITERATURE CITED

Ahsan, J. and M. I. R. Khan. 1972. _Pinus wallichiana_ A. B. Jackson in Pakistan. _In_: Biology of rust resistance in forest trees, p. 151-162. USDA Forest Serv., Misc. Publ. 1221.

Critchfield, W. B. and E. L. Little, Jr. 1966. Geographic distribution of pines of the world. USDA Forest Serv., Misc. Publ. 991, 97 p.

Dogra, P. D. 1972. Intrinsic qualities, growth- and adaptation-potential of _Pinus wallichiana_. _In_: Biology of rust resistance in forest trees, p. 163-178. USDA Forest Serv., Misc. Publ. 1221.

Kriebel, H. B. 1972. White pines in North and Central America: _Pinus strobus_ and introduced Asian and European species. _In_: Biology of rust resistance in forest trees, P. 201-214. USDA Forest Serv., Misc. Publ. 1221.