

Influence of Fertilizer on Seed Production in Allegheny Hardwood Stands

by John C. Bjorkbom
L. R. Auchmoody
and Donald E. Dorn



FOREST SERVICE RESEARCH PAPER NE-439
1979

FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
NORTHEASTERN FOREST EXPERIMENT STATION
370 REED ROAD, BROOMALL, PA. 19008

The Authors

JOHN C. BJORKBOM and L. R. AUCHMOODY are Research Foresters with the Northeastern Forest Experiment Station's Forestry Sciences Laboratory at Warren, Pennsylvania. DONALD E. DORN is a Geneticist, Region 9, National Forest System.

MANUSCRIPT RECEIVED FOR PUBLICATION 28 DECEMBER 1978

Abstract

Fertilizers applied in spring can stimulate production of black cherry and red maple seeds in Allegheny hardwood stands. Increased seed production begins in the year after application, but lasts only about 2 years. However, fertilizers do not increase seed production of individual black cherry trees that have a history of poor production, and they do not eliminate seed crop failures, affect seed soundness, or influence the time of seed dispersal.

ADVANCE REGENERATION of black cherry (*Prunus serotina* Ehrh.), red maple (*Acer rubrum* L.), sugar maple (*Acer saccharum* Marsh.), and white ash (*Fraxinus americana* L.) sometimes fails to develop in Allegheny hardwood stands. Failures result in part from the lack of a seed supply adequate to produce the number of advance seedlings needed to establish a new stand.

Good seed years cannot be reliably predicted. Additionally, it is not practical to schedule most regeneration cuttings to follow good seed crops. For these reasons, a way to improve seed production when and where it is needed would be silviculturally desirable.

We examined the influence of fertilizers on seed production in Allegheny hardwood stands as well as on individual black cherry trees that have a history of poor seed production. Time of seed dispersal and seed soundness after fertilization were also determined.

METHODS

In study areas in northwestern Pennsylvania that had been established primarily to determine growth response to fertilization, we also observed the effects of fertilizers on seed crop characteristics in two 60-year-old stands. Although these stands differed in species composition (Table 1), both were representative of Allegheny hardwood stands.

In this experiment, treatment plots of 1.2 acre were established as:

Control—unfertilized

NP—300 lb per acre N from urea and 87 lb per acre P from triple superphosphate

NPK—N and P at above rates plus 83 lb per acre K from potassium chloride

Table 1.—Basal area per acre by species, stand, and treatment, in square feet

Species	Stand 1			Stand 2		
	Control 1	Control 2	NPK	Control	NP	NPK
Black cherry	55	69	49	125	120	104
Red maple	7	10	56	13	5	18
Sugar maple	29	75	14	18	26	5
White ash	22	11	12	3	0	0
Other	8	8	19	26	14	36
Total	121	173	150	185	165	163

In 1972, the fertilizers were uniformly broadcast over the plots in two steps. One-half of the N and all of the P and K were applied at leaf-out time in early May. The balance of the N was applied about July 1. The treatments were repeated in 1973.

In the first stand, we arbitrarily selected the NPK plot to observe the effect of fertilizers on the seed production of black cherry, red maple, sugar maple, and white ash. The estimated production on this plot was compared with the seed production on two control plots. Estimates were made over a 6-year period from 1972 through 1977.

In 1973, we added a second stand. In this stand, we observed the seed crops of black cherry trees from 1973 through 1977. The plots included NP and NPK fertilizer treatments as well as a control.

In both stands, six seed traps were randomly located in each treatment plot. Trap size was 3.0 by 7.3 feet (0.5 milacre). Red maple seeds were trapped from May 15 to July 1, and collected biweekly. Black cherry, sugar maple, and white ash seeds were trapped from August 1 to November 1, and seed collections were made monthly.

Analysis of variance was used to test for significant differences in seed production and seed soundness at the 0.05 level.

In the second experiment, 24 black cherry trees with a history of poor seed production were selected from the superior tree candidates in the black cherry seed orchard program. These trees had an average diameter at breast height (dbh) of 18 inches, an average crown diameter of 25 feet, and ranged in age from 43 to 100 years. The trees were paired to be as alike as possible in age and size, and were located on sites having similar elevation, slope, and aspect—though the physical location varied greatly between the individual members of each pair. In each pair, one tree was fertilized and one was a control.

The fertilizer (NPK) was applied at the same rate with the same carriers as in the first experiment except that all of the N was applied at the same time (mid-May) and only one annual application was made. Application was within a 32-foot diameter plot around each selected tree. Although some roots may

have extended beyond this distance, most of the absorbing roots were probably concentrated beneath the crown (Kramer and others 1960, Fayle 1965). For this reason, the treated area was assumed to approximate the feeding zone of the root systems.

The size of flower and seed crops as well as seed soundness were evaluated over a 4-year period (1974-1977). Visual estimates of black cherry flower crops were based on the relative abundance of flowers borne on 20 to 30 twigs long enough to include the current and previous year's growth. These twigs were randomly selected from all sides of the upper one-half of the crown. Seed-crop estimates were based on the total number of fruits on approximately 40 twigs collected at random from all parts of the upper one-half of the crown. Only those trees bearing seed were sampled.

For group comparisons, a t-test was used to test for differences in flower production, seed production, and seed quality, between fertilized and unfertilized trees.

RESULTS

Forest stands

Regardless of treatment, the number of seeds caught in individual seed traps varied considerably. Such variability is common in seed-trapping experiments because seed is not dispersed uniformly over the area and an extremely large number of traps would be required to sample a seed crop adequately. Furthermore, seed production of individual trees is variable. As a result of this variability, extremely large differences between treatments are required to demonstrate statistical significance. Fertilization resulted in such differences for both black cherry and red maple.

Seed production of black cherry and red maple increased after the fertilizer applications of 1972 and 1973. For black cherry, the increased production occurred in the year following the fertilizer application. For red maple, the response was delayed 1 year because of a flower-crop failure. The fertilizer effects lasted about 2 years. In general, the time of the response and the duration of the

Table 2.—Black cherry seed production per acre by stand, treatment, and year, in thousands of seeds

Year	Stand 1			Stand 2		
	Control 1	Control 2	NPK	Control	NP	NPK
1972	41	33	40	^a	^a	^a
1973	222	470	890	108	1,022	1,420
1974	6	3	114	60	552	447
1975	333	317	380	1,749	2,296	2,167
1976	1	0	6	9	116	12
1977	230	173	430	594	674	329

^a Not trapped.

effect were similar to those reported for beech and sugar maple (Chandler 1938) and for white oak (Detwiler 1943).

Fertilization did not eliminate seed crop failures—no red maple seed was produced in 1973, and no sugar maple or white ash was produced at any time during the study.

Black cherry. Plots fertilized in 1972 and 1973 produced more seed in 1973, 1974, and 1975 than were produced on the unfertilized plots (Table 2). However, increases that resulted from fertilization were statistically significant only for Stand 2 in 1973. Nevertheless, observations made in 1973 and 1974 by climbing trees in both stands confirmed the presence of larger flower and seed crops on fertilized plots than on unfertilized. Based on these observations, and considering the large variations in seed-trap data previously mentioned, we feel that these figures represents meaningful increases.

The soundness of black cherry seed ranged from 84 to 100 percent. Soundness was not affected by fertilization and appeared to vary as much by year as it did by treatment.

Fertilization did not influence the time of dispersal of black cherry seeds. Generally most of the seed crop was dispersed in August.

Red maple. Seed-production data for red maple were collected only in Stand 1. It is apparent from Table 3 that the NPK treatment did not prevent a seed crop failure in 1973. Red maple flowered in that year but failed to produce any seed. This seed-crop failure was probably caused by temperatures below freezing in late April and early May, suggesting that fertilization does not improve the frost hardiness of the flowers.

Table 3.—Red maple seed production per acre in Stand 1 by treatment and year, in thousands of seeds

Year	Treatment		
	Control 1	Control 2	NPK
1972	413	^a	646
1973	0	0	0
1974	138	91	762
1975	83	38	621
1976	0	6	0
1977	193	4	172

^a Not trapped.

Seed-crop failures have not been eliminated, but crops increased in some years. In 1972, before red maple seed crops were affected by fertilization, there was no significant difference in seed production between fertilized and unfertilized plots ($P < 0.05$). Because seed crops failed on all plots in 1973, it was not until 1974 that fertilizer effects on seed production were first observed. In that year and in 1975, seed production was 6 to 10 times greater on the fertilized plot than on the controls. These differences were statistically significant at the 0.05 level in 1974 and the 0.10 level in 1975. By 1977, the fertilizer effects had worn off. Seed production on the fertilized plot had dwindled to about 25 percent of that achieved in 1974 and 1975 and was about equal to the production on the unfertilized controls.

Seed production of a stand is strongly influenced by the basal area per acre of the seeding species. The fertilized plot had more basal area in red maple than the control plot

and might, therefore, be expected to have higher red maple seed production even without fertilization. Although this might be true for the stand as a whole, the limited data from the seed traps do not show this—seed crops in 1972 and 1977, unaffected by fertilization, were not significantly different at the 0.05 level. Thus, the increases shown in the seed-trap data appear to be real effects of treatment, and not due to the greater basal area.

The soundness of red maple seed ranged from 76 to 86 percent. Soundness was not affected by fertilization and it varied as much or more by year as it did by treatment.

The time of seed dispersal was not influenced by fertilization. Red maple seed crops were dispersed in late May and early June.

Individual trees

In the second experiment, fertilizing individual black cherry trees that had a history of poor seed production did not improve the size of flower or seed crops.

The average number of flower racemes per twig (Table 4) did not differ significantly at the 0.05 level by treatment in any year of the study.

Only one of the sample trees produced seeds in 1974. This tree, fertilized in 1973, averaged 5.2 racemes per twig and 4.2 fruits per raceme. In 1975, seed production was slightly better. Seven of the 24 sample trees bore some seed—3 fertilized and 4 unfertilized trees. There was an average of 2.1 racemes per twig regardless of treatment and the average number of fruits per raceme was about the same—3.0 fruits when fertilized, 3.1 when not. All seeds collected were sound.

Table 4.—Average number of flower racemes per twig by year and by treatment, in second experiment

Year	Treatment	
	Fertilized trees	Unfertilized trees
1974	0.20	0.15
1975	1.02	1.65
1976	0.66	0.94
1977	1.01	0.61

DISCUSSION

Fertilization can increase seed production of black cherry and red maple in forest stands. Often the differences in seed production between fertilized and unfertilized stands were not significant, however, the differences in numbers of seeds produced can be important for regenerating a new stand. These differences are especially important for red maple whose seed does not remain viable in the forest floor for more than 1 year (Bjorkbom 1979, Marquis 1975) and for all species when poor seed crops might be expected.

The influence that fertilization might have on regeneration can be estimated from data from an earlier study of red maple seed and seedling production (Bjorkbom 1979). In that study, the average ratio of seeds to seedlings was estimated at about 6 to 1. Based on this, the estimates of seedlings produced from the red maple seed crops of 1974 and 1975 would be:

Seed year	<i>Number of seedlings expected per acre</i>	
	<i>Fertilized stands</i>	<i>Unfertilized stands</i>
1974	127,000	19,100
1975	103,500	10,100

These data indicate that a fertilized stand may produce up to 10 times as many red maple seedlings as would be produced in an unfertilized stand. This may mean the difference between adequate and inadequate regeneration.

Black cherry seeds differ from red maple seeds in their ability to remain viable in the humus for a period of years (Wendel 1977, Marquis 1975). Nevertheless, stimulating black cherry seed production in a poor seed year may be important in building up and maintaining advance regeneration. In a poor seed year, a fertilized stand can yield seven or more times as much black cherry seed as an unfertilized stand. This additional seed plus the seed stored in the humus ensures a relatively stable annual supply.

In fertilized forest stands, seed production was improved but this result was not achieved

by fertilizing individual black cherry trees that were inherently poor seed producers. These trees failed to show any increase in flower or seed crops.

Failure to produce seed is not uncommon in black cherry. Grisez (1975) reported that in a forest stand, 8 percent of the dominant and codominant cherry trees 10 inches in dbh and larger failed to produce more than a few seeds. However, when trees were selected for

rapid growth, excellent tree form, and high veneer quality as the trees in the black cherry seed orchard program were, one-third of these trees produced only negligible amounts of seed. Whether or not all trees chosen for these qualities are characteristically poor seed producers is not known. But unfruitful trees do exist, and they must be taken into consideration in evaluating the regeneration potential of a stand.

LITERATURE CITED

- Bjorkbom, John C.
1979. **Seed production and advance regeneration in Allegheny hardwood forests.** USDA For. Serv. Res. Pap. NE-435.
- Chandler, Robert F., Jr.
1938. **The influence of nitrogenous fertilizer applications upon seed production of certain deciduous forest trees.** J. For. 36:761-766.
- Detwiler, S. B.
1943. **Better acorns from a heavily fertilized white oak tree.** J. For. 41:915-916.
- Fayle, D. C. F.
1965. **Rooting habit of sugar maple and yellow birch.** Can. Dep. For. Pub. No. 1120. 31 p. illus.
- Grisez, Ted J.
1975. **Flowering and seed production in seven hardwood species.** USDA For. Serv. Res. Pap. NE-315.
- Kramer, Paul J., and Theodore T. Kozlowski.
1960. **Physiology of trees.** McGraw-Hill Book Co. Inc., New York. 642 p. illus.
- Marquis, David A.
1975. **Seed storage and germination under northern hardwood forests.** Can. J. For. Res. 5:478-484.
- Wendel, G. W.
1977. **Longevity of black cherry, wild grape, and sassafras seed in the forest floor.** USDA For. Serv. Res. Pap. NE-375.

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories and research units are maintained at:

- Amherst, Massachusetts.
 - Beltsville, Maryland.
 - Berea, Kentucky, in cooperation with Berea College.
 - Burlington, Vermont, in cooperation with the University of Vermont.
 - Delaware, Ohio.
 - Durham, New Hampshire, in cooperation with the University of New Hampshire.
 - Hamden, Connecticut, in cooperation with Yale University.
 - Kingston, Pennsylvania.
 - Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.
 - Orono, Maine, in cooperation with the University of Maine, Orono.
 - Parsons, West Virginia.
 - Princeton, West Virginia.
 - Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.
 - University Park, Pennsylvania.
 - Warren, Pennsylvania.
-