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Abstract. Chemical and mechanical methods of reducing herbaceous competition within tree plantings on three Iowa soil types were studied. Treatments included Garlon, Esteron-Dowpon, Simazin, Chloro IPC, Mylone, Vapam, disking, mowing, cultivation, and check. Survival and height growth of jack pine, white pine, cottonwood, and black walnut were determined for each method of control. Available light and soil moisture were also determined within each treatment as supplementary measures of the success of competition control. Tree seedling survival and height growth varied somewhat among treatments from soil type to soil type. However, survival and height growth were generally greatest on the cultivated plots followed in order by (1) Garlon and Esteron-Dowpon; (2) Simazin, Chloro IPC, and mowing; and (3) disking, Vapam, and Mylone. Thirty- to fifty-day differences in the length of effectiveness of the chemicals and major changes in weed composition during reinvasion affected responses noticeably. In general, tree survival and height growth varied directly with the effectiveness of weed control as reflected in available soil moisture and light intensities.

In a recent study, several methods of eliminating or reducing herbaceous vegetation within newly established forest-tree plantations were evaluated. The specific objective was to determine the effectiveness of weed control by each of 10 methods as reflected in survival and first-year height growth of 4 tree species and in improved light and soil-moisture conditions.

METHODS

Three separate experimental areas, each representing a different soil type, were selected near the Coralville Reservoir in the Iowa River valley in east-central Iowa. The soil types were Fayette silt loam, Waukegan loam, and Racine silt loam (imperfectly drained variant).

Natural weed cover on the experimental location ranged up to 3 to 5 feet in height and composition varied somewhat by areas. Principal weed species in order of importance were smooth brome grass (*Bromus inermis* Leyss), blue vervain (*Verbena hastata* L.), and horseweed (*Erigeron canadensis* L.) on the Fayette soil; giant ragweed (*Ambrosia trifida* L.), horseweed, timothy (*Phleum pratense* L.), and aster (*Aster multiflorus* Ait.)

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on the Waukegan; and giant ragweed, horseweed, blue vervain, and lambsquarters (*Chenopodium album* L.) on the Racine.

Experimental Design

A split-plot experimental design was used on each of the three areas (Cochran and Cox, 1950). Two blocks were established on each soil type and each block was divided into ten 12- by 30-foot plots. The weed-control treatments randomly assigned to plots within blocks were disking and the the application of Garlon, Esteron-Dowpon, Simazin, Chloro IPC, Mylone, or Vapam; disking and cultivation; disking and mowing; disking alone; and no treatment (check) (Table 1). Each of the four tree species—eastern white pine (*Pinus strobus* L.), jack pine (*P. banksiana* Lamb.), black walnut (*Juglans nigra* L.), and eastern cottonwood (*Populus deltoides* Bartr.)—was randomly assigned to subplots. Each subplot contained a 10-tree row of one species planted at a 3-foot spacing.

Table 1. Chemical composition of herbicides.

Trade Name	Chemical Composition
Garlon (Silvex and Dalapon, 1:8)	2-(2,4,5-trichlorophenoxy) propionic acid and 2,2-dichloropropionic acid
Esteron ten-ten	2,4-dichlorophenoxyacetic acid; propylene glycol
Dowpon	2,2-dichloropropionic acid, sodium salt
Simazin	2-chloro-4,6-bis-(ethylamino)-s-triazine
Chloro IPC	Isopropyl-N-(3-chlorophenyl) carbamate
Mylone	3,5-dimethyl tetrahydro-1, 3-5, 2-H-thiadiazine-2-thione
Vapam	Sodium methyl dithiocarbamate

A 10-foot isolation strip was left between plots to minimize effect of spray drift. Each treatment was extended to the center of the isolation strip to eliminate border effects.

Treatments

All of the plots (except check) were disked before further treatment. Additional treatment was as follows:

1. Garlon—applied in May as a foliage spray at the rate of 4 gallons per acre.

2. Esteron ten-ten (2 pounds acid equivalent per acre) and Dowpon (20 pounds per acre)—applied in May as a foliage spray.

3. Simazin—sprayed on the soil surface in May at the rate of 1½ pounds per acre.

4. Chloro IPC granules – mixed thoroughly with sand and placed on the soil surface in May at the rate of 8 pounds per acre.

5 & 6. Mylone (290 pounds per acre) and Vapam (109 gallons of the 33-percent form per acre)—applied as soil fumigants during the last week in April.

7. Cultivation—done (with a garden cultivator) when needed rather than on any pre-set date: once during early June and once in late July.

8. Two mowings—done once in early June and again in mid-July.

9. No treatment other than disking—done in mid-April.

10. No treatment at all (check).

Seedlings of black walnut, white pine, and jack pine and stem cuttings of cottonwood were hand-planted in each plot between May 4 and 16. Plots treated with Vapam and Mylone were not planted until 14 days after treatment to avoid residual effects of the chemicals. All other plots were planted before chemicals were applied. The trees were covered during the application of chemicals to prevent any direct contact.

Measurements

A survival count was made during late September and October. Total height and first-year height growth of each seedling were measured. Survival percentages were converted to arc sine values for statistical analysis.

The intensity of herbaceous competition was determined by the amount of light received at the tops of planted seedlings and the amount of soil moisture available to the seedlings throughout the growing season. Light intensities were measured with the Weston Illumination Meter by placing the photoelectric cell at the top of the seedling, perpendicular to the zenith. Surrounding and overtopping vegetation was not disturbed during measurement. Two readings were obtained within each species-subplot on clear days between 11:00 a.m. and 1:00 p.m.

Soil-moisture samples were taken at about 2-week intervals throughout the growing season. Composites of two samples at the 0-1 and the 1-2 foot depths were obtained in each plot. Moisture was determined by standard gravimetric procedures. Volumetric samples of the 0-1 and the 1-2 foot depths were taken for each soil type with the Ulland sampler, and their bulk densities were calculated as described by Baver (1956). Permanent wilting percentages for each soil type and each depth were determined with the pressure-membrane apparatus (Richards 1947).

Results

For the entire growing season, the two cultivations did best

in limiting weed size and density, and the two mowings kept planted trees from being overtopped. Weeds were satisfactorily controlled by the chemical treatments on all areas for 30 to 50 days, but invading species rapidly became re-established thereafter. Disking effects were short-lived.

The composition of weed regrowth differed somewhat by area and treatment. Foxtail (*Alopecurus* L.) was the principal invading species on plots receiving Dowpon and Esteron, Garlon, Vapam, Mylone, cultivation, and mowing. Except on the last two treatments, foxtail was accompanied by giant ragweed on the Fayette area, and Simazin plots were largely taken over by foxtail and velvet leaf (*Abutilon theophrasti* Medic.) on the Racine soil. The major species entering all other treatment-location combinations were about the same as originally present.

Survival of Planted Trees

Fayette silt loam area. Mean survival of the forest-tree seedlings was highest on the cultivated plots, followed in order by Garlon, disked, Esteron-Dowpon, check, mowed, Chloro IPC, Simazin, Vapam, and Mylone (Fig. 1). Treatment differences were significant at the 70-percent probability level. Available soil moisture averaged 0.48 inches more on the cultivated plots than on the Chloro IPC, Vapam, and Mylone treated plots. Light intensities on the cultivated plots averaged 9,100 ft-c over the growing sea-

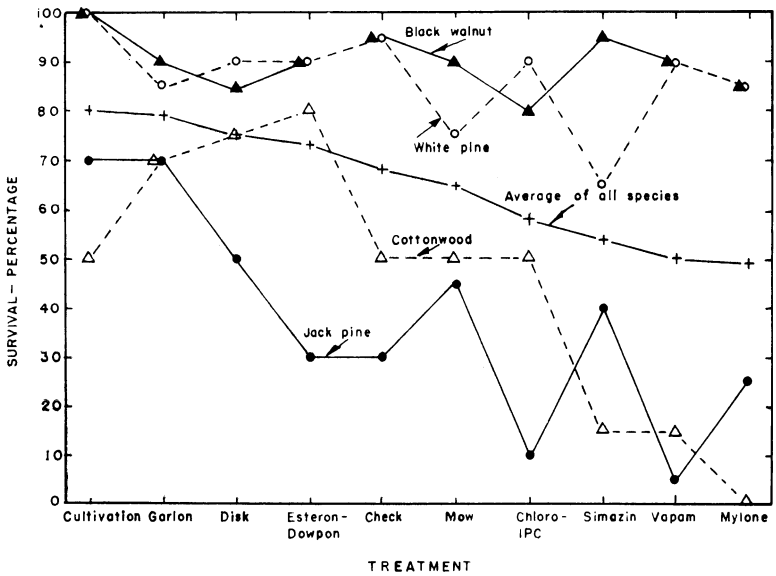

Figure 1. The effect of ten weed-control treatments on the mean survival of four tree species grown on the Fayette silt loam area.

son. Garlon, disking, and Esteron-Dowpon treatments gave significantly better survival than Vapam and Mylone. Available soil moisture and light intensities averaged approximately 0.41 inches and 600 ft-c greater throughout the growing season within the Garlon, disking, and Esteron-Dowpon treatment areas than within the Mylone treated plots.

The mean survival percentage of black walnut was 52 percent greater than that of jack pine, 44 percent greater than cottonwood, and 3 percent greater than white pine (Fig. 1). Differences between black walnut and jack pine, black walnut and cottonwood, white pine and jack pine, and white pine and cottonwood were highly significant.

White pine and black walnut survival was best on the cultivated plots; jack pine survival was greatest on the cultivated and Garlon plots. Cottonwood survival on Simazin, Vapam, and Mylone plots, and that of jack pine on Chloro IPC, Vapam, and Mylone plots were notably low.

Waukegan loam area. Mean survival of the tree seedlings was highest on the mowed plots followed in order by cultivated, Garlon, Esteron-Dowpon, Simazin, disked, Chloro IPC, check, Vapam, and Mylone (Fig. 2). Treatment differences were significant at the 90-percent probability level. The cultivation treatment gave significantly better survival than Vapam and Mylone. Available soil moisture and light intensities averaged approximately 1.50 inches and 2,400 ft-c greater on the cultivated plots than on the Vapam and Mylone treated plots throughout the growing season.

The mean survival of black walnut was approximately 62 percent greater than that of jack pine and cottonwood and 12 percent greater than that of white pine. The survival of black walnut and white pine was significantly greater than that of cottonwood and jack pine at the 99-percent probability level.

White pine and cottonwood survival was greatest on the mowed plots, jack pine survival was greatest on the cultivated plots, and black walnut survival was greatest on the disked plots. The survival of jack pine on check, Vapam, and Mylone plots, and the survival of cottonwood on disked, Chloro IPC, Vapam, and Mylone plots, were especially poor.

Racine silt loam (imperfectly drained) area. One replication of the Esteron-Dowpon, Chloro IPC, and check treatments was flooded during the growing season so only 7 treatments were available for comparisons on this area. Mean survival of seedlings was highest on the Simazin treated plots followed in order

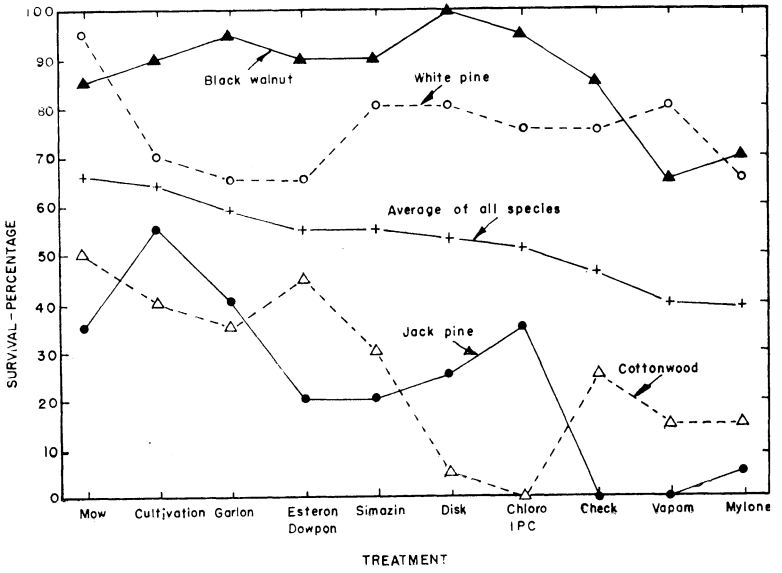

Figure 2. The effect of ten weed-control treatments on the mean survival of four tree species grown on the Waukegan loam area.

by the Mylone, Garlon, Vapam, cultivated, mowed, and disked plots (Fig. 3). Treatment differences were significant at the 70-percent probability level. Available soil moisture averaged 0.63 inches more on the Simazin, Mylone, and Garlon plots than on disked. Light intensities on the Simazin, Mylone, and Garlon plots averaged from 6,600 to 7,100 ft-c over the growing season.

Mean survival percentage of black walnut and white pine was 65 percent greater than cottonwood and 32 percent greater than jack pine. The differences between black walnut and cottonwood, black walnut and jack pine, white pine and cottonwood, and white pine and jack pine were highly significant.

White pine survival was best on Simazin plots, jack pine survival was greatest on the Garlon plots; black walnut survival was best on Simazin and Mylone plots, and cottonwood survival was greatest on Mylone plots.

Height Growth of Planted Trees

Height growth of white pine, jack pine, and black walnut was influenced little by treatment and site. Cottonwood, which grew 1½ feet to 3½ feet taller than the other species on these areas, generally grew best on cultivated plots. An exception occurred on the Racine soil where faster cottonwood growth was recorded on the Vapam plots. Although the cause of this difference is not

definitely known, it appears likely that higher mortality of small trees on Vapam treated plots resulted in greater average height of the survivors.

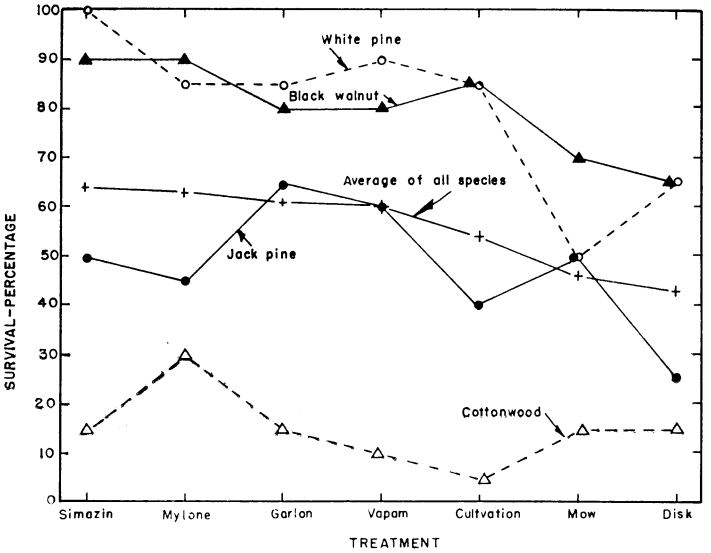

Figure 3. The effect of seven weed-control treatments on the mean survival of four tree species grown on the Racine silt loam (imperfectly drained) area.

Discussion

Tree seedling survival and height growth differed somewhat among treatments from soil type to soil type. However, regardless of soil type, survival and height growth were generally greatest on the cultivated plots followed in order by (1) Garlon and Esteron-Dowpon; (2) Simazin, Chloro IPC, and mowing; and (3) disking, Vapam, and Mylone. Variations in the length of effectiveness of the chemicals from 30 to 50 days and major changes in weed composition during reinvasion affected responses. In general, tree survival and height growth varied directly with the effectiveness of weed control as reflected in available water and light intensities. Although no noticeable symptoms of chemical toxicity were observed, low survival and growth within Vapam and Mylone treatments suggest a toxic-vapor effect.

The elimination of competition by cultivation, resulting in greater amounts of light, available soil moisture, and (possibly) nutrients, probably accounts for the greatest survival and height growth. However, frequency of treatment needed for maximum responses limits the usefulness of this method as a single tool.

Garlon and Esteron-Dowpon show promise as weed herbicides. These treatments eliminated all weed growth for approximately 50 days. Available soil moisture and light intensity were sufficient to insure good, early-growth response. For best results in using these chemicals, pre-planting application of Garlon or Esteron-Dowpon to give satisfactory weed control until early July, followed by cultivation when needed, is suggested.

Seedlings on the plots treated with Simazin or Chloro IPC had low survival and grew slowly because of limited moisture and light. Incomplete kill of herbaceous material and the shorter length of effectiveness probably resulted from low rates of chemical application. In later studies using Simazin at the rate of 4 to 6 pounds per acre, effective control was obtained throughout the growing season.

Although light intensity was adequate throughout the season on the mowed plots, limited soil moisture and (possibly) nutrients resulted in low survival and growth. However, mowing damage on one area may account partially for the poor response.

Disking, Vapam, and Mylone treatments gave the poorest seedling responses. An initial disking without subsequent treatment effected little change in the density or composition of competing vegetation. Light intensities and available soil moisture were generally lowest on the disked plots. Weeds were eliminated on the Vapam and Mylone plots for only 30 days. Limited length of effective weed control and persistent toxic vapors from these chemicals probably account for the low survival and height growth. Moreover, the large quantities of water needed for sealer treatments of Vapam and Mylone make these treatments impractical for pre-planting practices in old-field forestation.

Differences in the mean survival precentage of (1) black walnut and white pine and (2) jack pine and cottonwood were significant at the 99-percent probability level for all soil types. The lack of root formation on many of the cottonwood cuttings and the initiation of growth of jack pine seedlings before planting accounts in part for these differences. The greater shade-tolerance of white pine may explain its higher survival.

Cottonwood growth was affected by soil type and plot treatment during the one growing season, but no significant growth differences were shown by the other species. The greater height of the cottonwood can be attributed partially to inherent fast growth of this species. Carbohydrate reserves of the large cottonwood cuttings are used in initial shoot growth before or during root formation. Root systems of the other three species must

become established within the soil before any appreciable height growth occurs.

In summary, cultivation, Garlon, Esteron-Dowpon, Chloro IPC, and Simazin show promise for weed control in new forest plantings on three open-field sites in east-central Iowa. To improve the chances of successful forestation on these sites, additional research is needed to find the proper combination of chemical-mechanical methods and the optimum concentrations and times of application.

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