A SCOTS PINE CLONAL SEED ORCHARD OF PROVENANCE ORIGIN

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Abstract.--Scots pine trees exhibiting desirable Christmas tree characteristics were selected in 1969 from a 36-origin, 7-year-old provenance plantation in Nebraska. Scions from selected ortets were grafted, over a four-year period, onto potted Scots pine stock in the greenhouse (82% success) and on field grown stock (69% success). A one-thousand tree, 10-acre, clonal seed orchard has been established. The seed orchard is arranged in randomized complete blocks containing one ramet each of 42 selected ortets. Spacing is 20 feet x 20 feet. Details of grafting techniques, site preparation, care and maintenance, and time of expected seed production are given.

Keywords: Scots pine, Pinus sylvestris, seed orchard, grafting.

Conifers are being planted on the Great Plains for Christmas trees, for landscaping recreation areas and highways, for protecting rural homes, crops and livestock, and for beautifying urban homes. Eight species of conifers accounted for over 80 percent of the seedlings distributed in 1972 through the Clarke-McNary program in Nebraska, and Scots pine (Pinus sylvestris L.) ranked fourth among them.

While Scots pine has been planted on the Great Plains for nearly 100 years, its full potential as a tree for this region has not been realized because performance has been judged on relatively few and mostly unknown seed origins (Read 1971). It has become an important exotic in the last 20 years largely because of its greatly increased use for Christmas trees (Read 1973). Thus, there is a general need for improved strains of Scots pine seed for use in Great Plains forestry.

THE BASE POPULATION

In 1959, a range-wide provenance test of Scots pine was begun by researchers at Michigan State University (Wright and Bull 1963). Seed was collected from approximately 120 native and planted stands throughout the natural range of Scots pine from central Spain to western Siberia. Seedling progenies of these provenance sources were outplanted in 1961 and 1962 at six field locations in the north Central region of the United States, including Nebraska (Wright et al. 1966).

The Nebraska plantation was established in 1962 with 2+1 seedling stock from 36 of the 120 geographic origins. The distribution of provenance materials in this plantation extends across Europe and Asia, encompassing

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the region generally bounded by 10° west and 100° east longitude and 40° to 60° north latitude (Fig. 1).

Each origin is replicated seven times in 4-tree plots. Trees are spaced 7 feet apart within rows and 14 feet between rows. The plantation occupies 2.6 acres and contains about 1,000 trees. The trees ranged in height from 7 to 16 feet at the end of the eighth growing season (Read 1971).

Improved Scots pine from these origins could be obtained for use in Nebraska in two ways: (1) by obtaining seeds from native stands in Europe and Asia that proved to be best adapted and most desirable in Nebraska, and (2) by establishing a clonal seed orchard from progeny-tested trees selected from our provenance plantation. Both methods are being utilized--the latter is reported in this paper.

Clonal seed orchards are usually established with ramets propagated vegetatively from ortets selected from natural populations within the same geographic region in which the seed from the orchard is to be planted. With a non-indigenous species such as Scots pine, however, selections must necessarily originate either from private or commercial plantings--often of doubtful or unknown origin--or from experimental plantings comprised of a wide range of seed sources, but of known origin. The former category is essentially non-existent in Nebraska, but our provenance plantation is an excellent example of the latter category.

Johnson (1960) reported that seed of a good race hybrid, pure or in mixture with parent trees, can be mass produced in a clonal seed orchard. He reported that several of the plus-tree orchards in Sweden have a certain character of being race-hybridization orchards in that they contain plus-trees from a wider geographic area than the orchards will serve in seed distribution.

METHODS AND MATERIALS

Selection

Trees in the provenance plantation were inspected on the basis of their desirability for: (1) winter foliage color, (2) straightness of stem, (3) taper, (4) crown density, and (5) symmetry of crown, or balance (Polk 1964). Provenance origin was not considered. The plantation yielded 65 candidate trees. This group was then rated quantitatively by means of a "Desirability Index"--an adaptation of the hybrid index developed by Anderson (1949). From these, 45 trees with the highest index scores were retained as the plus tree selections. Eighteen of the 36 provenances in the plantation were represented among the selections, and the number of selected trees within a provenance range from one to seven.

All selected trees, except a few of central European and Scottish origin (Nos. 318, 527 and 265) are from the southern provenances. Their distribution forms an east-west transect across the southern portion of the

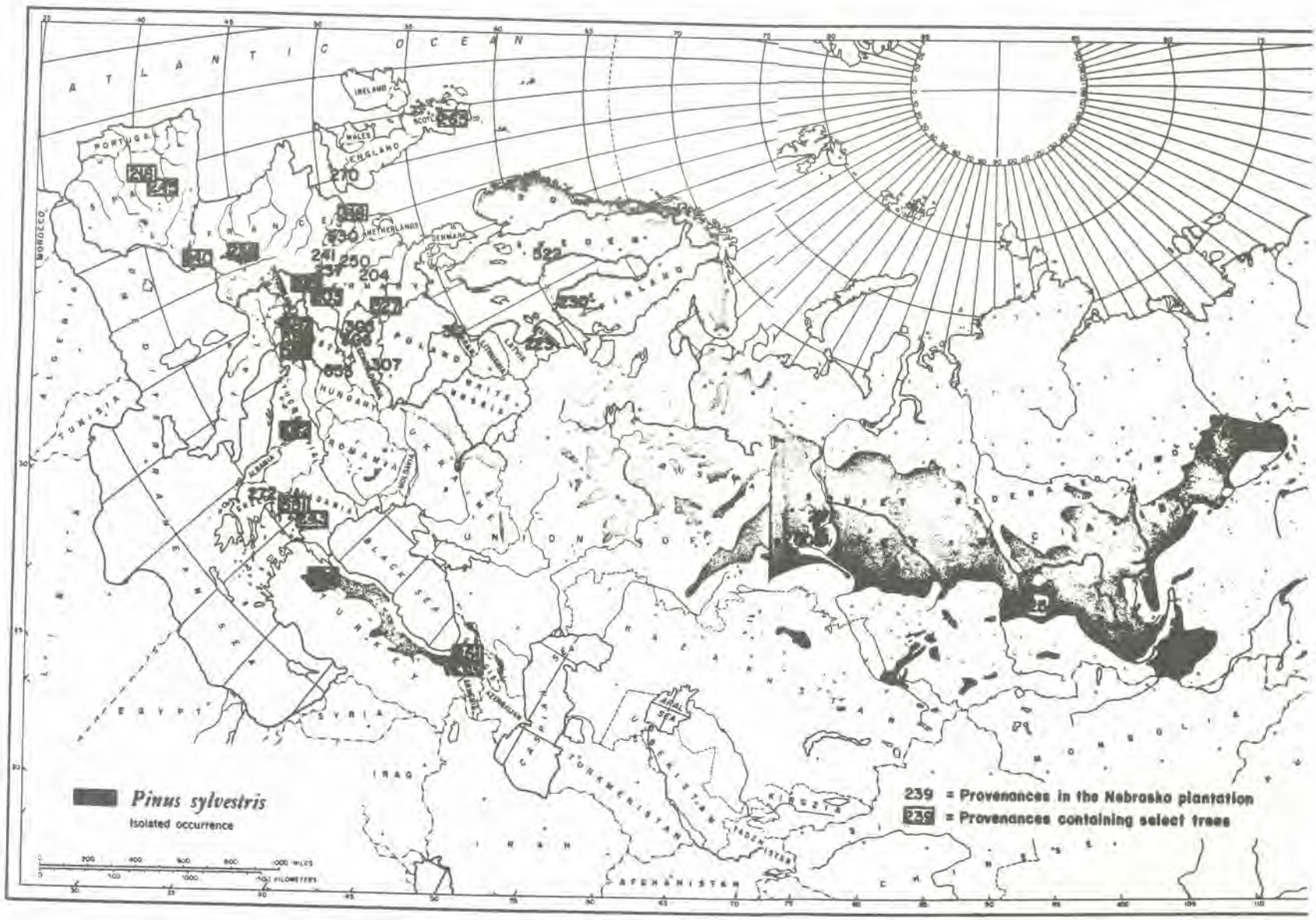

Figure 1.--Distribution of Scots pine seed sources growing in the Nebraska provenance test. Numbers are Michigan State University origin designations. Blocked numbers indicate origins selected for the seed orchard program.

range of the species. While trees of excellent stem straightness, taper, density, and balance were also found in more northerly provenances, they failed to qualify because their winter foliage was yellow--an undesirable Christmas tree trait.

Vegetative Propagation--Greenhouse Grafting

For convenience and efficiency, we grafted mostly onto potted Scots pine seedling stock in the greenhouse. We used 2+1 stock from the U.S. Forest Service Bessey Nursery at Halsey, Nebraska and the Raymond Nelson Nursery in Dubois, Pennsylvania ("Nelson King Strain") 2/. Seedlings were lifted in November following a hard freeze, planted in 2-gallon plastic nursery pots containing a 1:1:1 mix of soil, peat, and sand, and placed in the greenhouse to break dormancy. A night temperature of 15° C (60° F) was maintained. Grafting was begun in early March after the stock plants initiated root and shoot growth.

In late February or early March, scions were collected from the upper third of the crowns of select trees. They were cut 15-20 cm. (6-8 inches) long, placed in polyethylene freezer bags containing a small amount of damp sphagnum moss, and stored at 2° C (35° F) until time of grafting. Storage time varied from 1 to 3 weeks. Scions were prepared for grafting by submerging their cut tips in water overnight to increase turgidity.

The following steps were used in our greenhouse grafting procedure:

1. Trim scions 11 to 12 cm. long, and remove all needles except for 3 cm. below the bud.
2. Cut end of scion to form two opposite wedge-shaped surfaces each 4 cm. long to insure a minimum of 8 cm. of exposed cambial surface for union on each face of cut.
3. Cut diagonally and downward about 4 cm. into 1-year-old wood of stock stem, where the stem diameter permits best matching of the cambial surfaces of scion and stock tissue.
4. Insert scion, match cambial surfaces, hold stock and scion securely in position, wrap wound area snugly with grafting rubber, and paint wound area with neutral, black grafting compound (Tree Seal).
5. Attach tag to seedling containing tree identification, date grafted, and initials of grafter.
6. Slip non-perforated polyethylene bag over top of plant, covering graft wound but leaving bag open at bottom.
7. Maintain moderately shaded greenhouse condition with whitewash on glass, keep soil of stock plants moist, and keep greenhouse humid with twice daily syringings of walks, walls, and glass.
8. Do not apply supplemental lighting or shade cloth; they tend to increase heat build-up inside bags, causing unnecessary stimulation of top growth, and reduce air circulation.

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.

9. Remove plastic bags as newly emerging needles on scions attain "pinfeather" stage of development; support and straighten uncovered plants with cane stakes.

Successful grafts were kept in the greenhouse in cool, humid conditions until after danger of killing frost (mid-May in Nebraska). Grafted trees were then moved out-of-doors into a 50-percent-shaded lath house. Pots were buried to the soil line in sand under an automatic sprinkler system to maintain moisture and high humidity.

Stock plant foliage was removed in prunings of one-third each time over a 3-month period in July, August, and September (Zak 1955). Trees were transplanted into seed orchard positions during April of the following year.

Average percentages of 72, 84, 83, and 88 were attained with greenhouse grafting for the years 1970 through 1973, respectively (Table 1). The 1972 and 1973 data represent experiments (randomized complete blocks with 6 replications) designed to detect differences in ease of grafting among clones. Significant differences at the probability level of 0.01 were demonstrated. These data suggest that certain clones (K-203-2, D-235-4, F-242-4, F-554-4, M-557-2, M-551-2, B-220-3, and F-264-1) tend to be more difficult to graft than others. The lack of yearly consistency is unexplainable, however; therefore, no clones have been discarded from the program solely on the basis of low grafting success.

Vegetative Propagation--Field Grafting

Our experience with field-grafted plants was limited to one season. The technique was apparently satisfactory, however, and the results were encouraging.

Scions were collected in April, before shoots began elongation. Collection and storage procedures were as described for greenhouse grafting.

In late April 1970, scions were grafted onto 2+2+2 field-grown stock plants. Techniques were the same as in greenhouse grafting, except that: (1) the polyethylene bags were closed around the stem of the stock plant with a "twistem", and (2) an aluminum hood, open on the north side, was wrapped around and over the polyethylene bag encasing each graft (Webb 1961). The protective coverings were inspected weekly for damage by wind or other causes.

After the newly emerging needles on the scions reached the "pinfeather" stage, the nearly air-tight seal of the polyethylene bags was broken by loosening the "twistems" and poking holes in the bags with a pencil. The hoods and bags were completely removed after the needles on the scions developed beyond the pinfeather stage. Knitting of the cambial tissues--as with the greenhouse grafts--required 4 to 6 weeks. Plants were inspected periodically throughout the summer, pruned as were the greenhouse-grafted trees, and watered twice--once in July and again in August.

Table 1.-- Summary of greenhouse and field grafting (1970-1973) of Scots pine

Tree ID	Prov. origin	Greenhouse[1] 1970	Greenhouse 1971	Greenhouse 1972	Greenhouse 1973	Field[2] 1970	Tree ID	Prov. origin	Greenhouse 1970	Greenhouse 1971	Greenhouse 1972	Greenhouse 1973	Field 1970
		Percent											
G-265-2	SCO	-	89	83	100		B-554-4	ITA	-	63	100	67	
							F-554-4	"	-	78	67	50	
D-318-3	BEL	-	100	100	100	80							
							G-556-1	ITA	-	67	67	83	
H-218-1	SPA	17	75	83	100	100							
L-218-3	"	100	100	100	83		G-557-1	ITA	-	100	83	100	
							M-557-2	"	-	100	50	83	
F-245-1	SPA	100	100	83	100								
F-245-4[3]	"	50	-	-	-	75	F-242-4	YUG	-	11	0	100	0
G-245-1	"	-	89	83	100		G-242-1	"	-	100	83	100	50
J-245-1	"	-	100	100	100		G-242-3	"	100	-	83	100	100
J-245-4	"	-	100	83	100	75	L-242-1	"	-	80	83	100	60
K-245-2	"	67	100	83	100		B-551-3	GRE	83	100	67	100	25
N-245-3	"	50	100	100	100		H-551-3	"	83	100	100	100	
							M-551-2	"	83	50	100	50	
A-240-4	FRA	83	-	83	100	100							
D-240-2[3]	"	-	-	-	-	75	I-243-1	GRE	0	67	67	100	
I-240-1	"	100	-	83	100		G-243-4	"	-	89	83	100	
I-240-4	"	83	75	83	67								
N-240-4	"	-	100	100	100	100	B-220-3	TUR	-	100	83	67	
							M-220-4	"	-	100	100	100	60
E-239-2	FRA	71	100	83	33								
K-239-1	"	-	80	100	83	50	E-261-2	RUS	67	100	100	67	
							G-261-2	"	-	-	-	100	
D-235-4	FRA	100	100	33	67	50	L-261-3	"	100	67	100	83	
I-203-2	GER	17	88	83	83		F-264-1	RUS	83	-	83	67	100
K-203-2	"	-	71	50	33	0	J-264-1	"	-	50	100	100	100
							N-264-2	"	100	100	100	100	
B-527-3	GER	-	100	83	100	100							
L-527-4	"	50	67	83	100	75							
								Average	72	84	83	88%	

1/ Percentages based on 6 grafts each year, except 1971 when numbers varied from 2 to 9 grafts.

2/ Based on 4 or 5 grafts per tree.

3/ Destroyed by tornadic winds.

The results--69 percent success--were encouraging (Table 1). Some of the clones which were difficult to graft on potted stock in the greenhouse were also more difficult to graft in the field (K-203-2, D-235-4, and F-242-4 are examples).

SEED ORCHARD ESTABLISHMENT

Our seed orchard was begun in the spring of 1971, when all available grafted trees were hand-planted in assigned positions. All remaining positions were machine-planted with two 2+0 Scots pine seedlings for two reasons: (1) to have all seed orchard positions filled for convenience of establishment and maintenance, and (2) to provide opportunity for completing blocks, either by establishing a field graft or by planting a greenhouse-grafted tree, whichever could be obtained first. The seedlings were cut out if a greenhouse-grafted tree was ready first, or if the field graft was unsuccessful.

We planted the grafted trees in randomized complete blocks of (6x7) 42 trees, containing one ramet each of 42 ortets at a spacing of 20 by 20 feet. Positions for clonal material within each block were assigned randomly, except that if ramets from the same ortet or provenance source occurred next to one another, they were reassigned to be at least two positions apart. It is possible, although not probable, that ramets from the same provenance could be half-sibs, and could, thus, contribute to inbreeding depression. Also, tester trees (staminate pollen donors) used in our concurrent progeny testing program were structured within each block to insure adequate pollen dispersal throughout the orchard by known heavy pollen producers.

Twenty blocks containing 840 trees, and an additional 160 positions around the block borders and odd corners, have been established with grafted trees during four planting seasons. The seed orchard is about 10 acres in size.

A few blocks contain some clones represented more than once where we were unable to produce sufficient numbers of grafts of particular clones. Field survival has averaged above 98 percent to date.

CARE AND MAINTENANCE

Our seed orchard was established in a field of milo stubble, with no site preparation prior to planting. Potted grafts were hand-planted, and 2+0 stock seedlings were machine-planted into the weed-free and undisturbed stubble.

The unplowed milo stubble presented no planting problems, and was considered an asset rather than a liability to the establishment of the trees. The stubble trapped and held snow on the site during the previous winter, thus increasing soil moisture during the spring. The stubble also provided some protection in the early spring when strong, dry winds sometimes desiccate seedling tops before root action begins in the colder soil.

Simazine at 4 lbs. per acre was sprayed in a 40-inch band over the trees after planting to control weed growth. This spray has been repeated at the beginning of each subsequent growing season. Some hand hoeing has been necessary each summer to remove weeds in the immediate vicinity of the trees.

Until 1974 the orchard was disked between the tree rows periodically during each growing season, and annual oats was sown as a cover crop each fall to provide protection from blowing soil. No trees sustained noticeable winter-burn.

Clean cultivation by disking was discontinued during the summer of 1974, and the orchard was planted to a permanent cover of perennial grasses. It will be kept mowed and simazine will be applied for several more years for weed control around each tree until the tree crowns are dense enough to shade out competing vegetation.

Wire screens 18 inches in diameter and 2 to 3 feet tall were placed around each tree during the first two years as a precaution against rabbit injury. Rabbits partially stripped the foliage from a few trees during a prolonged period of snow in the winter of 1973, but no buds were nipped off and all trees have recovered. Trees have been watered with a tanker truck three times during excessively dry periods, and plans are being made to install a pipe irrigation system.

No insect problems of consequence have been encountered to date, but evidence of brown spot needle blight (Scirrhia acicola (Dearn) Siggers) has recently been identified in the provenance plantation on some of the short-needled southern sources.

While many trees are producing a few cones even now, we anticipate substantial seed production in about 10 years.

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