Nitrogen fertilization stimulates germination of dormant pin cherry seed[1]

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Nitrogen fertilizers triggered germination of dormant *Prunus pensylvanica* L. seed naturally buried in the forest floor of 60-year-old Allegheny hardwood stands. Neither triple superphosphate nor muriate of potash applied with urea increased germination over that which occurred with urea alone. Rates as low as 56 kg/ha N from urea and calcium nitrate and 112 kg/ha N from ammonium sulfate stimulated germination. Nitrate was apparently responsible for breaking dormancy.

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Les engrais azotés ont déclanché la germination de semences dormantes de *Prunus pensylvanica* L., enfouies naturellement dans la couverture d'humus de peuplements feuillus de l'Allegheny. L'addition conjointe avec l'urée de superphosphate triple ou de muriate de potasse n'ont eu aucun effet additionnel à celui de l'urée seule. La germination fut stimulée à des taux d'application aussi bas que 56 kg/ha N d'urée ou de nitrate de calcium et 112 kg/ha N de sulfate d'ammonium. L'application de nitrate a apparemment brisé la dormance.

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Pin cherry (*Prunus pensylvanica* L.), a component of many eastern upland hardwood forests in North America, regenerates after heavy cutting, windthrow, or fire; however, it rarely persists in these stands for more than 35 years. After a forest disturbance, pin cherry seedlings develop from seed that has remained dormant in the forest floor for many years. These seeds originate from pin cherry in the initial stand and from deposits by birds and small mammals. Estimates of dormant pin cherry seed contained in the duff of certain middle-aged northeastern deciduous forests range from 250 000 to more than 4.5 million per hectare (Olmsted and Curtis 1947; Marks 1974; Marquis 1975). Rarely do more than a few of these seeds germinate annually unless forests are disturbed.

The mechanism responsible for germination has long been associated with forest disturbance, and hence with accompanying changes in light intensity and quality, mechanical stirring of the forest floor, and different soil temperature and moisture regimes. This paper provides evidence that germination is also promoted by increased soluble N concentrations in the soil.

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Methods

Germination of dormant pin cherry seeds after fertilization was assessed in two separate field experiments located in 60-year-old Allegheny hardwood stands in northwestern Pennsylvania, U.S.A. The stands used in both experiments were fully stocked, with an average basal area of 34 m^2/ha in trees larger than 2.5 cm diameter at breast height. Pin cherry was not represented in these stands, although it was a component at earlier ages, as evidenced by rotted remains of pin cherry logs and large numbers of pin cherry seed in the forest floor.

In the first experiment, conducted for other purposes, the treatments were as follows: (1) unfertilized (control); (2) nitrogen, 336 kg/ha as urea (N_{336}); (3) N_{336} + 98 kg/ha phosphorus as triple superphosphate (P_{98}); (4) N_{336} + P_{98} + 93 kg/ha potassium as potassium chloride (K_{93}).

The four treatments were arranged in randomized complete blocks and replicated at six independent test sites. The fertilizers were applied to 0.5-ha plots during late May in 2 successive years.

The first experiment was installed to test overstory response to fertilizers. No dramatic changes were expected in the seedling understory; nevertheless, one block was selected at the start of the study to monitor regeneration. Seedlings were counted on six randomly located 0.4-m^2 plots in each treatment (24 plots total). In years 1 and 2, counts were made before each fertilizer application, after application in mid-June, and again in early September. In years 3 and 4, counts were made only in mid-June. When extensive pin cherry germination was discovered on these plots, qualitative observations were made at the other five test sites, but no counts were taken.

The second experiment was designed to test the effect of several N carriers and N rates on germination of dormant

TABLE 1. Mean number of newly germinated pin cherry seedlings (1000 seedlings per hectare) in an uncut 60-year-old Allegheny hardwood stand after two annual fertilizer applications (fertilizers broadcast in years 1 and 2)[a]

Time of germination	Treatment			
	Unfertilized	N	NP	NPK
Year 1	0	0	0	4
Year 2	0	272	675	424[b]
Year 3	0	17	169	152[b]
Year 4	0	0	0	0
Total	0	289	844	576

[a]Sampling design based on six 0.4-m² plots per treatment at one location.
[b]Differences among N, NP, and NPK are not significant ($P \leq 0.05$).

pin cherry seeds, and to identify the form of N responsible for stimulating germination. Ammonium sulfate, calcium nitrate, and urea were applied at 56, 112, 224, and 336 kg/ha N with an untreated control for a total of 13 treatments. Plots were 1.5 m² and were replicated three times in randomized complete blocks. Fertilizers were broadcast in early November when daytime temperature of the upper 3 cm of soil was 10 to 12°C. Germination counts were made during mid-June and early September for 2 years thereafter.

Results

In the first experiment, fertilization with N, NP, and NPK stimulated germination of many dormant pin cherry seeds that were in the soil at the time of treatment (Table 1). Germination did not take place in the season when fertilizers were first applied (year 1), but in the following season (year 2) germination averaged between 272 000 and 675 000 seedlings per hectare. The fertilizer applications in year 2 further stimulated germination on the same plots in year 3, although to a lesser degree. There was no germination on any of the treated plots thereafter, which suggests a short-lived stimulus or a lack of additional viable seed. Although mean differences between urea alone, urea plus P, and urea plus P and K are large, none are significant ($P \leq 0.05$). No germination was observed on unfertilized plots during the 4-year study period. Seedlings that germinated on fertilized plots generally survived less than 3 months beneath the closed forest canopy.

Observations at each of the five remaining test sites confirmed that (*i*) there was no germination on unfertilized plots, (*ii*) treatment with urea stimulated abundant germination of resident pin cherry seeds, and (*iii*) the addition of P or PK with urea did not further influence germination. Thus, it appears that in addition to other factors such as light, temperature, or moisture, soluble N can play an important role in triggering dormant pin cherry seeds to germinate.

TABLE 2. Mean number of newly germinated pin cherry seedlings (1000 seedlings per hectare) in an uncut 60-year-old Allegheny hardwood stand in the first growing season after fall application of three nitrogen carriers at different nitrogen rates (second experiment; no germination on control plots or in year 2)

Nitrogen rate, kg/ha	Carrier		
	Ammonium sulfate	Calcium nitrate	Urea
56	0[a]	198	173
112	124	247	124
224	148	222	247
336	198	124	222

[a]The unfertilized and 56 kg/ha ammonium sulfate treatments do not differ but both are significantly different from remaining treatments. The differences among other rates and fertilizers are not significant ($P \leq 0.05$).

In the second experiment, urea, calcium nitrate, and ammonium sulfate promoted pin cherry germination at all rates except ammonium sulfate at 56 kg/ha N (Table 2). All germination was complete by mid-June of the first season after fertilization in the previous fall. There were no significant differences ($P \leq 0.05$) among nitrogen carriers or rates (except 56 kg/ha N from ammonium sulfate), which suggests that even moderate increases in soluble N will trigger germination.

Discussion

After application to the soil, urea and ammonium sulfate would undergo transformation, including conversion of ammonium to nitrate. Of the several products occurring in these transformations (NH_3, NH_4^+, NO_2^-, NO_3^-), only nitrate (NO_3^-) is common to all three carriers, which suggests that nitrate was responsible for breaking seed dormancy. This interpretation seems plausible in view of the results from other studies which have shown that nitrate-containing compounds are effective in stimulating germination of dormant seeds, but that ammonium sources usually are not (Vegis 1964; Hendricks and Taylorson 1974). An alternative, but less likely explanation, is that nitrogen compounds stimulate germination indirectly by increasing the release or production of some other substance from humus or through soil microorganisms.

The results of both experiments suggest that a chilling period is necessary to break dormancy after buried pin cherry seeds have been exposed to increased NO_3^- concentrations. In both studies, gremination occurred only after an overwinter period had followed high soluble N concentrations in the soil. Although the duration of exposure to

NO_3^- is probably important as well, the minimum time seems to have been exceeded even with the fall fertilizer applications.

The apparent large differences in seedling numbers among the fertilizer treatments (Table 1) seem due to the irregular distribution and variable numbers of seeds on the plots at the time of fertilization, and not to the addition of P and K fertilizers. This was substantiated by observations at the other five test sites, where all N-treated plots had large and about equal numbers of newly germinated pin cherry regardless of whether P or K had been applied.

From the present studies it seems that repeated applications of N to existing sawtimber stands could reduce the pin cherry in future stands. In situations where pin cherry outgrows other more desirable species after regeneration cuttings, N fertilization might be used beneficially in maturing stands to increase growth rates of residual trees and to reduce the numbers of pin cherry seeds that would germinate and later compete with preferred reproduction.

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