TECHNIQUE OF PRODUCING SILVER MAPLE SEED UNDER GREENHOUSE CONDITIONS

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Silver maple (Acer saccharinum L.) has been selected as one of the commercial species to replace the dying American elm (Ulmus americanus L.) in the swamps of southern Ontario. Nineteen, fast-growing, veneer quality silver maple phenotypes have been located since 1958 in the Burford, Beverly, and Grennock swamps of southwestern Ontario. They have all been asexually reproduced either by budding, layering, or by cuttings and the resulting ramets will be set out in seed orchards in the three main swamps as soon as possible. Here they will be evaluated for growth, form, site adaptability, and seed production. However, rather than wait 8 or 9 years for these clones to produce seed, it was decided to develop a practical technique for producing sufficient seed for progeny testing under artificial conditions from the original ortets. Such a technique if successful would permit the immediate production of progeny from crossing of the selected parents under controlled conditions. The resulting progeny could then be outplanted in the swamps within two years and be evaluated immediately.

To successfully understand the problems and conditions of sexual reproduction of silver maple, records have been kept on flower and seed development under natural conditions since 1953. This information has served as a guideline in the production of seed under greenhouse conditions since 1967. The first-year

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breeding program in 1967 was confined to four phenotypes within one population; in 1968 to seven phenotypes within three populations; and in 1969 to eight phenotypes within three populations, as well as an interspecific cross of three silver maple with a female-type red maple (Acer rubrum).

GENETICAL STRUCTURE

Silver maple is a tetraploid with 52 chromosomes and yet it is able to cross with red maple which is an octoploid with 104 chromosomes. However, the main purpose of this breeding program is to produce high-quality progeny from what is belived to be superior silver maple genotypes occuring in three distinct and widely separated populations in southwestern Ontario.

FLORAL FEATURES

The genus Acer has been defined in the 7th edition of Gray's Manual of Botany as being polygamodioecious. This definition would indicate that hermaphrodite and unisexual flowers sometimes occur on the same tree, but generally they occur on different trees within the same species.

Our observations have indicated that there are four types of silver maple trees based on floral features. One type is entirely male and possesses only male flowers. Such flowers have only stamens and no apparent rudimentary pistil. The second type is entirely female except that all female flowers contain rudimentary stamens which rarely produce pollen. The third type has mostly male flowers and a few female flowers. And, the fourth type has mostly male flowers, a few female flowers, and a scattering of hermaphrodite flowers.

It was observed that, from each flower bud, five pairs of pistillate flowers emerged making a total of 10 potential flowers per flower bud.

NATURAL SEED PRODUCTION

Silver maple growing under natural conditions in the swamps of south-western Ontario is generally the first tree species to flower in the spring. Flowering usually commences about the second week of April prior to leaf development. Some years it is a week earlier and other years up to two weeks later depending on temperature. Weather permitting, the receptive flowers are cross-pollinated by bees within a week of floral maturity. However, it is not unusual in some years for the flowers to remain unfertilized for a week or more as the temperature may remain below 60°F which not only seems to slow up floral development, but also prevents the honey bees from working efficiently on the flowers. Weather records collected at Millgrove at a station close to the study area have been analyzed for the past 15 years and have indicated considerable fluctuations in temperature both above and below 60°F during the flowering period. Low temperatures were particularly prolonged in April of 1953, 1961, and 1965, where only from one to three days in the month had maximum temperatures of 60°F or higher.

Since ideal weather conditions for pollination are often uncertain in the spring, this species appears to have developed safeguards to ensure at least

artial seed production under adverse weather conditions. For instance, there ppears to be not only early- and late-flowering genotypes within the species but ost trees produce a few late flowers which open from one to three days later than do the rest of the flowers on the same tree.

ARTIFICIAL SEED PRODUCTION

Selection of Breeding Stock

Since 1958, 19 high-quality silver maple phenotypes have been located for propagation purposes. Fourteen occurred in the Burford swamp, four in the Beverly swamp, and one in the Grennock swamp. From four to eight of the fastest- growing, veneer-quality type trees with the best form have been crossed in 1967, 1968, and 1969. All the trees selected for propagation were healthy, had two clean logs, sound centers, and had an annual increment of 0.5 inches in diameter when released from competition of adjoining stems.

It was noted that there was considerable variation in the inflorescence of the trees selected for propagation. For instance, in 1969, four trees had only female flowers; one had only male flowers; two had mostly male flowers and a few female flowers; and the remaining tree had mostly male flowers, a few female flowers, and a few hermophrodite flowers as well. In that year, six of the trees were from the Burford swamp population and were crossed within the same population as well as being out-crossed with a selection from the Beverly and from the Grennock swamps. At the same time, the male-type trees bearing a few female flowers were also inter-crossed with each other. In addition, the pollen from one of the mostly male type trees was selfed with the female flowers on the same tree.

Procuring Flower Branches

The original idea of using severed branches in the silver maple breeding program originated with Dr. J. Farrar, Faculty of Forestry, University of Toronto, who succeeded in producing silver maple seed indoors from branches while demonstrating seed development to his students.

Flower-branches were procured at the latter part of March in 1967, in mid- March 1968, and at the beginning of March in 1969. They were shot off the selected trees with a high-velocity 225 caliber rifle equipped with a telescopic sight. All branches were approximately from one to two inches in diameter at point of severence and were from eight to ten feet tall.

Treatment of Flower Branches

The severed branches were put in pails of water in a cold room at a temperature of 50°F. They were kept under these conditions until required for breeding purposes. After all of the branches from the selected trees were procured, they were removed from the cold room and were placed in pails of water in the greenhouse at a temperature of about 70°F and a relative

Pollination Techniques

The branches from each of the female trees in 1969 were separated into approximately four equal sections by painting a boundary line between each section to accomodate the four male crosses. Each of these sections wag/identified by printing in black ink with a felt pen the specific cross and the time of pollination.

After the branches were properly divided into marked sections, pollination was accomplished by simply passing a moist one-quarter-inch wide paint brush over, the stamens of the male tree and then brushing the adhering pollen over the receptive pistils of all female flowers in the designated section. After each male tree was crossed with the female trees, the brushes were thoroughly washed with distilled water and used again to cross the next male tree with each of the selected female trees. This process was repeated until all male type trees had been crossed not only with the female trees, but with each other and also with the scattered female flowers occurring on the hermophrodite tree.

Pollination Success

A study was made in 1969 to determine the pollination success of the different crosses. This analysis was based on 10 full seeds per flower cluster as constituting 100 percent success. A record was made of the number of developed seed in each flower cluster occurring in a number of flower buds from each of the crosses. Table 1 indicates that some crosses appear to be more compatible than others. For instance in the Bu4 x Bu7 cross, 65 percent of the flower clusters had 2 full seeds per cluster as compared to the Bu5 XBe5 cross, where only 3 percent of the flower clusters had two full seeds per cluster. It is interesting to note that Bu7 and Bey appeared to be more compatible with red maple than Bu6. Insofar as total pollination success, Bu4 XBu7 and Bu4 XBe5 were definitely the most compatible crosses made in 1969 (Table 1), where 80 and 75 percent, respectively, of the flowers produced ful] seed as compared to a low of 23 percent for the Bu8 XBu6 cross.

Seed-Branch Culture

Immediately after pollination in 1967, 1968, and 1969, the branches were sprayed at four-hour intervals each day between 9:00 a.m. and 5:00 p.m. with a fine mist. This process was continued until the seed was harvested from three to four weeks after pollination. In addition, the water in the pails was changed once every two days, and approximately one inch at the end of each branch was severed at the same time to facilitate maximum intake of water into the branch. In 1967 and in 1968 a commercial fertilizer was added to the water, but this proved to be detrimental as it stimulated an excess of bacteria and algae in the water which appeared to clog the conducting tissue in the branches causing some wilting as well as an obnoxious odor.

The temperature and humidity varied each year. For instance, in 1967 the initial temperature was set at 75°F with a relative humidity of 50 percent. Temperature controls were imperfect, and on sunny days the temperature rose to more than 90°F causing the foliage to wilt. When this condition was observed in the greenhouse, the temperature was immediately dropped to a day temperature of 65°F and a night temperature of 50°F. Unfortunately, some damage had already been done and the seed did not develop as well as it would have under natural conditions, being only about one inch in length at maturity as compared to 1.5 to 2.5 inches for seed produced under natural conditions.

Table 1. -- Pollination Success in 1969

Cross	No. of flower buds	% of seed per flower cluster 0	1	2	Total clusters	Total seed actual amount	Total seed maximum potential	% success
Bu0xBe5	13	28	55	17	65	58	130	45
Bu4xBu7	4	5	30	65	20	32	40	80
Bu4xBe5	6	13	23	64	30	45	60	75
Bu5xBu6	2	70	20	10	10	4	20	20
Bu5xBu7	7	37	49	14	35	27	70	39
Bu5xBe5	19	55	42	3	95	66	190	35
Bu6xBu7	29	30	32	38	145	157	290	54
Bu6xBe5	27	32	41	27	135	129	270	48
Bu8xBu6	7	37	23	40	35	16	70	23
Bu8xBu7	19	23	43	37	95	105	190	55
Bu8xBe5	11	22	49	29	55	59	110	54
Be5xBu6	15	56	40	4	75	36	150	24
Be5xBu7	21	50	46	4	105	56	210	27
Mr1xBu6	17	69	27	4	85	29	170	17
Mr1xBu7	28	57	36	7	140	70	280	25
Mr1xBe5	29	56	38	6	145	75	290	26

In 1968, the temperature was kept constant at 70°F both day and night and at a relative humidity of 60 percent. Again, the temperature rose on sunny days to over 90°F, which had a particularly adverse effect on those branches with heavy foliage, causing them to wilt and the seed to develop poorly. In addition, fertilization of the water impeded water uptake which appeared to also cause wilting of the branches and, undoubtedly, contributed to dwarfing some seedlots. That year there were three distinct sizes of seed produced; namely, large - 1.75 inches, medium - 1.25 inches, and small - 0.75 inches. The small size class was immature when harvested, and there was some doubt if the seed would germinate. However, it did germinate well but was slower in germination than the larger seed. At the same time, the resulting cotyledous seedlings were generally smaller at the time of transplanting, being only 0.10 feet as compared to 0.23 to 0.25 feet for the seedlings from the large size classes. Some of the progeny from the smaller seed remained small during the 1968 growing season while other progeny from small seed eventually caught up to the progeny of the large seed that year.

In 1969, pollination was done on the 4th and the 5th of March, the temperature was kept constant at 65°F, and the relative humidity at 70 percent. Water was changed once every two days and the bottom inch of each seed-branch was cut diagonally to permit maximum uptake of water.

Seed Development

A daily record was kept on the development of the seed following pollination in 1969. Within 24 hours of fertilization, the calyx and the styles withered and the ovary swelled. Within three to seven days after pollination, the seed length was approximately 0.25 inches; by two weeks most of the seed was from 1.5 inches to 1.7 inches long, and by the end of three weeks at the time of harvest, the seed was almost two inches in length. The length of peduncle at the time of harvest also varied considerably from 1.0 to 3.5 inches, depending on the branch origin.

The viability of the seed in 13 of the crosses (Table 2) was generally over 90 percent, while the remaining seed of the 5 crosses ranged from 57 to 76 percent viable. Even the viability of the silver maple and red maple cross was extremely high (Table 2).

Table 2. -- Percent germination of the 1969 silver maple seed

Cross	No. of seed	No. of seedlings	% germination viability
Bu0xBu6	7	7	100
Bu0xBu7	39	37	95
Bu0xBe5	73	72	98
Bu4xBu7	30	30	100
Bu4xBe5	40	40	100
Bu5xBu6	4	4	100
Bu5xBu7	26	26	100
Bu5xBe5	60	60	100
Bu6xBu7	120	84	70
Bu6xBe5	130	86	66
Bu8xBu6	16	16	100
Bu8xBu7	102	100	98
Bu8xBe5	58	56	96
Be5xBu6	32	32	100
Be5xBu7	52	50	96
Gr41xBu6	52	30	57
Gr41xBu7	100	76	76
Gr41xBe5	100	76	76
Mr1xBu6	25	24	99
Mr1xBu7	51	51	100
Mr1xBe5	50	41	82

In 1969 all of the silver maple crosses had large seed being generally about two inches long. It was harvested three weeks after pollination. The seed from each cross was put in a marked envelope and placed in the cold room at 40 °F until sown in flats in the greenhouse about 10 days after harvesting.

Insect Pests

Two insect pests apparently came into the greenhouse in the egg and in the adult stage on the dormant branches of the silver maple in 1968 and in 1969. When the fruit was almost mature, it was noted that about 10 percent of the large seed was weeviled and, at the same time, the developing leaves on some branches were being eaten by a Lepidoptera larvae. In the future, all dormant branches should be sprayed with a contact insecticide about one week after pollination.

SUMMARY

Silver and red maple seed can be easily produced from selected stock by removing 8- to 10-foot branches of the desired material and putting them in Rails of water under artificial conditions at a constant temperature of 65° to 70 F and a relative humidity of 70 percent to permit optimum development of the flowers and seed. Such flowers can be readily pollinated by using a moist, one-quarter inch paint brush to collect the pollen of the male flowers and rub it over the pistils of the female flowers. The seed of both species can be harvested within three weeks of pollination and can be sown immediately in tubes or flats. Germination takes approximately from 3 to 12 days for silver maple and approximately from two to three weeks for the red maple hybrids. These can be out-planted in the nursery by the middle of May and will reach from 1.0 to 1.5 feet in height by September of that year.

CONCLUSIONS

This technique as outlined appears to be feasible for both horticulturists and foresters to produce seed from selected high-quality trees for both ornamental and forestry purposes.

DISCUSSION

DORN - Warren, Pennsylvania. I have two questions. Did you have any problem with fungi getting in the blossoms? You didn't mention it, so I assume you didn't. You mentioned fertilizer in the water and it didn't work out. Did you use tap water or did you put any nutrients in the water at all?

LARSSON - We had problems when we added fertilizer to the water. These nutrients caused bacteria to flourish in the water which appeared to clog the conducting tissue. The water we used was the water at the Station. It is fairly

high lime and is from an artesian well. We added RX15 which is a commercial fertilizer. It is highly soluble. We thought it might produce bigger seed. Regarding pests, we had a weevil in the seed, and we also had some Lepidoptera larvae which ate the leaves. I think the weevil must have come in on the branches in the adult stage and laid eggs on the developing seed. Whereas the Lepidopterus insect must have come in on the egg stage because the larvae commenced feeding when the leaves were almost fully developed.

SANTAMOUR - I wouldn't get too excited about getting selfs on sugar maple. I think this is entirely possible. But you remember the NEFTIC meeting at Beltsville; we tracked through about 1500 silver-red hybrids. There was a large vacant space in the middle of that planting where Ernie had put in some 84 silver maple selfs. They grew well for about nine years, and then all of a sudden completely pooped out and we put up a sign reading, "This space for rent." So silver maple can be selfed, but apparently it suffers somewhere along the line in its development--maybe about the time it reaches fruiting age.

LARSSON - Thanks for bringing this up, Frank. I wasn't aware.

LEDIG - Do you think this procedure would work with sugarmaple?

LARSSON - I would not think so, because at the end of three weeks the silver maple branches are fully leaved and they will wilt if not sprayed two or three times a day. In fact, by four weeks, most of the leaves have wilted regardless of the care given them. I don't know how you will be able to keep the sugar maple branches going for the length of time it would take to develop their seed.

HUNT - How many various times could you force these branches by bringing in all these new branches and still make it through the greenhouse season? Can you raise two or three crops of these?

LARSSON - Yes. We have taken them on the first of March, the middle of March, and the end of March; and they were all successful. I think the last of March was better than the first of March. The branches at that time seemed to be more vigorous and gave larger seed than those at the beginning of the month.

GABRIEL - Your presentation was very interesting and the photographs were excellent. I also feel that you have given me an insight into the evolutionary relationship of silver and sugar maple. The hermaphroditic flowers in silver maple are truly hermaphroditic, shedding pollen and developing female flowers. The so-called hermaphroditic flowers of sugar maple are really pseudo-hermaphroditic as the male flowers never bloom. To me, this means that sugar maple is more advanced, with reference to dioeciousness, compared to silver maple. Branches alive from
say May until September, this is a lot longer than 30 days, but I feel if you have the time and the money it is possible. I don't think you are going to do it in a year or two years. We are five already, and we're not anywhere near.

LARSSON - There are going to be some real problems. Any other questions from the floor?

HUNT - A comment on Gabriel's comment. In 1960 we had a refrigerated water tank in the greenhouse at Syracuse. We could hold the water temperature down to 35° -39° F. Starting in February with female white ash branches and cutting off an inch or so of wood from the base of the submerged branch every third or fourth

day (as a precaution against plugging of the xylem elements), we were able to hold branches for at least two months and often longer. The branches went through pollination, the seeds filled and, in the heat of the greenhouse in May, dried just like they would on the tree in August or September in the forest. None of these filled seed ever germinated (but even the September field-collected seed exhibited erratic and delayed germination). We did not test any after that. I would expect the ripening process could be hustled along to mature in early summer.

LARSSON - I think possibly that the silver maple seed development is faster on the branches in the greenhouse than it is under natural conditions on the tree.

LEDIG - I have one more question. It's somewhat off the point of your talk and concerns the technique for rooting epicormics. Do you use current year's growth--succulent epicormics?

LARSSON - Yes. We don't like the cuttings too succulent because they tend to wilt even when using a misting system.

LEDIG - So when do you collect them?

LARSSON - We usually like to take the cuttings from the first week of July to the third week of July.

ANONYMOUS - Did you report a year or so ago on your south wood cutting?

LARSSON - Yes. Our data were not complete. We were just reporting what had been done to date.