SUGAR MAPLE SEED RESEARCH

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ABSTRACT

Summarizes results of sugar maple seed studies at the Northeastern Forest Experiment Station's research unit at Burlington, Vermont: the timing of seed collections to insure maximum germination, methods for separating filled from empty samaras , procedures for drying seed, long-term storage requirements of sugar maple seed, methods for seed testing, and time and methods for sowing seeds in the nursery.

SEED HANDLING

Successful programs of artificial regeneration depend upon knowledge of the methods of collecting, treating, and storing seed, Research scientists at the U. S. Department of Agriculture's Northeastern Forest Experiment Station have developed this information for sugar maple seed, which is summarized here.

SEEDCOLLECTION

Seeds are collected most efficiently from wide-crowned, open-grown trees Where they can be reached from the ground or from raised platforms, the ripe samaras are easily stripped from the branches by hand. Pruning poles can be used to clip seed-bearing branches in the higher portions of the crown When the seeds are fully ripe, large quantities can be gathered quickly by shaking them from the branches onto drop cloths. However, this method does not work well on windy days .

A recent study has shown that proper timing of the collections is important to insure maximum seed viability. Germination tests of seeds collected at weekly intervals from August to seedfall indicated that the time of seed maturation may vary by as much as 3 weeks between trees. And further, the seeds of one tree may be shed before the seeds of another tree are ripe.

For timing seed collections , we attempted to correlate external morphological characteristics of the seed with ripeness. But because of the wide variability in seed development between trees , we could not develop criteria applicable to seed crops in general.

Instead, we found that collections had to be timed on an individual tree basis. Seeds will generally reach their maximum germination potential (95 percent or more) when the fruit coats show a yellow-orange color mottled with red or brown, and the seed coats or testae become tinged with a bronze color or turn completely bronze. Once they have reached this condition, they can be collected at any time until seedfall.

If the samaras turn completely brown, the seeds should be picked immediately. Our experience has shown that they will soon be shed after developing to this stage.

Moisture content is another indicator of ripeness. Our data show that the seed are ripe (will produce 95 percent germination) when the moisture content of the samaras has fallen to 145 percent. This moisture content may or may not coincide with the development in coloration described above. Moisture content is the better criteria for timing seed collections , but it is more difficult to use. These criteria were established from trees in northern Vermont, so we do not know how well they apply throughout the rest of the sugar maple range.

SEED SEPARATION

Only about 50 percent of the sugar maple samaras contain seeds; this figure can vary between 20 and 74 percent among individual trees (Carl and Yawney 1966). To reduce handling and storage space, and to provide more positive control of seedling density in the nursery, we need some method to separate the empty and filled samaras.

We were able to achieve some separation by wind, but the results were highly variable. Separation in most liquids proved ineffective because of the bouyancy of the samaras . However, a report (McLemore 1965) on the successful use of n-pentane for separating filled and empty longleaf pine seed prompted us to try this liquid for sugar maple samaras. Pentane proved to be highly effective: the empty samaras floated and the filled samaras sank instantly. Further tests were then made to determine the degree of separating efficiency, and to determine if pentane affected sugar maple seed viability.

We found that between 95 and 100 percent of the sinkers were filled The small proportion of empty samaras that did sink contained larvae, frass, or holes in the fruit coats. Separation worked well only when the seeds had moisture content of 50 percent or more. At lower moisture content, some filled seed did not sink. For this reason it is important that the separations be made as soon as possible after the seed is collected.

Germination tests indicated that viability was not affected when seeds were soaked in pentane for periods as long as 1 hour Although there were no permanent adverse affects , soaking for 5 minutes or more did delay germination by 2 weeks . Pentane might affect germination of seeds that are to be stored before use, and we now have a study under way to investigate this possibility However, no adverse effects have been found on seeds stored up to 6 months after separation:

SEED DRYING

When picked, seeds normally have a moisture content well above 50 percent. Even if the seed is to be stored only a short time, drying is necessary to preserve viability. Because we do not know what effect rapid drying has, our procedure is to air-dry the collections slowly in an unheated building. We spread the samaras on wire screens to a depth of 1 inch, and we stir them daily. However, if the moisture content is to be reduced to 10 percent, as recommended for long-term storage, it may be necessary to transfer the seeds to a heated room.

SEED STORAGE

Sugar maple produces a small quantity of seed every year, but good seed crops occur only at 2- to 7-year intervals (U. S Forest Service 1948, Eyre and Zillgitt 1953, and Harlow and Harrar 1958). Because of this variability in seed crops, some means of storing seed is needed to sustain a continuing planting program. Therefore, we studied the long-term storage requirements of sugar maple seed.

Our study dealt with storage temperature and seed moisture content--factors that are easily controlled and that have generally been found to have the greatest effect in preserving seed viability of other species. Our study included four temperatures (18°, 7°, 2°, and -10° C) and four seed moisture contents (35, 25, 17, and 10 percent). And it included storage periods of 6 months; and 1 1/2, 2 1/2, 3 1/2, and 4 1/2 years.

Temperature and seed moisture content were equally important in determining the storage life of sugar maple seeds. Seed viability remained high longest in those treatments where temperature and seed moisture content were lowest (table 1). After 4 1/2 years, seed viability remained relatively unaffected in only 4 of the 16 temperature-and-seed moisture combinations tested. These were: 17 percent moisture content in combination with -10°C.; and 10 percent. moisture content in combination with +7, +2, and -10°C.

Table 1.--Effects of seed moisture content, storage temperature, and length of time in storage on the percent viability of sugar maple seed.

Seed moisture content	Storage temperature	Months in Storage 6	18	30	42	54
Percent	°C.	Percent	Percent	Percent	Percent	Percent
35	18	0.0	0.0	0.0	0.0	0.0
	7	89.6	0.0	0.0	0.0	0.0
	2	94.4	9.6	0.5	0.0	0.0
	-10	94.7	93.4	88.2	2.8	0.5
25	18	16.0	0.0	0.0	0.0	0.0
	7	97.0	47.3	0.9	0.0	0.0
	2	97.3	91.8	44.9	2.6	0.0
	-10	94.8	97.2	97.1	17.4	3.3
17	18	40.6	0.0	0.0	0.0	0.0
	7	97.2	82.2	1.9	0.0	0.0
	2	98.5	95.1	85.9	51.4	25.3
	-10	97.7	97.6	96.4	93.7	93.4
10	18	94.8	74.2	3.6	0.0	0.0
	7	94.1	95.3	95.5	94.5	90.9
	2	96.6	97.2	94.6	94.7	96.6
	-10	96.6	96.2	97.5	94.9	95.9

1/Table extracted from the paper "Artificial Regeneration of Sugar Maple" given by the senior author at the Sugar Maple Conference, Michigan Technological University, Houghton, Michigan, August 20-22, 1968.

Although all four conditions apparently provided satisfactory long-term storage, we recommend that sugar maple seeds be stored at 10-percent moisture content and -10°C. Under these conditions, storage much longer than 4 1/2 years should be possible.

SEED TESTING

Knowledge of the germination that can be expected from various seed lots is important in any seed-handling program. Because we had no efficient germination procedure for testing large numbers of sugar maple seed samples, we developed a laboratory germination technique that has worked well for all our seed studies .

Since it had been reported (Jones 1920) that stratification is required to after-ripen sugar maple seeds before germination, we first compared the effect of various stratification media. We found stratification at 2° to 4°C. in sand, perlite, sphagnum moss, or germination paper (with seed stratified in plastic boxes on a layer of germination paper) all to be equally effective. We also found that the seed germinated well in the stratification media (Carl and Yawney 1966).

Germination usually began after about 35 days' stratification, but some seeds required up to 90 days to germinate. This extreme variability made it difficult for us to know when to remove the seeds from stratification to begin germination tests. Because the seeds germinated well in the stratification media, we combined the stratification and germination stages in this procedure.

First, we soaked the samples in water for 24 hours to shorten the imbibition period. Then we spread them on moist germination paper--supported by paraffin-coated wire-screens over 1/2 inch of water--in plastic boxes The paper--and therefore the seeds--was kept moist continuously by dipping the ends in water. The samples were then placed in a walk-in cooler for 90 days at 2 º to 4°C. Germination--as evidenced by radicle emergence through the fruit coat--was recorded periodically throughout this period.

NURSERY SOWING PRACTICE

Most northern Forest Service nurseries sow nearly all their species in the fall because this practice results in better germination and larger seedlings than sowing in the spring (Clifford 1955). Undoubtedly this improved response can be attributed to the natural stratification afforded fall-sown seeds. Seedlings that result from fall-sown seeds also benefit from a longer growing season because soil conditions often delay spring sowings.

Heit (1939) was one of the first to report better results with fall-sown sugar maple seeds. He found that unstratified sugar maple seeds sown in the spring did not germinate until the following year. And when he attempted to stratify the seeds before spring sowing they germinated during the stratification period.

We compared spring and fall sowing in a similar study. Seeds used in the spring were stratified for 60, 49, or 38 days before sowing. We hoped that one of these stratification periods would bring the seeds to the brink of germination but not allow large numbers of them to germinate before they could be sown in the seedbeds . In this study, a large number of seeds germinated during stratification (80 and 42 percent, respectively) in the 60- and 49-day treatments , but only 5 percent germinated after the 38-day stratification treatment.

After stratification, both germinated and ungerminated seeds were carefully hand-sown in the nursery. Germination continued in the seedbeds, but total germination of the seeds stratified 38 days increased only to 30 percent. Total germination of the seeds stratified 60 days increased to 89 percent, but hand-planting of partially-germinated seeds, which we did, would not be practical on a large scale.

In contrast, the fall-sown seed produced nearly 100 percent germination, And seedlings that originated from fall-sown seeds had less mortality (5 percent versus 1 1 , 7, and 7 percent, respectively, for the 60-, 49-, and 38-day stratified spring seeds) , and they grew taller (7,1 versus 5,5, 5,2, and 4 , 6 inches) than seedlings from spring-sown seed, The better height attained in the fall-sown treatment was probably due to the earlier start that these seedlings received, Many of them germinated nearly 3 weeks before the spring-sown treatments could be installed.

Before sugar maple can be sown successfully in the spring, a method will have to be perfected that will provide for prompt and complete germination after stratification, As our studies have shown, simply stratifying the seeds at 2° to 4°C, for a given length of time is inadequate. Sugar maple seeds seem to have individual stratification thresholds, and a stratification period short of this threshold results in cessation of the physiological processes leading to germination.

We do not know why some seeds require a longer stratification period than others. Webb and Dumbroff 1/

1/ Webb, D. Paul and E. B. Dumbroff. 1968. Personal communication.

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suggested that the restricted movement of water through the seed coat serves as an effective timer, complimenting the metabolic block in the embryo by prolonging the dormant condition, Other factors may also be involved in the dormancy mechanism, such as seed maturity, photo reaction, temperature, and the presence of inhibitors in the pericarp, testa, or within the embryo itself.

To date, no specific studies have been made on sowing depth and seed covering material for sugar maple, However, the fall sowing practice we have been following in our experimental nursery has proved satisfactory. The seeds are sown in 1/4-inch depressions in rows 6 to 8 inches apart, and are then covered with about 1/4 inch of sawdust This sowing rate provides a density of approximately 15 seedlings per square feet, as recommended by Stoeckeler and Jones (1957) , A winter mulch is necessary to prevent erosion and frost heaving. Marsh grass has been particularly effective for this purpose in our Vermont nursery.

RECOMMENDATIONS

To insure maximum germination potential, sugar maple seeds should be collected when the fruit coats have turned a yellow-orange mottled with red and brown and the seed coats have turned bronze color. Moisture content of the samaras is another indicator of ripeness, and seeds can be collected after the moisture content has dropped below 145 percent.

Pentane is extremely effective for separating filled and empty samaras. Best results are achieved when the moisture contents of the collections are above 50 percent, and we recommend that the separations be made as soon as possible after the collections are made.

Seeds can be satisfactorily stored for short periods at various seed moisture and temperature levels. However, for long-term storage, a combination of 10 percent moisture content and -10°C. appears to be best.

When testing sugar maple seed, either moist sand, spagnum moss, perlite, or germination paper can be used with equal reliability as a stratification media; but germination paper is recommended because of its greater ease and convenience. The testing procedure we presently use is: (1) soak the seeds in water for 24 hours , (2) place them on moist germination paper in plastic boxes, and (3) keep them at 2° to 4°C, for 90 days.

Fall sowing has several advantages over spring sowing. Therefore, we recommend that seed be sown in the fall in rows spaced 6 to 8 inches apart at a density of about 15 seedlings per square foot, and covering them with a 1/4-inch layer of sawdust. It is essential that a winter mulch be applied to protect the beds from erosion and frost heaving.

Table 1.--Effects of seed moisture content, storage temperature, and length of time in storage on the percent viability of sugar maple seed[1/]

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	2	96.6	97.2	94,6	94,7	96.6
	-10	96.6	96.2	97.5	94,9	95.9

[1/]Table from Artificial Regeneration of Sugar Maple (Yawney), a paper given at the Sugar Maple Conference, Michigan Technological University, oughton, Michigan, August 20-22, 1968.

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