The Influence of Spring Sowing on Black Walnut Germination in Northern Vermont

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Spring sowing after artificial stratification resulted in 134 percent more germination of black walnut than fall sowing. Seeds from northern provenances germinated 182 percent better when sown in the spring, but seeds from southern provenances germinated only 22 percent better when sown in spring rather than in the fall.

Black walnut (*Juglans nigra* L.) is one of the most commonly planted hardwood forest tree species in the Central and Midwestern United States. Because of its high timber value, rapid juvenile growth, and desirable nut crop, growers in northern regions have also become interested in planting this species. With this interest has come a growing demand for quality planting stock suited to northern conditions.

Insufficient seed and poor or delayed germination are among the major problems limiting black walnut seedling production (8). To attain the greatest possible seedling yields from a limited seed supply, it is necessary for nursery personnel to maximize seed germination. Research in Central and Southern States has shown that fall sowing of black walnuts generally results in greater germination (*1, 6*) and larger seedlings (*6*) than does spring sowing following indoor cold stratification. This report compares the effects of fall versus spring (following artificial stratification) sowing on the germination and growth of black walnut from 10 provenances in a northern Vermont nursery.

Materials and Methods

During fall 1978, a black walnut provenance test was initiated in Vermont with the collection of seeds from 101 stands located throughout the Eastern United States and southeastern Canada. Because seeds from some provenances were not received until early winter, it was necessary to sow some seedlots in fall and others in spring. As a result, a study was undertaken to determine the effects of sowing season on the germination and first-year growth of black walnut from 10 provenances for which sufficient seeds were obtained.

The study followed a completely randomized design. Nine plots of each provenance were sown in random order from November 7 to 9, 1978, at the Vermont State Nursery in Essex)unction, Vt. Each plot consisted of three rows 102 centimeters wide, and each row contained nine nuts (27 nuts per plot) sown at a depth of 5 centimeters. Rows were separated at 31-centimeter intervals along the nurserybeds. After sowing, beds were covered with chicken-wire to minimize rodent pilferage. Seeds from some sources had been hulled before shipment, while others had their husks intact. Because a study had demonstrated no clear germination differences between hulled and unhulled nuts (*6*), seeds were sown as received with no additional hulling performed. Following fall sowing, the remaining seeds from each provenance were placed in cold storage at 2° C. On January 3,1979, the seeds were sealed in polyethylene bags containing moist peat moss. On April 6,1979, the seeds were removed from cold storage and sown using the same procedures as in fall except that the number of plots per provenance varied from 2 to 18, depending on the number of seeds remaining.

On July 10 and again on September 15,1979, seedling counts were made and the percentage of germinated seeds per plot was recorded. There were not appreciable or consistent differences in numbers of seedlings per plot between the two dates, so only the July 10 data are presented. The height of nine randomly selected seedlings per plot was measured on September 15. If fewer than nine seedlings were present, all were measured. Analyses of variance were used to determine the significance of germination and height differences due to season, provenance, and season X provenance interaction.

Results

Germination. Season of sowing had an overwhelming effect on black walnut germination. When averaged over all provenances, spring sowing following indoor stratification resulted in 134 percent greater germination than fall sowing (table 1). This conflicts with the find-

Table 1.—*Average germination and height of black walnut seedlings from 10 provenances as affected by season of sowing in a northern Vermont nursery*

UVM # and origin	Germination when sown in:		Relative increase with spring sowing	Height when sown in:	
	Fall	Spring		Fall	Spring
Northern sources	*Percent*			*Cm*	*Cm*
0654 VT	8	26	225	29	34
0672 NY	24	65	171	35	39
0675 NY	28	62	121	25	29
0700 OH	21	44	110	28	34
0707 NY	28	57	104	37	34
07310NT	13	62	377	22	25
0734 ONT	28	75	168	26	23
Mean	21	56	182	29	31
Southern sources					
06661N	49	62	27	43	39
06671N	24	31	29	34	29
0725 KY	54	60	11	35	37
Mean	42	51	22	37	35
Overall mean	28	54	134	31	32

ings reported from Central and Southern States (*1,6*), but is consistent with those reported from upper New York State (*3*). It appears that the optimum season for sowing black walnuts may be different in cool northern regions.

Although seeds from all provenances germinated better when sown in spring, the relative increase in germination varied with latitude of the provenances ($r = 0.73$, $P \leq .05$, 8 d.f.). Seeds from northern provenances (north of 40° latitude) germinated *182* percent better when sown in spring than fall, while seeds from southern provenances germinated only *22* percent better when sown in spring (table 1). One northern provenance (No. 0731, ONT) yielded nearly 400 percent more seedlings when sown in spring.

Height. Season of sowing and provenance X season interaction did not have significant effects on the height of year-old black walnut seedlings. Seedlings from spring-sown nuts averaged *32* centimeters in height and those from fall-sown nuts averaged *31* centimeters in height (table 1). Williams (6) found that fall-sown nuts germinated earlier than spring-sown nuts in Central States nurseries and grew taller the first year, presumably because of the longer growing season afforded by early germination. No clear-cut differences in time of germination were noted between springand fall-sown nuts in our study.

Provenance differences in height were significant. In general, southern provenances were fastest growing, but two provenances from New York were also above average in height (table 1).

Discussion

There are two possible explanations for the sowing season differences in black walnut germination found in this study. Fall-sown nuts may have been injured by low temperatures or some unknown factor during the winter and spring in the nursery. If this were the case, then nuts from northern provenances were more severely injured than those from southern provenances, since the latter had only a small relative increase in germination when sown in spring. Although possible, this explanation does not seem logical and there is no empirical evidence to substantiate it.

An alternative and more plausible explanation is that fall-sown nuts were not fully stratified in the outdoor seedbeds. Natural stratification may have been incomplete because the fall-sown nuts were frozen in the seedbeds from approximately early January to early April. Heavy rains in early January followed by prolonged subfreezing temperatures

resulted in frozen seedbeds until snowmelt in early April. Some evidence exists to indicate that subfreezing temperatures may retard the stratification process and breaking of seed dormancy in black walnut. Williams (*7*) has shown that black walnut seeds can be stored at subfreezing temperatures for 1 year without losing viability, but that subsequent stratification is necessary for adequate germination (R.D. Williams, personal communication, 1980). In addition, Von Althen (*5*) reported that nuts stratified for 7 months in moist sand at 0° C had only 10 to 25-percent germinability, while germinability exceeded 80 percent for those stratified under the same conditions for 16 or 19 months. The delayed germination was attributed to a moisture deficiency resulting from a freeze-drying effect on the moist sand (F. W. Von Althen, personal communication, 1980). In contrast, nuts stratified for 3 to 4 months at above-freezing temperatures generally exhibit 50- to 75-percent germinability (*2,4*). In the nurseries of the Central and Southern States, prolonged freezing of the seedbeds is uncommon and fall-sown black walnuts are adequately stratified during the winter.

Germination of fall-sown nuts was only slightly less than spring-sown nuts for southern provenances, but was considerably less for northern provenances. Such a pattern suggests that black walnut provenances may vary in the amount of stratification required to overcome seed dormancy. The strong latitudinal pattern to the variation in relative germination with spring sowing supports this hypothesis. If southern provenances of black walnut require a shorter stratification period than northern provenances, then seed dormancy in southern provenances may have been largely overcome before the seedbeds became frozen in early January. This would explain why fall-sown nuts of the southern provenances germinated nearly as well as artificially stratified spring-sown nuts. Provenance differences in length of stratification requirement have been demonstrated for some coniferous species, but mild-climate seed sources generally have a longer requirement than cool-climate sources. The extent and pattern of provenance variation in seed stratification requirement of black walnut has not been documented to date.

Conclusions

Under northern Vermont conditions, spring sowing after 3 months of indoor stratification at 2° C resulted in far better germination of black walnut than fall sowing, but did not influence the height of 1-year-old seedlings. Germination was particularly low in fall-sown nuts from northern provenances. Differences in germination probably reflect incomplete stratification of fall-sown nuts, rather than a response to season of sowing as such. Prolonged freezing of seedbeds may result in fall-sown nuts being essentially "stored in the ground" instead of functionally stratified, thereby reducing germination the following spring. Whether our findings are typical of northern conditions or are the result of unusual weather conditions in northern Vermont or for a particular winter is not known. However, growers in regions that typically have extended periods with frozen nursery soils are urged to try spring sowing and artificial stratification in an attempt to circumvent poor or delayed germination of black walnut.

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