by L. R. Auchmoody
and G. W. Wendel

EFFECT OF CALCIUM CYANAMIDE

On Growth and Nutrition Of Planted Yellow-Poplar Seedlings

USDA FOREST SERVICE RESEARCH PAPER NE-265
1973

FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
NORTHEASTERN FOREST EXPERIMENT STATION
6816 MARKET STREET, UPPER DARBY, PA. 19082
WARREN T. DOOLITTLE, DIRECTOR

The Authors

L. R. AUCHMOODY received his B. S. and M. S. degrees from the State University of New York College of Forestry at Syracuse University. After joining the Northeastern Forest Experiment Station in 1965, he conducted research with Appalachian hardwoods at the Timber and Watershed Laboratory at Parsons, West Virginia. He is currently on the staff at the Station's Forestry Sciences Laboratory at Warren, Pennsylvania.

G. W. WENDEL has been a research forester at the Northeastern Forest Experiment Station, Timber and Watershed Laboratory, Parsons, West Virginia, since 1962. He received his B. S. in Forestry from Iowa State University in June 1951 and his M. F. from Yale University School of Forestry in June 1957. Prior to joining the Northeastern Forest Experiment Station, he worked for 5 years at the Southern Forest Experiment Station and 3 years at the New Jersey Department of Conservation and Economic Development.

MANUSCRIPT RECEIVED FOR PUBLICATION 21 AUGUST 1972

EFFECT OF CALCIUM CYANAMIDE

On Growth and Nutrition Of Planted Yellow-Poplar Seedlings

ABSTRACT

Calcium cyanamide, a nitrogenous fertilizer that also acts as an herbicide, was evaluated over a 3-year period for use in establishing planted yellow-poplar on an old-field site. Results of this study show that first and second year growth of yellow-poplar can be increased by broadcasting $CaCN_2$ around the seedlings. When applied at rates of 400 to 500 pounds of nitrogen per acre, $CaCN_2$ eliminated competing ground cover and supplied nitrogen to the seedlings that promoted vigor and rapid early growth.

CALCIUM CYANAMIDE, ($CaCN_2$), a nitrogen fertilizer that also acts as an herbicide, was evaluated over a 3-year period for use in establishing planted yellow-poplar on an old-field site. Results of this study show that first and second year growth of yellow-poplar can be increased by broadcasting $CaCN_2$ around the seedlings. When applied at rates of 400 to 500 pounds of nitrogen per acre, $CaCN_2$ eliminated competing ground cover and supplied nitrogen to the seedlings that promoted vigor and rapid early growth. Control of competing vegetation was limited mainly to the first season, but a portion of the nitrogen supplied by the cyanamide was available during the second year. As a result of these tests, we recommend this material for yellow-poplar plantings on sites where there is a need to eliminate competing ground cover and where nitrogen supply may be critical.

Fertilization has been recommended as a way of increasing growth of planted hardwood seedlings. However, surface-applied nitrogen fertilizers can stimulate growth of competing vegetation to the extent that seedling growth may often be retarded. Because control of ground cover by plowing and disking is costly and the more common herbicides that might be used for this purpose are generally toxic to hardwoods, there is a need for a nitrogenous fertilizer that does not stimulate competing vegetation.

Calcium cyanamide is a strongly alkaline inorganic compound that contains about 21 percent nitrogen. In the soil, it is hydrolyzed to urea and calcium hydroxide with formation of several unstable intermediate cyanide compounds that are toxic to both seeds and plants. In the presence of ample soil moisture, the toxic substances disappear in 2 to 3 weeks (*2, 5*). In agriculture, it has been used as a pre-plant, pre-emergent, and defoliating herbicide and also as a nitrogenous fertilizer (*4, 5, 6*); but its use in forestry has been limited (*1, 3, 7*). Its usefulness for establishing hardwoods on abandoned agricultural land has not heretofore been investigated.

Between 1969 and 1971, we evaluated the effects of $CaCN_2$ on the control of competing vegetation and upon the growth, survival, and nutrition of yellow-poplar (*Liriodendron tulipifera* L.) seedlings planted on an old field site in north central West Virginia. In these studies, $CaCN_2$ was effective as a nitrogen fertilizer that gave simultaneous control of competing sod and herbaceous vegetation without adverse effects on the seedlings.

THE STUDY AREA

The study area was located near Leadmine, West Virginia, on a flat bottomland site (fig. 1). Agriculture was discontinued in the area 12 years before the study began. There was a variety of herbaceous and grass species on the site as well as a few widely-scattered white pine, sycamore, and yellow-poplar seedlings.

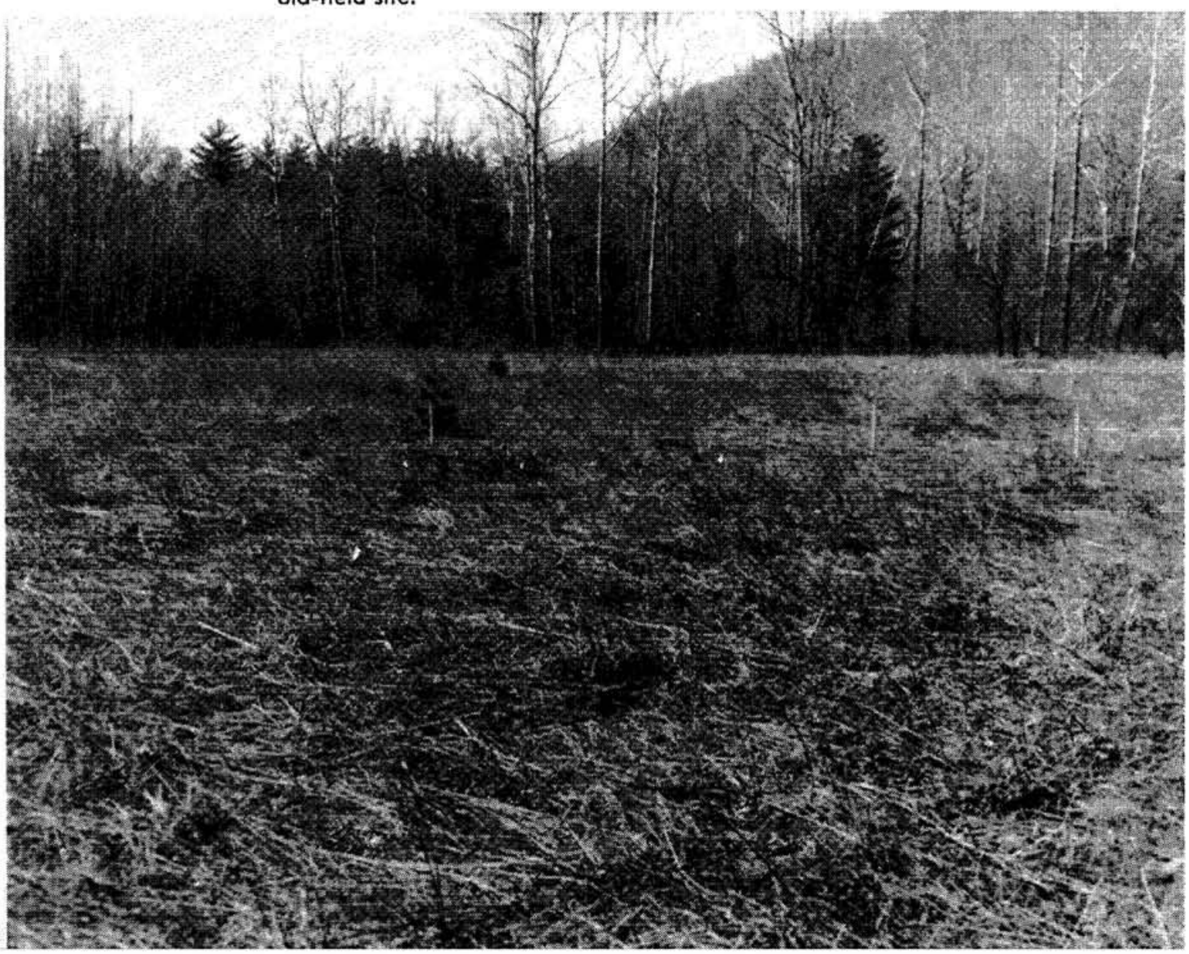
The soil, Pope loam formed from alluvial deposits weathered from acid gray sandstone and shale of adjoining uplands, is deep and well-drained. The A_p horizon averaged 7 inches deep and had a loamy texture. From 7 to 24 inches, the soil was generally loamy to light silt loam; and between 24 and 60 inches, the texture was predominately fine sand. Fertility of the experimental area was moderately good — probably better than most abandoned agricultural sites in the area (table 1).

Table 1.—*Average soil fertility of the study area*[a]

Horizon	Sampling depth (inches)	pH	P	K	Ca	Mg
			- - *Pounds*	*per acre* - -		
A_p	0-7	5.8	22	101	2,470	63
C	7-12	5.4	15	86	832	44

[a] pH by glass electrode in 1:1 soil water solution; P colorimetrically after extraction with 0.002 *N* H_2SO_4; K, Ca, Mg by atomic absorption after extraction with NH_4OA_c. Each value is the average of 10 samples.

Figure 1.—The study area was a topographically uniform old-field site.



METHODS

Early in 1969, we installed a randomized complete block experiment to test the effects of six levels of $CaCN_2$ on weed control and on yellow-poplar growth and nutrition. Rates of $CaCN_2$ corresponded to 0, 100, 200, 300, 400, and 500 pounds per acre of N.[1] There were five blocks, each containing six 9-tree plots. In each plot, trees were planted in three rows at a spacing of 5 by 5 feet. Plots were separated by 10-foot wide isolation strips.

On March 4, 1969, 1-0 yellow-poplar seedlings selected for their uniformity in height and stem caliber were outplanted. Before the seedlings were planted, their roots were pruned to 8 inches. Their height averaged 10.2 inches, and only seedlings within $\pm$ 2 inches of the average were used.

Pre-weighed amounts of powdered, reagent grade $CaCN_2$ for each of the treatment rates were each mixed with a pound of fine sand to give the material bulk. This mixture was broadcast uniformly over a 3-foot diameter area surrounding each seedling on March 27, 1969. The area of application was controlled by a circular template and protective sleeve placed over the seedling (fig. 2).

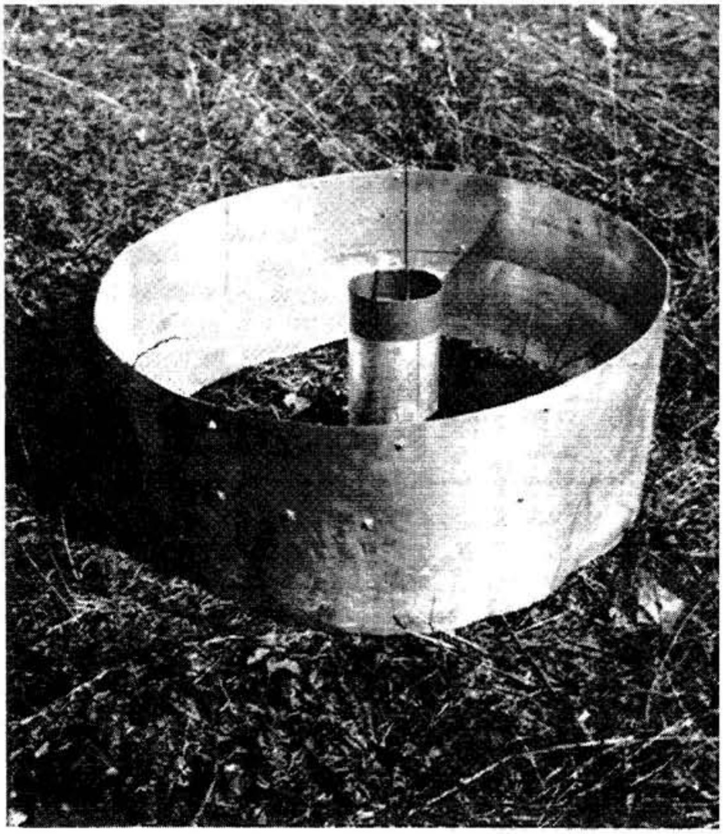


Figure 2.—A circular template and protective sleeve were used to control applications of $CaCN_2$.

The height of the seedlings was recorded at planting time and was remeasured at the end of the 1969 and 1970 growing seasons. Observations on control of competing vegetation were made weekly in 1969 and at 2-week intervals in 1970.

To determine the effect of treatments on the nutrition of the seedlings, samples of mature leaves free from insect and disease damage were collected from each treatment plot in mid-September of 1969 and 1970. Petioles were discarded and blades were dried at 70° C., weighed, and ground to pass a 20-mesh screen. N was determined by the Kjeldahl method. P was measured by the vanadomolybdophosphoric yellow method after wet washing with nitric and perchloric acids, and K, Ca, and Mg by atomic absorption. Nutrients in the leaves were expressed as concentration (percent of leaf dry weight) and as content (milligrams per leaf).

In the spring of 1971 when the seedlings were 3 years old, a second study was superimposed on the original study to determine: (1) whether $CaCN_2$ could be safely applied to established yellow-poplar seedlings; (2) whether protection of the seedlings from the $CaCN_2$ was necessary; and (3) whether time of application was critical.

The new study treatments were applied to 75 seedlings of uniform size in a completely random field design. Treatments were replicated 15 times on single-tree plots, which were 3 feet in diameter. All seedlings except those in the control group received $CaCN_2$ (granular form) at a rate of 500 pounds N per acre. Triple superphosphate at 200 pounds per acre P_2O_5 was applied to all seedlings.

Treatment 1 — Application March 15 with seedlings protected

Treatment 2 — Application May 1 with seedlings protected

[1] These rates correspond to 0, 34, 68, 102, 136, and 170 grams of $CaCN_2$ per tree, distributed over an area of 7 square feet.

Treatment 3 — Application June 15 with seedlings not protected

Treatment 4 — Application June 15 with seedlings protected

Treatment 5 — Control

Observations on the control of competing vegetation and on seedling mortality were made periodically throughout the growing season. Seeding height was measured in the dormant season.

RESULTS

1969 Study

Control of Competing Ground Cover

$CaCn_2$ was very effective in controlling competing ground cover when applied at rates equivalent to 400 or 500 pounds of N per acre (fig. 3). At 300 pounds per acre, it was considerably less effective than at the higher levels; and at rates of 100 or 200 pounds per acre, there was no observable difference between the treated plots and the controls.

At the 400 and 500 pounds per acre rates, much of the ground cover was killed or failed to develop substantially during the first growing season. Both treatments were equally effective, both killed ground cover immediately, and there was no difference in the length of time the vegetation was suppressed. Excellent control of goldenrod, ragweed, yarrow, thistles, joe-pye-weed, cinquefoil, plantain, dock, field basil, ground ivy, red top, timothy, and velvet grass was obtained. (Appendix I).

Dewberry — a ground running member of the blackberry family — was only partially controlled. Although the aerial parts of dewberry were killed, roots in the treated areas had sprouted by the end of the growing season and vines from adjacent untreated areas had encroached upon the plots.

The absence of annual species when $CaCN_2$ was applied at these rates suggests that all

Figure 3.—$CaCN_2$ broadcast at 400-500 pounds per acre N equivalent effectively eliminated most ground cover. Note the sharp boundary between the treated and untreated areas around the seedling.

of the weed seed stored in the surface layer of soil was killed.

At 300 pounds per acre, good control was obtained early in the growing season; but after June, plants and seeds that survived the treatment responded vigorously to reduced competition and abundant N and managed to occupy the site almost fully as the season progressed.

In the beginning of the second growing season, less vegetation was observed only on plots treated at 400 and 500 pounds per acre, but this effect diminished as the season progressed. We feel that the initial reduction in cover was related to a limited seed supply caused by the almost complete kill of vegetation in the preceding year. We also feel that the diminishing effect within the season resulted from rapid development of fall-maturing species, particularly goldenrod, which grew quickly with limited competition and ample N supply.

Seedling Survival

We did not observe any seedling mortality that could be attributed directly to the $CaCN_2$ treatments. This suggests that the toxic cyanide compounds produced in the soil did not penetrate downward into the rooting zone of the planted seedlings; or if this did occur, concentrations were so diluted that they were not critical to yellow-poplar. The sharp line of lush vegetation outside the treated plots and within the small untreated area surrounding the seedlings (fig. 3) is good evidence that these compounds are immobile and do not diffuse laterally within the soil during their short life span.

Elimination of competing vegetation around the seedlings did not affect first or second year survival. However, where competition was not controlled by $CaCN_2$, seedlings were poor in vigor. Therefore, it is possible that there might be later differences in survival between plots where sod and weeds were eliminated and those where they were not.

Seedling Height

At the end of the first growing season, seedlings treated at rates of 300, 400, and 500 pounds per acre were significantly taller than untreated seedlings or those fertilized at rates of 100 and 200 pounds per acre (fig. 4). No significant height differences existed within either of these two treatment groups (table 2). Seedlings treated at the three highest rates were also substantially larger in caliper and

Figure 4.—Mean total height of yellow-poplar seedlings at outplanting and at the end of the 1969 and 1970 growing seasons.

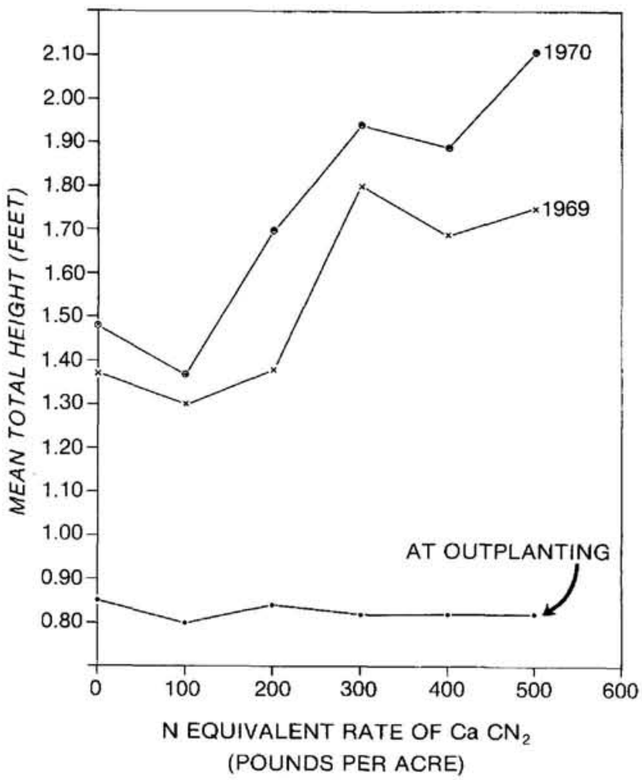


Table 2.—*Mean total heights of yellow-poplar seedlings 1 and 2 years after treatment with varying rates of* $CaCN_2$[a]

N equivalent rate of $CaCN_2$ (pounds per acre)	Mean height (feet)	
	1969	*1970*
0	1.37 a	1.48 a
100	1.30 a	1.37 a
200	1.38 a	1.70 ab
300	1.80 b	1.94 ab
400	1.69 b	1.89 ab
500	1.75 b	2.11 b

[a] Values in the same column followed by the same letter are not significantly different (.05 level) as determined by the Student-Newman-Keuls multiple range test.

more vigorous than controls and seedlings treated with 100 and 200 pounds per acre. At the end of the second growing season, only the 500 pounds per acre treatment had significantly taller seedlings than the control (table 2).

The fact that $CaCN_2$ can be used to supply N without stimulating competing cover is of much greater importance than the actual magnitude of response obtained upon this particular site. Because response to any fertilizer is proportional to the degree of nutrient deficiency (if other growth limiting factors are not critical), the increase in growth obtainable from $CaCN_2$ will vary with the N supply of the particular site in question.

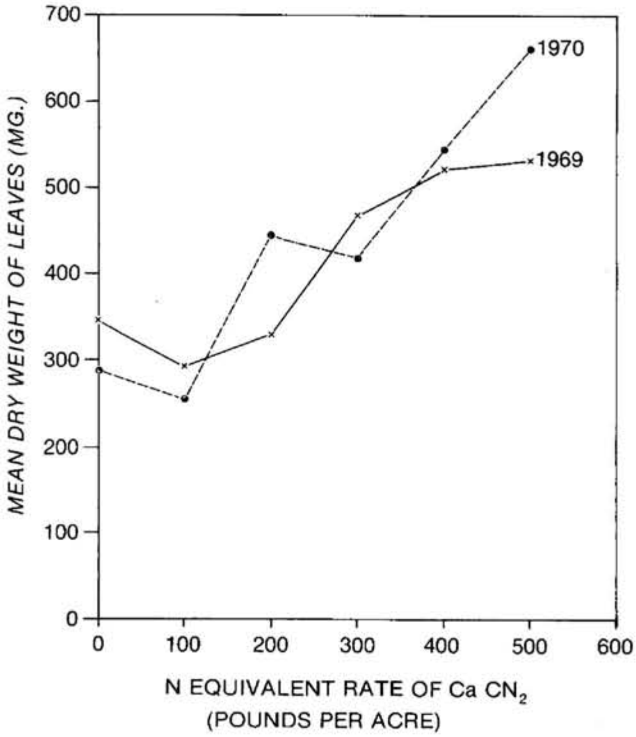
Two uncontrollable factors had pronounced effect on the growth on the plots treated with the two heaviest concentrations of $CaCN_2$. First, late spring frosts in both seasons killed back new growth, leaving the seedlings weakened. During the second season, damage was greater on the larger seedlings where growth had been stimulated by the $CaCN_2$.

Second, oviposition damage from the snowy tree cricket (*Oecanthus niveus*) in the new growth of both years tended to be concentrated in the larger seedlings and may have caused a reduction in potential height obtainable from the $CaCN_2$. We feel that these factors have masked to some unknown degree the full benefits on growth that might have otherwise been achieved.

Seedling Nutrition

Leaf Weight. — Average leaf weight increased with increasing rates of $CaCN_2$ above

Figure 5. — Relationship of average leaf weight to N equivalent rate of $CaCN_2$.



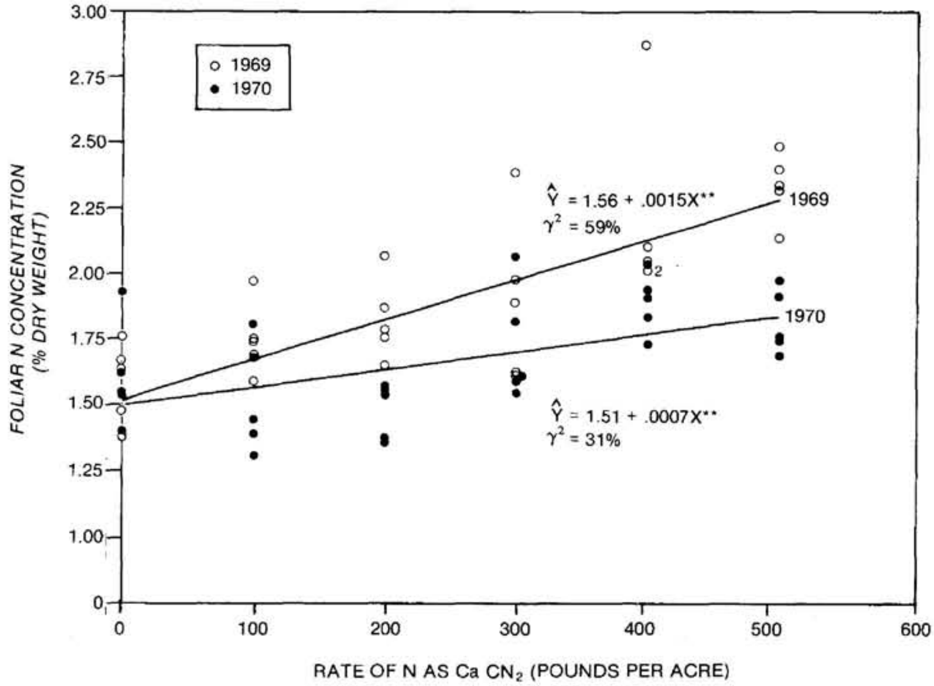
300 pounds per acre, although the 200 pounds per acre rate also showed a small increase during the second season (fig. 5). At the end of the first season, leaves from seedlings treated at the 300, 400, and 500 pounds per acre rates were significantly heavier than those from seedlings in control and 100 and 200 pounds per acre plots (table 3). In the second season, however, only seedlings treated

Table 3.—*Concentration and content of N and dry weight of the leaves of yellow-poplar seedlings treated with varying rates of $CaCN_2$*[a]

N equivalent rate of $CaCN_2$ (pounds per acre)	Dry weight per leaf (milligrams)		Concentration (percent dry weight)		Content (milligrams per leaf)	
	1969	*1970*	*1969*	*1970*	*1969*	*1970*
0	346 a	289 a	1.58 a	1.61 a	5.40 a	4.48 a
100	293 a	255 a	1.75 a	1.53 a	5.08 a	3.85 a
200	330 a	445 abc	1.83 a	1.48 a	5.97 a	6.68 a
300	469 b	419 ab	1.90 a	1.73 a	8.74 b	6.37 a
400	521 b	545 bc	2.22 b	1.90 b	11.55 c	10.33 b
500	531 b	661 c	2.34 b	1.82 a	12.37 c	12.00 b

[a]Values in each column followed by the same letter are not significantly different (.05 level) as determined by the Student-Newman-Keuls multiple-range test.

Figure 6.—Relationship between N concentration in yellow-poplar foliage and N equivalent rates of $CaCN_2$ in September of the first and second seasons after treatment.



at 400 and 500 pounds per acre had significantly heavier leaves than the controls.

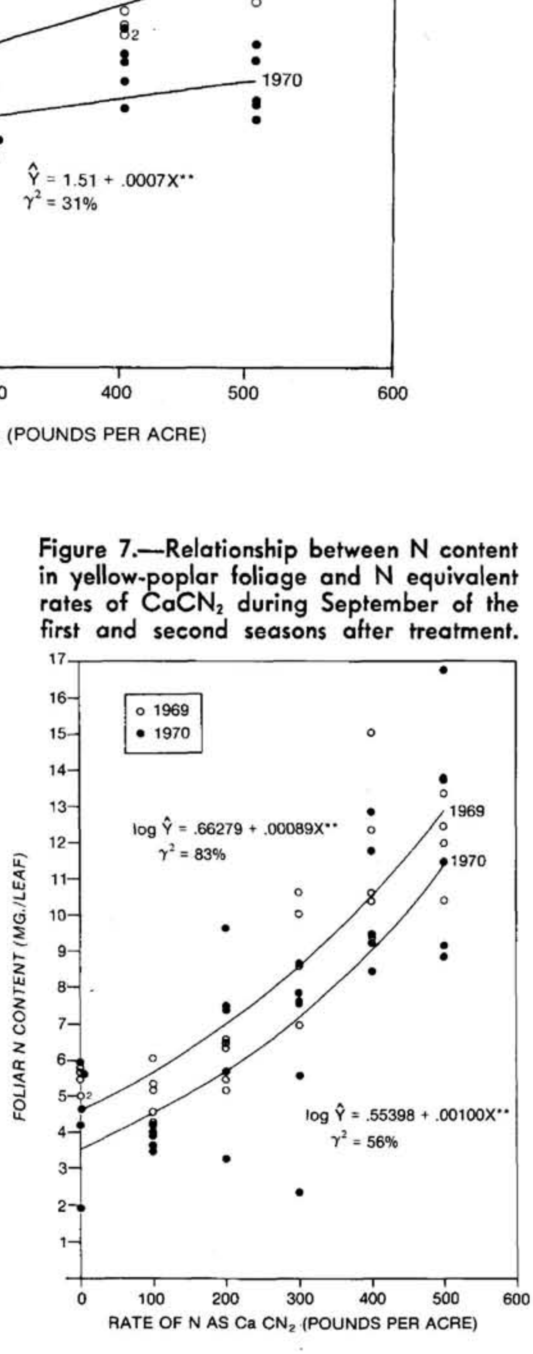
Therefore, leaf weight increased during the first season at rates of 300 pounds per acre or more, but significant carryover of effects into the second season is obtainable only at rates of 400 pounds per acre or more.

Foliar N. — Foliar N concentration (percent of dry weight) and actual content of N in the leaves (mg. per leaf) were both significantly and positively ($P < .01$) related to the amount of N applied to the seedlings as $CaCN_2$ (figs. 6 and 7).[2] The relationships were generally linear for concentration and logarithmic for content and were stronger for the first season than they were for the second.

During the first year, the treatments at 400 and 500 pounds per acre significantly increased N concentrations above levels occurring in control seedlings (table 3). At the end

[2] This study did not separate effects of fertilization from those stemming from weed control. Therefore an unknown portion of the growth stimulation and nutrient uptake may have resulted from weed control only.

Figure 7.—Relationship between N content in yellow-poplar foliage and N equivalent rates of $CaCN_2$ during September of the first and second seasons after treatment.



of the second season, seedlings treated at the 400 pounds per acre rate were still significantly higher in foliar N than all other treatments, although seedlings treated at the 500 pounds per acre rate also had about the same concentrations.

The same general pattern was also observed for the actual content of N in the leaves (table 3). In both years, N content was significantly increased by application of $CaCN_2$ corresponding to 400 and 500 pounds per acre, whereas only minor differences occurred between lower rates and controls. There was one exception: in 1969, seedlings treated at the 300 pounds per acre rate had foliar N significantly higher than the controls and lower than the seedlings treated at 400 and 500 pounds per acre.

Table 4.—Concentration and content of Ca in the leaves of yellow-poplar seedlings treated with varying rates of $CaCN_2$[a]

N equivalent rate of $CaCN_2$ (pounds per acre)	Concentration (percent dry weight)		Content (milligrams per leaf)	
	1969	*1970*	*1969*	*1970*
0	2.65 a	2.83 a	9.12 a	9.60 ab
100	2.53 ab	2.66 ab	7.37 a	6.74 b
200	2.32 b	2.66 ab	7.66 a	11.85 ab
300	2.02 c	2.77 a	9.45 a	10.17 ab
400	2.04 c	2.45 b	9.79 a	13.30 ab
500	1.78 c	2.38 b	9.49 a	15.63 a

[a] Values in each column followed by the same letter are not significantly different (.05 level) as determined by the Student-Newman-Keuls mulitple-range test.

Table 5.—P, K, and Mg concentrations in the foliage of yellow-poplar seedlings treated with varying rates of $CaCN_2$[a]

N equivalent rate of $CaCN_2$ (pounds per acre)	Phosphorus		Potassium		Magnesium	
	1969	1970	1969	1970	1969	1970
			Percent dry weight			
0	.11 a	.12 a	.66 a	.88 a	.17 a	.30 a
100	.11 a	.11 a	.56 a	.94 a	.17 a	.27 a
200	.12 a	.12 a	.61 a	.84 a	.16 a	.29 a
300	.11 a	.12 a	.55 a	.68 a	.15 a	.22 a
400	.12 a	.13 a	.60 a	.75 a	.18 a	.27 a
500	.10 a	.12 a	.59 a	.72 a	.20 a	.27 a

[a] Values in each column followed by the same letter are not significantly different (.05 level) as determined by the Student-Newman-Keuls multiple-range test.

Table 6.—Content of P, K, and Mg in the foliage of yellow-poplar seedlings treated with varying rates of $CaCN_2$[a]

N equivalent rate of $CaCN_2$ (pounds per acre)	Phosphorus		Potassium		Magnesium	
	1969	1970	1969	1970	1969	1970
			Milligrams per leaf			
0	.37 a	.40 a	2.27 abc	3.07 a	.60 a	1.04 ab
100	.32 a	.29 a	1.67 a	2.44 ab	.53 a	.68 a
200	.39 a	.53 ab	2.02 ab	3.66 ab	.54 a	1.25 ab
300	.50 b	.43 a	2.50 bcd	2.45 ab	.72 ab	.76 a
400	.58 b	.67 bc	2.93 cd	4.01 ab	.94 ab	1.45 ab
500	.54 b	.78 c	3.08 d	4.72 b	1.04 b	1.80 b

[a] Values in each column followed by the same letter are not significantly different (.05 level) as determined by the Student-Newman-Keuls multiple-range test.

These results indicate that part of the N from $CaCN_2$ applied at rates of 400 and 500 pounds per acre will be retained for use during the second year. At rates below 400 pounds per acre, N will only be available during the first year. Foliar N concentrations of 1.60 percent or less in yellow-poplar seedling leaves indicate N deficiency, and a growth response can be expected from $CaCN_2$ applied at 400 or 500 pounds per acre.

Foliar Ca. — Ca concentrations (in percent dry weight) decreased with increasing rates of $CaCN_2$, and the decrease was greater during the first year than during the second (table 4). In the first year, rates of 200, 300, 400, and 500 pounds per acre N equivalent resulted in significantly ($P < .05$) lower foliar Ca concentrations than those that occurred in the controls. But in the second year, only the two heaviest treatments still showed significantly lower concentrations.

In contrast, there were no differences in Ca content (mg./leaf) of the foliage due to treatment until the second growing season. This suggests that lower concentrations were the result of increasingly heavier leaf weights that were uncompensated for by comparable gains in Ca uptake. If further suggests that the Ca contained in the $CaCN_2$ was not available for use by the seedlings until sometime during the second growing season.

Foliar P, K, and Mg. — Foliar concentrations of P, K, and Mg were not generally affected by $CaCN_2$ treatments (table 5). In contrast, however, significant gains in content of these nutrients in the foliage were associated with increasing rates of $CaCN_2$ (table 6) and were the direct result of positive changes in leaf dry weight.

1971 Study

Time of Application

Generally, competing vegetation was controlled longer when the $CaCN_2$ was applied during the dormant period (March 15) or early in the season (May 1) as compared to the mid-season (June 15) treatment. Vegetation from the March 15 and May 1 applications was controlled until mid-July, but thereafter the effects diminished. The June 15 treatment, did not completely control the cover; much of the vegetation was merely set back.

There were considerable differences in completeness of kill and length of time vegetation was controlled from the two early $CaCN_2$ applications in this second study compared to those obtained in the first study. Possibly, this was because the $CaCN_2$ used in the 1969 study was the powdered reagent grade $CaCN_2$, whereas in the 1971 study, $CaCN_2$ in granular form was used. The 1969 application killed the weeds completely and lasted longer.

No seedling mortality or serious ill effects were observed from application of 500 pounds per acre, regardless of whether it was broadcast when the seedlings were dormant or actively growing. However, the June 15 treatment did produce very mild orange-colored mottling on the leaves of some seedlings. But this did not result in defoliation or in decrease of seedling vigor.

Seedling growth was equally good and was significantly ($P < .05$) better for all $CaCN_2$ treatments than for control (table 7). Similarly, leaves on the treated seedlings were significantly heavier ($P < .05$) than those on the controls. Leaves on seedlings fertilized on May 15 were significantly heavier than those given any other treatment.

These results show that $CaCN_2$ at 500 pounds per acre (in granular form) can be safely applied to established yellow-poplars

Table 7.—*Mean height growth and mean leaf weight of yellow-poplar seedlings fertilized with $CaCN_2$ (500 pounds per acre N equivalent) at different times during the growing season*[a]

Treatment (time $CaCN_2$ was applied)	Average height growth	Average leaf weight
	Inches	*Grams*
Control	12.0 a	0.59 a
March 15	17.6 b	.81 b
May 15	20.1 b	1.12 c
June 15	17.8 b	.89 b
June 15 (No seedling protection)	18.0 b	.89 b

[a] Values in each column followed by the same letter are not significantly different (.05 level) as determined by the Student-Newman-Keuls multiple-range test.

without protecting the seedlings from the $CaCN_2$. Application in this locality can be made between mid-March and mid-June without inducing mortality or forfeiting response.

CONCLUSIONS

1. Yellow-poplar seedlings responded favorably in growth and showed better N nutrition when treated with $CaCN_2$. What is of much greater significance though, is that this compound can be used to supply N without stimulating growth of competing vegetation or harming the planted seedlings.

2. $CaCN_2$ affected seedling nutrition by increasing foliar N concentrations and decreasing Ca concentrations. It had little effect on concentrations of P, K, or Mg. Generally, however, foliar nutrient uptake (milligrams per leaf) increased with increasing levels of $CaCN_2$ due to increases in leaf dry weight. During 1969, Ca uptake was unchanged by the $CaCN_2$ treatments and thus deviated from this general trend.

3. Yellow-poplar seedlings responded in height growth to $CaCN_2$ treatment when foliar N concentrations were about 1.60 percent dry weight, and the best growth was obtained at the 500 pounds per acre N equivalent rate (170 grams of $CaCN_2$ per seedling).

4. $CaCN_2$ broadcast at rates of N equivalent to 400 or 500 pounds per acre during the dormant season controlled competing ground cover around planted yellow-poplar seedlings for the entire first growing season; 300 pounds per acre gave substantially less control, and 100 and 200 pounds per acre rates were not effective.

5. On plots treated with 400 to 500 pounds per acre there was less competition from ground cover during the beginning of the second season, but these effects gradually diminished as the season progressed.

6. $CaCN_2$ broadcast at rates of up to 500 pounds per acre was not toxic to yellow-poplar seedlings. This was true for newly planted stock and for seedlings outplanted for 2 years.

7. $CaCN_2$ in granular form can be broadcast directly around established seedlings without having adverse effects. There is no need to protect the seedlings from the $CaCN_2$ or control the area to which it is applied as long as the proper application rate is maintained.

8. The time of $CaCN_2$ application is not critical. In this study, applications made between March 15 and June 15 all had about the same effect on height growth.

LITERATURE CITED

1. Armson, K. A.
1967. REVIEW OF FOREST FERTILIZATION IN CANADA. Forest. Branch Departmental Pub. 1186, 175 p.

2. Baule, Hubert, and Claude Fricker.
1970. THE FERTILIZER TREATMENT OF FOREST TREES. BLV, Munich, Germany. 259 p.

3. Knight, H.
1963. THE EFFECT OF NITROGEN FERTILIZATION ON HEIGHT GROWTH OF DOUGLAS FIR ON A POOR SITE. Forest. Chron. 39: 403-411.

4. Kriner, R. R., and J. L. Pearson.
1966. HERBICIDES AND GROWTH REGULATORS. *In* Pesticide Information Manual, Section G., Coop. Ext. Serv. of the Northeast Land Grant Coll. 36 p.

5. Schreiner, Oswald, Albert R. Metz, and B. E. Brown.
1938. FERTILIZER MATERIALS. *In* 1938 Yearbook of Agr. pp. 487-521.

6. Tisdale, Samuel L., and Werner L. Nelson.
1966. SOIL FERTILITY AND FERTILIZERS. The Macmillan Co., New York. 694 p.

7. Wilde, S. A.
1946. FOREST SOILS AND FOREST GROWTH. Chronica Botanica, Waltham, Mass. 241 p.

APPENDIX I

COMMON AND SCIENTIFIC NAMES

Yellow-poplar (*Liriodendron tulipifera* L.)
American sycamore (*Platanus occidentalis* L.)
Eastern white pine (*Pinus strobus* L.)
Redtop (*Agrostis alba* L.)
Timothy (*Phleum pratense* L.)
Velvet grass (*Holcus lanatus* L.)
Common yarrow (*Achillea millefolium* L.)
Common ragweed (*Ambrosia artemisiifolia* L.)
Goldenrod (*Solidago ulmifolia* Muhl.)
Joe-pye-weed (*Eupatorium fistulosum* Barratt)
Common thistle (*Cirsium vulgare* (Savi) Tenore)
Old-field-cinquefoil (*Potentilla simplex* Michx)
Upright cinquefoil (*Potentilla recta* L.)
Dewberry (*Rubus* sp.)
Dock (*Rumex* sp.)
Common plantain (*Plantago rugellii* Dane.)
Buckhorn plantain (*Plantago lanceolata* L.)
Field basil (*Satureja vulgaris* (L.) Fritsch)
Ground ivy (*Glechoma hederocea* L.)

APPENDIX II

PESTICIDE PRECAUTIONARY STATEMENT

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

PROTECT

Use Pesticides Safely
FOLLOW THE LABEL
U.S. DEPARTMENT OF AGRICULTURE

THE FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.