GERMINATION CAPACITY IN AMERICAN BASSWOOD

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In the course of several years work on basswood (*Tilia americana* L.) a number of fruit collections were obtained, from many of which seed was extracted and germinated. The yield of sound seed and germination characteristics of each fruit lot were assessed as germination capacity. This capacity was related to year of collection, insect damage, geographic origin, and other factors.

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Materials and Methods

One approach was to plant untreated fruits in the garden with and without straw mulch or in flats with potting soil. The flats were retained in the greenhouse or, more usually, placed out in a coldframe. A few embryos were also dissected from seed and grown in the laboratory. The great majority of fruits was treated with concentrated nitric acid for approximately three hours, the seed shelled out, dried, treated with concentrated sulfuric acid for 15 minutes, stratified in moist vermiculite or sphagnum for three or four months at 36° F, and sown in the greenhouse or garden under presumably favorable germination conditions (Spaeth, 1934; U. S. Department of Agriculture, 1948). The germination figures reported are for the appearance of the cotyledons above ground. Sprouting of the hypocotyl which took place during stratification was generally correlated with the subsequent emergence of the cotyledons and is not reported. A trial was made of the Johnson (1946) method in which fruits were soaked in water for several days, treated with concentrated sulfuric acid for 40 minutes, rinsed, and planted.

Forty-five collections obtained during the years 1955 through 1959 included fruits from various parts of the natural distribution of American basswood, North Carolina to Manitoba and Maine to Minnesota. The fruits varied in size, extent of hairiness and persistence of the style. Samples from the various sources were retained as herbarium material by the author. The numbers of fruits within the several collections varied greatly. This in part reflected variations in fruit production from tree to tree, year to year and locality to locality.

Results

Embryos removed from the seed soon started growth on moist filter paper. In contrast, no germination was observed from untreated fruits planted in the greenhouse for periods up to 18 months. During this period the fruit coats disintegrated, but the seed remained hard. Untreated fruits planted outdoors in flats or in the garden in spring or fall of one year germinated in late April of the first, second or (in lesser numbers) third spring after planting. Germination in the first season reached 15%, in agreement with Bailey (1961).

Considerably higher germination values were found the same spring as planting for acid-treated and stratified seeds (Spaeth, 1934; Johnson 1946). In Table 1 the highest value found is 78%. Appreciable variation was noted from one seed lot to another. For those studies with acid-treated and stratified seed continued for a second spring, less than 5% additional germination was recorded. The average first season germination percentages were 39% for 1822 seed in 1957 and 34% for 1695 seed in 1958. The seedlings from various seed lots were usually very similiar in appearance. One accession of 177 seed from southeastern Wisconsin had over 10% tricot and one tetracot seedling. No other unusual types of seedlings were observed. Treatments given to stratified seed after spring planting, such as mulching with straw or shading (Ashby, 1961), resulted in less rapid emergence but approximately equal final numbers of seedlings.

Additional factors were of importance in determining basswood's regenerative capacity (Table 1). The several collections totalling several thousand fruits varied in yield of sound seed from zero to nearly 100%. Filled fruits were usually one-seeded. Collections yielding high percentages of fruit with seed often had several percent of fruit with double or even triple seed. Seed quality varied from nearly 100% sound to 100% which rotted when stratified after acid treatment. Some otherwise sound seed lots had up to 30% insect infestation. An apparent yearly correlation in Table 1 of high percentages of multiple-seeded fruit and high values of damaged or unfilled seed was not true for individual seed lots. Ground collections, while sometimes good, tended to give poorer seed yields than tree collections. Average seed weights for 13 collections in 1958 varied from 12 to 38 mg with an average of 31 mg.

Fruit production, which was found on some trees in the Chicago region each year of the study, occurred with greatest abundance in 1957. Collections made from a single tree in southern Wisconsin had many poorly-filled seed and no multiple-seeded fruits in 1956, while in 1957 fruits were greater in amount with no poor seed and some multiple-seeded fruits. On a trip in October, 1958 to parts of Iowa, Minnesota, and Wisconsin, I found only one tree with fruit out of hundreds of trees examined.

Comparisons of fruit quality for individual trees are illustrated by data from four trees in a small valley in the St. Lawrence River sec-

TABLE 1.—Characteristics of Basswood Fruits and Seeds.

Characteristic	Year of Collection			
	1955	1956	1957	1958
Number of collections with				
Seed yield 0-33%	7	1	2	2
Seed yield 34-67%	0	3	2	3
Seed yield 68-100%	1	2	10	4
Percent of the above collections with				
Multiple-seeded fruit	0%	33%	21%	11%
Seed poorly filled, insect damage, etc.	25%	83%	57%	44%
Percent germination of				
Apparently sound acid-treated and stratified seed	0-70%	0-78%	0-52%	0-20%*

* Germination in garden rather than greenhouse.

tion of New York State. Seed yield in 1958 ranged from 100 to 5% and emergence in the garden for apparently sound stratified seed from 15 to 0%. The tree yielding 100% seed per fruit had multiple-seeded fruit and some poorly filled seed. Most of the seed from the poorest yielding tree were poorly filled.

Basswood germination was observed each spring in several field areas of the Chicago region. The numbers varied from year to year. Only one instance of very abundant basswood seed germination was found. This occurred in a presumably protected area in southwestern Michigan which had been invaded by campers the previous autumn. The nature of the altered seed bed was not determined.

DISCUSSION

Germination capacity in basswood is related to the several factors studied: fruit production, numbers of seed per fruit, percent of sound seed, and germination percentage (Spaeth, 1934). The delayed germination leads to annual appearance of seedlings despite the yearly variations in fruit production and quality. Other investigators (Den Uyl, *et al.*, 1938; Hart, 1958, 1959; McConkey, 1960, 1961; Rudolph, 1950-61; Spaeth, 1934) have reported marked annual and geographic variation in fruiting of forest tree species, including basswood. Factors outside the scope of the present investigation which determine regeneration capacity include animal use of seed (which I have observed on occasion to be extensive), distribution of seed to favorable sites, and suitable soil and climatic conditions. My present concept is that in the Chicago region the production and germination capacity of American basswood seed is rarely a substantial limiting factor where mature trees are found. I am not yet satisfied that such is the case in southern Illinois.

A second type of regeneration in basswood involves sprouting from the base of the trunk. This serves to maintain the species, once established. In only one instance was such a sprout found as far as one foot from a trunk. If true root sprouts occur, they are rare in comparison to the common trunk sprouts.

Length of the stratification period was not systematically studied for its effect on germination. This probably affected the absolute performance of one seed lot versus another. My criterion for removing the seed from stratification conditions and planting them was evidence of growth by the radicle. As a rule several seed lots were removed at one time. The percentages of seed in which growth of the radicle was evident might differ for the several seed lots. Seed for comparative tests were sorted for response to stratification and the treatments were given to representative groupings. I did find that "hard" seed may give very low emergence percentages after a stratification period which leads to good emergence by seed on which sprouting is evident. Thus intra-seed-lot differences need to be considered in evaluating inter-seed-lot performance. A requirement for prolonged stratification (Spaeth, 1934) would influence the germination capacity of individual seed.

Summary

Basswood fruit collections varied in seed yield from 100% to 0%. Germination of acid-treated and stratified selected seed ranged from 78% to 0%. Fruiting alone is not a satisfactory measure of basswood seed production and quality. Delayed germination can lead to annual appearance of seedlings despite the yearly variations in seed production and quality.

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