NORTH CENTRAL FOREST EXPERIMENT STATION

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SEED QUALITY IN FIVE JACK PINE STANDS IN NORTH CENTRAL WISCONSIN

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ABSTRACT.--Hundred-seed weights from 15 trees in each stand averaged 330 mg; 100-seed weights differed significantly among trees within stands and among stands. Germination of filled seed averaged 95 percent; germination differed significantly among trees within stands, but not among stands. Detailed seed records should be kept for all seed orchards.

KEY WORDS: *Pinus banksiana,* seed weight, seed germination, variation, seed quality.

Jack pine (*Pinus banksiana* Lamb.) exhibits rapid juvenile growth, begins to produce seed at a very young age, grows on a wide variety of sites, and produces high fiber yields. When grown for short rotations (30 to 40 years) on good soils, locally adapted jack pine may produce more wood per acre than red pine or other indigenous conifers (Rudolph and Yeatman 1982). In Canada and the Lake States it is a major source of pulpwood. During 1979, approximately 599,500 cords of jack pine pulpwood were harvested in Michigan, Minnesota, and Wisconsin (Blyth and Smith 1981). This amounted to 40 percent of all conifer pulpwood harvested in these States. Jack pine currently ranks number one among the conifers in pulpwood production and use in the Lake States.

In the Lake States jack pine is commonly reproduced through clearcutting and discing of lopped and scattered branches and it ranks third in artificial regeneration. The national forests in the region plant 2 million seedlings and direct seed 350 lbs of jack pine seed annually. Production of 1.6, 0.2, and 3.3. million seedlings in Minnesota, Wisconsin, and Michigan, respectively, in 1980-1981 attest to similar substantial planting programs on state and private lands in these States. Planting is expected to increase in coming decades in response to a realization of the need to maintain species diversity and of jack pine's great biological potential when grown under intensive culture for short rotations (Zavitkovski *et al.* 1981).

A key ingredient to successful artificial regeneration is seed quality. Much information is available on quality of jack pine seed from individual cones, trees, natural stands, plantations, provenance tests, and young seed orchards (Cecich and Rudolph 1982; Eyre and Le Barron 1944; Fowler 1965; Radsliff 1981; Rudolph 1966, 1976, 1979; Rudolph and Cecich 1979; Rudolph and Yeatman 1982; Todhunter and Polk 1981). Little information, however, is available on the variation in seed quality within and among stands from a small geographic area. This paper reports on: (1) variation in weight of filled seed, and (2) variation in germination of seed from individual trees in five jack pine stands in north central Wisconsin.

METHODS

Five jack pine stands were selected in Oneida County in north central Wisconsin on private and state lands (table 1). All five stands are located within 25 miles (40 km) of each other.

Fifteen of the best phenotypes were selected in each stand for use in studies of rooting, flowering, and seed production in seedling and clonal seed orchards. Trees

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Table 1.--*Location, age, height, and diameter of selected jack pine stands*

Stand	Latitude	Longitude	Age	Height	DBH
			Years	*Feet (m)*	*Inch (cm)*
American Legion State Forest 9 (AL 9)	45° 54′	89° 30′	50	67 (20.4)	10.0 (25.4)
American Legion State Forest 11 (AL 11)	45° 55′	89° 27′	45	62 (18.9)	8.6 (21.8)
Consolidated Papers (CON)	45° 43′	89° 21′	43	57 (17.4)	12.0 (30.5)
Nekoosa-Edwards Paper (N-E)	45° 48′	89° 46′	64	74 (22.6)	12.6 (32.0)
Owens-Illinois (0-I)	45° 44′	89° 46′	57	66 (20.1)	9.0 (22.9)

were selected visually on the basis of average or above average height and diameter growth, good form, and no evidence of serious insect or disease problems. Most of the selections within each stand were located at least 300 feet (91 m) apart to minimize relatedness among selections. The 75 selections were felled in midwinter and all current year cones plus a few one-and two-year-old cones were collected from each tree.

Cones from each of the 75 selections were opened by dipping the cones in boiling water for up to 30 seconds followed by drying in an oven at 130°F (55°C) for 24 hours. Seed was extracted by shaking the cones in a paper sack. After dewinging, all foreign matter and obviously damaged seed were removed from each seedlot. Prior to separation of filled and empty seed, a single 100-seed sample was drawn from each seedlot for preliminary germination testing. This test was made on moist perlite in an incubator under a 17-hour light period and a temperature regime of 75°F/70°F (24°C/21°C) during the light/dark period. Germination was scored at 4 and 10 days after sowing. A seed was counted as germinated when the length of the radicle exceeded the length of the seed. In this preliminary test percent germination 10 days after sowing was extremely variable and ranged from 3 to 97 percent for individual tree seedlots.

Each individual tree seedlot was then cleaned repeatedly with a seed blower until X-ray evaluation showed that 95 to 100 percent of the seed was filled--containing both endosperm and embryo. Three 100-seed samples were drawn from each cleaned lot and weighed to the nearest milligram. Although seed moisture content was not standardized for individual seedlots, all lots were extracted, cleaned, and stored under the same conditions for several months. It was assumed that they all stabilized at the same moisture content during this treatment. Germination tests were run on each 100-seed sample under the same conditions used for uncleaned seedlots.

RESULTS AND DISCUSSION

Seed Weight

Average 100-seed weight of filled seed (98.1 percent filled as determined on X-ray plates) from the 75 selections was 330 mg. Weights ranged from 307 mg for the 15 seedlots from the Nekoosa-Edwards stand to 355 mg for the 15 seedlots from the American Legion 11 stand (table 2). In general, 100-seed weight decreased with increasing stand age. Baker (1980) attributes this trend to the fact that photosynthates are more readily translocated in young trees for initiation and development of reproductive structures which result in heavier seed in younger trees. Variation in 100-seed weights among individual tree seedlots ranged

Table 2.--*Hundred-seed weights of filled seed and seeds per kilogram*

Stand	Hundred-seed weight		Filled seeds per kilogram[1]	
	Average	Range	Average	Range
	mg			
AL 9	324	237-400	308,800	250,000-421,900
AL 11	355	282-406	281,700	246,300-354,600
CON	350	288-425	285,800	235,300-347,200
N-E	307	242-360	325,400	277,800-413,200
0-I	313	228-393	319,600	254,500-438,600
Average	330	255-397	304,300	252,800-395,100

[1]98.1 percent filled seed.

from 228 to 425 mg, a difference of 186 percent; 22 seedlots (29 percent) had 100-seed weights of less than 300 mg; 50 seedlots (67 percent) had seed weights of 300 to 400 mg; and 3 seedlots (4 percent) had weights exceeding 400 mg. These figures compare to an average 100-seed weight of 346 mg and a range from 181 mg to 639 mg for 423 commercial seedlots reported in the U.S. Department of Agriculture Forest Service Handbook No. 450 (1974). These differences in 100-seed weight among stands and among trees within stands are statistically significant (table 4). In contrast, seed weight among the three 100-seed subsamples from each seedlot was very uniform.

The average 100-seed weight of 330 mg, and range among the 75 seedlots of 228 to 425 mg, converts to an average of 304,300 and a range of 235,300 to 438,600 full seed per kilogram of seed (table 2). Comparable figures in the U.S. Department of Agriculture Forest Service Handbook No. 450 (1974) are an average of 288,800 and a range of 156,500 to 551,200 full seed per kilogram for the 423 commercial seedlots. Thus, on the average, seed from the selected trees in this study was lighter and variation among seedlots was considerably less than reported for commercial seedlots of jack pine.

With such great variation in seed weight among individual tree seedlots, nursery managers may be tempted to sort seed according to size because uniform seed size greatly simplifies mechanical sowing. Large seed may yield larger seedlings, but many studies have shown that this superior development often is temporary. Sorting according to seed size may actually eliminate some desirable genotypes entirely due to difference in seed size among individual parent trees (Silen and Osterhaus 1979).

The great variation in seed weight among seedlots found in this study emphasizes that yield of seed from an orchard on a weight basis alone is unjustified. It is more important to know the number of seed produced by the orchard, and by each clone or family within the orchard. This kind of detailed information, therefore, necessitates maintaining detailed and accurate seed production records for all seed orchard components early in the production history of the orchard. The records will be required for several seasons, until the essential parameters have been determined including percent filled seed, seed weight of filled seed, and the germination of filled seed.

SEED GERMINATION

Total Seed

Germination of total seed (before separation of filled and empty seed) averaged 72 percent 4 days after sowing and 80 percent after 10 days (table 3). Variation in 10-day average germination among the five stands ranged from 74 percent for the Owens-Illinois stand to 90 percent for the American Legion 9 stand. Variation among individual trees ranged from 44 to 97 percent. This extreme variation in germination suggests that considerable variation existed among individual tree seedlots in percent of filled seed before separation of filled and empty seed.

Full Seed

Germination as a percent of filled seed (average of 98.1 percent filled seed) averaged 91 percent 4 days after sowing and 97 percent 10 days after sowing (table 3). Among stands average germination after 10 days ranged from 96 to 98 percent; among individual tree seedlots ranged from 86 to 100 percent. The differences among individuals within stands in germination of filled seed were significant; but, differences among stands were not significant (table 4). These results

Table 3.--*Percent germination of total and filled seed*

(In percent)

Stand	Germination of all uncleaned seed			Germination[1] of filled seed		
	Average after 4 days	Average after 10 days	Range after 10 days	Average after 4 days	Average after 10 days	Range after 10 days
AL 9	85	90	85-95	92	97	86-100
AL 11	72	84	70-94	94	98	95-100
CON	71	79	52-97	90	96	87-100
N-E	65	75	57-94	88	96	88-100
O-I	68	74	44-94	92	98	94-100
Average	72	80	62-95	91	97	90-100

[1]Percent of cleaned filled seed that germinated.

Table 4.--*Analyses of variance for 100-seed weight and percent germination*

Variable	d.f.	MS	F
HUNDRED-SEED-WEIGHT			
Stands	4	21,190	3.73**[1]
Families/stands	70	5,672	111.21**
Reps/families/stands	150	51	
GERMINATION OF FULL SEED			
Stands	4	45.0	1.51 ns[1]
Families/stands	70	29.7	5.12**
Reps/families/stands	150	5.8	

[1]Significance levels: ** = 1 percent
ns = not significant.

indicate that germination of jack pine seed is under strong genetic control and variation among individuals in germination tend to even out among jack pine stands from the same general locality.

The average of 97 percent of filled seed that germinated is comparable to the 96 to 99 percent germination of filled seed reported by Cecich and Rudolph (1982), Rudolph and Cecich (1979), and Roe (1963). Sixty-three of the 75 seedlots had better than 95 percent germination of filled seed and only three seedlots had less than 90 percent germination. For 98 percent of the seedlots only 3 to 4 percent of the filled seed, as determined from X-rays, did not germinate. This apparent lack of germination may have been due to delayed germination or partial dormancy (Rudolph and Yeatman 1982), misclassification of filled seed on the radiographs, damaged seed, or to some other, possibly genetic, cause. These excellent germination results indicate that jack pine seed that appears to be filled on radiographs are viable and, with few exceptions, will germinate.

The results of this study also show that average germination of jack pine seedlots can be increased by 15 percent or more by carefully cleaning the seed. Increases of this magnitude will more than offset the additional cost of removing empty seed. Use of good quality, improved seed, can also result in good quality seedlings.

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GPO 556-170 4/85