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Chemical Weed Control in Shelterbelts

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By

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This thesis is approved as a creditable independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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CHAPTER I

THE PROBLEM AND DEFINITION OF TERMS USED

The most important single factor in successful shelterbelt establishment in the Northern Great Plains is elimination of weed and grass competition. While removal of competing vegetation <u>between</u> the tree rows can readily be accomplished with machinery, removal of such vegetation <u>in</u> the tree rows is a difficult problem. Hand hoeing is effective, but involves a great deal of time and labor. No mechanical means of removing competing vegetation from the row has proven entirely satisfactory.

<u>Statement of the problem.</u> It was the purpose of this study; (1) to find a herbicide that would effectively destroy competing vegetation in shelterbelt tree rows without damaging the trees; (2) to determine the effect of chemical weeding on growth and survival of shelterbelt trees and shrubs; (3) to determine the optimum date for application of the herbicides tested.

<u>Importance of the study.</u> Each spring approximately 7,000,000 trees and shrubs are planted in shelterbelts on South Dakota farms. This makes a total of about 8,000 row miles of new planting each year. To secure satisfactory establishment it is necessary to cultivate a shelterbelt at least three seasons. With slow growing species, less favorable sites, periods of low rainfall, or in cases where wide

spacing has been used in or between rows, cultivation may be required for five or more years before the trees are large enough to shade out weed growth. To control thoroughly all competing vegetation, more than one cultivation per season is necessary. In most cases, at least two row cultivations are needed. Since 8,000 row miles of new shelterbelts are planted each year and must be cultivated at least two times each year for a minimum of three years, 48,000 row miles needs cultivation annually.

Several thousand miles of shelterbelts have been planted in South Dakota since the Federal shelterbelt program was launched in 1935. Many of these older plantings are heavily infested with weed growth, while tree growth has progressed to the point where it is impossible to get between the rows with tillage equipment. Weed growth in these older shelterbelts is not only detrimental to the trees, but also furnishes a constant supply of weed seed for re-infestation of adjacent cultivated land. Chemical weed control appears to be the only feasible method of eliminating weeds in established shelterbelts.

Definitions of Terms Used

Shelterbelt. A planting of trees and shrubs, composed of one or more rows, that has been established for protection of farm buildings or cropland. The term "windbreak" is

frequently used when referring to a planting established primarily for protection of the farmstead. "Shelterbelt" is sometimes considered to mean a planting established primarily for protection of cropland. In this study "shelterbelt" includes both types of plantings.

Row miles. Total length of all rows in a shelterbelt converted to miles.

CHAPTER II

REVIEW OF LITERATURE

When this experiment was initiated, there was much information available concerning the effects of various herbicides on weeds, agronomic and horticultural crops, but information on the effects of chemical weed control on forest plantations was limited. Use of chemicals in controlling weeds in forest nurseries has received much attention, but experimental work on use of herbicides after seedlings are transplanted to the field is limited.

Kuntz and Riker (2) found that a mixture of 2,4-D (isopropyl ester, five pounds per acre) and TCA (ammonium and sodium salts, 25 pounds per acre) applied in early spring to circular areas 27 inches in diameter around dormant Cottonwood cuttings gave excellent weed control with no apparent injury to the trees. The exposed part of the cutting was protected during treatment. Gilbert and Holm (1) used CMU,

3-CICP and Endothal in a young sour cherry orchard and concluded that these herbicides appeared to hold real promise for weed control in orchards.

Wester (11) tested the effectiveness of ammonium sulfamate, borax and 2,4-D in controlling poison ivy and honeysuckle growing as an understory in deciduous and evergreen tree plantings. Ammonium sulfamate was applied as a spray and also in the dry form. He found that the wet treatment with ammonium sulfamate, borax and 2,4-D were usually very injurious to young trees. The dry treatment of ammonium sulfamate caused relatively little or no injury to young trees. Mahlstede (5) treated conifer and deciduous transplant beds with SES, NPA and NPI. Efficient weed control was secured with SES without apparent injury to conifers. Direct application of SES at four pounds per acre caused severe injury to deciduous transplants.

Pridham (6) used 2,4-D and six other herbicides as soil sterilants before transplanting Taxus media Hicksii and Taxus cuspidata. He found that 2,4-D used in the range of 15 to 75 pounds per acre at the time of plowing gave promise of eradicating quackgrass and other perennial weeds.

Stoeckeler (9) reported reduction in costs up to 76 per cent by using mineral spirits instead of hand weeding in conifer seedbeds. Sweet and Havis (10) investigated the possibility of weeding transplanted vegetable crops with chemicals to eliminate hand hoeing. Of six chemicals tested, four

showed distinct possibilities, namely HAN, HN, DOW Contact and Varsol two.

The Lake States Forest Experiment Station (3) found that two pounds of CMU per acre applied immediately after seeding greatly reduced weed stands in conifer seedbeds.

Larson et al (4) used TCA to control quack grass in nursery seedbeds without injury to the species tested.

Shaulis (7) tested oil-dinitro materials in a Concord vineyard and found grape growth and yield similar to that obtained with mechanical tillage.

CHAPTER III

MATERIAL AND METHODS

One of the experiments was conducted in a shelterbelt planted in the spring of 1952, located on the Ora Crosser farm in the NW 1/4 of Section 29; Township 111 N; Range 49 W; Brookings County, South Dakota. The second experiment was conducted in a shelterbelt planted in the spring of 1952, located on the grounds of Camp Lakodia, a 4-H Club Camp in the SE 1/4 of Section 15; Township 106 N; Range 53 W; Lake County, South Dakota. The soil on the Crosser farm has been classified as Kransburg silty clay loam. The shelterbelt is located on a ridge with simple slopes of about two per

cent. The shelterbelt at Camp Lakodia is located on a medium textured surface soil and subsoil which totals 8"-13" in thickness. The substratum is a loamy, gravelly outwash. This shelterbelt is also located on a ridge with simple slopes of about four per cent.

Both shelterbelts were uniformly covered with a relatively heavy stand of broad-leaved and grassy weeds. Counts made on June 10 in the Crosser shelterbelt gave an average stand of 16.5 broad-leaved weeds and 52.1 grassy weeds per square foot. On June 12 counts made in the Camp Lakodia shelterbelt gave an average stand of 21 broad-leaved weeds and 55 grassy weeds per square foot. Grassy weeds in both shelterbelts consisted almost entirely of green foxtail (*Setaria viridis*) and wild barley (*Hordeum jubatum*). Prostrate pigweed (*Amaranthus blitoides*) greatly outnumbered all other broad-leaved weeds in the Crosser shelterbelt, although some rough pigweed (*Amaranthus retroflexus*) and lambsquarters (*Chenopodium album*) were present. Broad-leaved weeds in the Camp Lakodia shelterbelt consisted mainly of lambsquarters and rough pigweed. Very little prostrate pigweed was present.

Field plot designs. Both experiments consisted of a randomized block with three replications. Because of limited length, check plots were not replicated in the Camp Lakodia shelterbelt and were not included in the statistical analyses.

Species. Five species of trees and shrubs were included

in each of the experiments. In the Crosser shelterbelt treatments were applied to rows containing Tatarian honeysuckle (Lonicera tatarica); Eastern redcedar (Juniperus virginiana); Green ash (Fraxinus pennsylvanica lanceolata); Hackberry (Celtis occidentalis) and American elm (Ulmus americana). In the Camp Lakodia shelterbelt treatments were applied to rows containing Nanking cherry (Prunus tomentosa); Eastern redcedar (Juniperus virginiana); Green ash (Fraxinus pennsylvanica lanceolata); Harbin pear (Pyrus ussuriensis) and Chinkota elm (Ulmus pumila).

Treatments

Five rows in each shelterbelt were divided into plots 18 feet in length and a band one foot in width extending the entire length of each plot was treated. The following herbicides were applied with a knapsack sprayer at the rate recommended by the manufacturer:

CMU:	3-(p-chlorophenyl)-1, 1 dimethylurea; 80 per cent active ingredient
DNBP:	Dinitro-o-sec-butylphenol; 55 per cent active ingredient
Stoddard Solvent:	Petroleum naptha; 100 per cent active ingredient
Ammate:	Ammoniem sulfamate; 80 per cent active ingredient
Crag Herbicide I:	Sodium 2,4-dichlorophenoxyethyl sulfate; 90 per cent active ingredient

Each herbicide was applied on two dates in the Grosser shelterbelt. Because of limited length, each herbicide was applied on a single date in the Camp Lakodia shelterbelt. No attempt was made to avoid hitting the trees with Crag Herbicide I, since this chemical is supposed to be non-injurious to foliage. An effort was made to avoid hitting the foliage of the trees with all of the other herbicides tested, but no effort was made to avoid hitting the trunks of the trees.

Rate of application of each herbicide was the same for all dates of treatment. These rates are listed in Table 1.

TABLE 1. RATE OF APPLICATION OF HERBICIDES

Treatment	Rate of application (per acre)
DNBP	1 1/8# (1)
Stoddard Solvent	50 gals.
Ammate	352# (2)
CMU	20# (3)
Crag Herbicide I	2 1/4# (4)

(1) Phenol equivalent.(Mixed with 16 gals. diesel oil and 144 gals. water.)

(2) Active ingredient.(0.8# per gal. of water.)

(3) Active ingredient.(Applied in 435 gals. of water.)

(4) Active ingredient.(Applied in 40 gals. of water.)

Height to the nearest inch, and diameter at the ground line to the nearest 1/32 inch, was recorded for all trees at the start of the growing season. Height only was recorded in the case of Honeysuckle, since its multiple-stemmed growth habit made it impossible to secure accurate diameter measurements. Height and diameter measurements were again secured at the end of the growing season to determine what effect the herbicides might have had on growth.

Square foot samples, one in each 18 foot test plot, were selected at random and all weeds in each sample were counted to determine the number of weeds not killed by the herbicides. The number of broad-leaved and grassy weeds were recorded separately. These counts were compared with untreated check plots to determine which herbicide was most effective. All statistical analyses were made as prescribed by Snedecor (8).

A 100 per cent survival count of trees and shrubs in the test plots was made at the start of the growing season and again at the end of the season to determine the effect of chemical weeding on survival.

Soil moisture determinations were made at the close of the growing season to compare the effects of clean cultivation, no cultivation and chemical treatment on soil moisture content.

Stages of Weed Growth

Since Crag Herbicide I is not effective unless applied when weeds are less than 1/4 inch in height, the first application of this chemical was made before any weeds had emerged in the Crosser shelterbelt. At the time of the second application of this chemical weeds were just beginning to emerge, but had not reached 1/4 inch in height. At Camp Lakodia weeds were just starting to emerge when Crag Herbicide I was applied but were less than 1/4 inch in height. Broad-leaved weeds averaged two inches high and grassy weeds six inches when the first application of the remaining four chemicals was made in the Crosser shelterbelt on June 10. At the time of the June 20 application of these four chemicals in the Crosser shelterbelt broad-leaved weeds averaged four inches in height and grassy weeds averaged 10 inches in height.

At Camp Lakodia weeds averaged about 1/4 inch in height when CMU was applied on May 19. On June 3, when Stoddard Solvent was applied, broad-leaved weeds averaged one inch in height and grassy weeds averaged three inches in height. Ammate was applied on June 12, and at that time broad-leaved weeds had reached an average height of four inches while grassy weeds averaged six inches in height. When DNBP was applied on June 18, broad-leaved weeds ranged from six inches to 24 inches in height, averaging approximately 10 inches high. Grassy weeds averaged 12 inches in height.

Climatological Data

A record of temperature, clearness of the sky and estimated wind velocity for each date of treatment is shown in Tables two and three.

TABLE 2. CLIMATIC CONDITIONS AT TIME OF TREATMENT - CROSSER SHELTERBELT.

Treatment	Date	Temperature °F	Sky	Est. Wind Velocity
Crag Herbicide I	5/7/53	69	Clear	10
Crag Herbicide I	5/14/53	60	Clear	Calm
DNBP	6/10/53	75	Overcast	8
Stoddard Solvent	6/10/53	75	Overcast	8
Ammate	6/10/53	75	Overcast	8
CMU	6/10/53	75	Overcast	8
DNBP	6/20/53	67	Overcast	15
Stoddard Solvent	6/20/53	67	Overcast	15
Ammate	6/20/53	67	Overcast	15
CMU	6/20/53	67	Overcast	15

TABLE 3. CLIMATIC CONDITIONS AT TIME OF TREATMENT - CAMP LAKODIA SHELTERBELT.

Treatment	Date	Temperature °F	Sky	Est. Wind Velocity
Crag Herbicide	5/7/53	84	Clear	Calm
CMU	5/19/53	70	Clear	10
Stoddard Solvent	6/3/53	83	Overcast	12
Ammate	6/12/53	95	Clear	Calm
DNBp	6/18/53	94	Clear	Calm

Rainfall data at Madison are not available for the years prior to 1939. The U.S. Weather Station at Wentworth is located nine miles from Madison and it is expected that the amount of rainfall would be approximately the same at these two points.

TABLE 4. TOTAL RAINFALL AT BROOKINGS AND MADISON FOR MAY, JUNE AND JULY OF 1953 AND THE 1931 TO 1950 AVERAGE AT BROOKINGS AND WENTWORTH FOR THE SAME PERIODS.

Amount of rainfall in inches - 1953			Average 1931 - 1950	
Month	Brookings	Madison	Brookings	Wentworth
May	3.58	5.09	2.69	2.92
June	6.40	4.58	3.88	3.92
July	3.24	1.89	2.10	2.88
Total	13.22	11.56	8.67	9.72

As indicated in Table four, the amount of rainfall received at both Brookings and Madison is higher than the 1931-1950 average for the months of May, June and July.

CHAPTER IV

TECHNIQUE AND RESULTS OF THE INDIVIDUAL EXPERIMENTS

Crosser Shelterbelt

Machine cultivation was carried on between the rows in the Crosser shelterbelt at regular intervals throughout the growing season and a thorough job of weed control was accomplished. A band of weeds varying from 12 to 18 inches in width, not possible to remove with the tillage equipment used, remained in each tree row.

Each of the herbicides used in the experiment was applied with a five-gallon hand pressure knapsack sprayer equipped with a fan-shaped nozzle. Care was taken to apply the spray to a band one foot wide in each tree row. Each herbicide was applied on 10 eighteen-foot plots in each of the three replications, making a total of 30 plots treated with each herbicide. Half of these were treated on one date and half on a later date. Five untreated eighteen-foot check plots were included in each of the three replications.

Effect on Weed Growth

The average number of broad-leaved and grassy weeds per square foot is given for each treatment and date of treatment in Table five. The analysis of variance is shown in Table six.

TABLE 5. AVERAGE NUMBER OF WEEDS PER SQUARE FOOT AFTER TREATMENT WITH FIVE HERBICIDES APPLIED ON TWO DATES.

Treatment	Date Applied	Average number of weeds per square foot[1] July 4, 1953	Compared with untreated
Untreated	--	80.1	--
DNBP	6/10/53	24.0	-56.1**
DNBP	6/20/53	65.3	-14.8
Stoddard Solvent	6/10/53	31.5	-48.6**
Stoddard Solvent	6/20/53	74.0	- 6.1
Ammate	6/10/53	27.9	-52.2**
Ammate	6/20/53	30.0	-50.1**
CMU	6/10/53	3.5	-76.6**
CMU	6/20/53	1.5	-78.6**
Crag Herbicide I	5/5/53	48.3	-31.8**
Crag Herbicide I	5/14/53	37.6	-42.5**

**Significant at 1% level.

[1] Level required for significance at .05 = 20.2 weeds; at .01 = 27.5 weeds.

TABLE 6. THE ANALYSIS OF VARIANCE OF WEEDS PER SQUARE FOOT WHEN TREATED WITH FIVE HERBICIDES APPLIED ON TWO DATES.

Source of variation	d.f.	Mean square
Replications	2	1088.28
Treatments	10	2320.94**
Check vs. treatments	1	5763.38**
DNBP 6/10 vs. DNBP 6/20	1	3313.50**
Stoddard Solvent 6/10 vs. Stoddard Solvent 6/20	1	4466.28**
Ammate 6/10 vs. Ammate 6/20	1	8.17
CMU 6/10 vs. CMU 6/20	1	6.00
Crag 5/5 vs. Crag 5/14	1	172.81
Error	20	140.25
Total	38	------

**Significant at 1% level.

It will be noted that a highly significant difference due to treatments is established. As indicated in Table six, statistically significant differences exist between dates of treatment for both DNBP and Stoddard Solvent while no significant differences exist between dates for Ammate, CMU or Crag Herbicide I. More efficient weed control obtained with the earlier applications of DNBP and Stoddard Solvent as contrasted with the later applications of these two herbicides is probably due to the fact that grassy weed growth averaged

six inches in height at the time of the June 10 application and 10 inches in height on June 20. Broad-leaved weeds averaged two inches in height on June 10 and four inches on June 20. Taller weed growth on the later date made it difficult to wet the plants thoroughly with the spray. Weather conditions might also have had some influence. Temperature at time of application on June 10 was 75°F., with a slight breeze blowing. On June 20 the temperature was 67°F. at time of application and a strong wind caused considerable spray drift.

The average number of grassy weeds per square foot for each treatment and date of treatment is given in Table seven. The analysis of variance is shown in Table eight. It will be noted that a significant difference due to treatments is established. As indicated in Table seven, the least significant difference obtained reveals that while all treatments were significant on one date or the other, two of the later treatments and one of the earlier treatments show no significant difference. In the case of DNBP and Stoddard Solvent this is probably due to the factors mentioned in the discussion of Table six. However, in the case of Crag Herbicide I the stage of weed growth could not have exerted an influence since this chemical was applied before any weeds had emerged. Lack of a significant difference in the case of the early treatment with Crag Herbicide I may be explained

by the difference in soil moisture content at time of application, since this herbicide must go into solution with the soil water to be effective. Soil moisture determinations were made at the time of application. On May 7 the average soil moisture percentage was 11.9 while on May 14 it was 18.9.

TABLE 7. AVERAGE NUMBER OF GRASSY WEEDS PER SQUARE FOOT AFTER TREATMENT WITH FIVE HERBICIDES APPLIED ON TWO DATES.

Treatment	Date Applied	Average number of weeds per square foot[1] July 4, 1953	Compared with untreated
Untreated	---	61.2	---
DNBP	6/10/53	22.4	-38.8*
DNBP	6/20/53	46.7	-14.5
Stoddard Solvent	6/10/53	18.5	-42.7**
Stoddard Solvent	6/20/53	57.2	- 4.0
Ammate	6/10/53	11.5	-49.7**
Ammate	6/20/52	27.5	-33.7*
CMU	6/10/53	3.3	-57.9**
CMU	6/20/53	1.3	-59.9**
Crag Herbicide I	5/5/53	39.1	-22.1
Crag Herbicide I	5/14/53	29.6	-31.6*

**Significant at 1% level

*Significant at 5% level

[1] Level required for significance at .05=30.0 weeds; at .01=40.9 weeds

TABLE 8. THE ANALYSIS OF VARIANCE OF GRASSY WEEDS PER SQUARE FOOT WHEN TREATED WITH FIVE HERBICIDES APPLIED ON TWO DATES.

Source of variation	d.f.	Mean Square
Replications	2	5023.47
Treatments	10	1240.62**
Error	20	309.71
Total	32	----

**Significant at 1% level.

As shown in Table nine, a significant F-test was not obtained for treatments.

TABLE 9. THE ANALYSIS OF VARIANCE OF BROAD-LEAVED WEEDS PER SQUARE FOOT WHEN TREATED WITH FIVE HERBICIDES APPLIED ON TWO DATES.

Source of variation	d.f.	Mean Square
Replications	2	1163.33
Treatments	10	169.64
Error	20	153.03
Total	32	----

Failure to secure a significant F-test for treatments appears to be due to at least two factors. Grassy weeds, averaging considerably taller than broad-leaved weeds, tended to shield them from the spray. Secondly, elimination of grassy weed competition gave broad-leaved weeds a chance to germinate new seedlings after treatments were applied.

Effect on Tree Growth

As indicated in Table 10, a highly significant difference in height growth was obtained for Eastern redcedar (*Juniperus virginiana*) treated with CMU. The analysis of variance is shown in Table 11. F-tests were applied to all other species in the experiment, but failed to show any significant differences in height growth. With the exception of CMU, none of the herbicides tested exerted a significantly beneficial or harmful effect on height growth of any of the species included in the experiment. Since Eastern redcedar is a slow growing tree, it is quickly overtopped by competing vegetation. Excellent weed control obtained with CMU apparently benefitted the slow growing Redcedar to a much greater extent than the faster growing hardwoods.

TABLE 10. AVERAGE HEIGHT GROWTH OF EASTERN RED-CEDAR (JUNIPERUS VIRGINIANA) AFTER TREATMENT WITH FIVE HERBICIDES.

Treatment	Average height growth (Inches)	Average height growth compared with untreated[1] (Inches)
Untreated	5.6	---
DNBP	5.9	+ 0.3
Stoddard Solvent	6.3	+ 0.7
Ammate	4.7	-0.9
CMU	10.0	+ 4.4**
Crag Herbicide I	6.2	+ 0.6

**Significant at 1% level.

[1]Level required for significance at .05 = 2.8 inches; at .01 = 4.0 inches

TABLE 11. ANALYSIS OF VARIANCE OF HEIGHT GROWTH OF EASTERN REDCEDAR (JUNIPERUS VIRGINIANA) AFTER TREATMENT WITH FIVE HERBICIDES.

Source of variation	d.f.	Mean square
Replications	2	5.07
Treatments	5	10.03*
Error	10	2.40
Total	17	---

*Significant at 5% level.

Effect on Tree Survival

All live trees in the experimental plots were counted at the beginning of the growing season and again at the end of the season. Table 12 shows that little difference in survival exists between the various treatments and that all treatments except Ammate are slightly better than the check.

TABLE 12. AVERAGE TREE SURVIVAL PERCENTAGES AFTER TREATMENT WITH FIVE HERBICIDES APPLIED ON TWO DATES.

Treatment	Honey-suckle	Red-Cedar	Green-ash	Hack-Berry	American Elm	Average for all species
Untreated	100.0	75.0	100.0	100.0	100.0	95.0
DNBP	100.0	85.6	100.0	100.0	100.0	97.1
Stoddard Solvent	95.5	93.8	100.0	100.0	100.0	97.9
Ammate	100.0	84.6	93.8	92.3	100.0	94.1
CMU	100.0	100.0	100.0	100.0	100.0	100.0
Crag Herbicide I	100.0	86.7	100.0	100.0	100.0	97.3
Average survival per cent by species excluding check.	99.1	90.1	98.8	98.5	100.0	97.3

Reduction in weed competition should reduce tree losses, provided no damage is done to the trees by the herbicides used to eliminate the weeds. This would be especially noticeable in dry years in newly established shelterbelts. Since

the trees in the Grosser shelterbelt were well established and rainfall was 4.55 inches above normal for the three months during which the experiment was conducted, no reduction in loss is noted, except in the case of Redcedar.

Stoddard Solvent appears to have slightly depressed survival in Honeysuckle, while Ammate appears to have caused some reduction in survival of Green ash and Hackberry. Since an average of only 16 trees of each species were in the plots treated with each of the herbicides, it is not considered safe to conclude that Stoddard Solvent and Ammate actually caused this reduction in survival. Comparing the average survival for all species and all treatments against the check reveals a survival increase of 2.3 per cent for trees in the treated plots. It is concluded that the herbicides tested had no adverse effect on tree survival.

Effect on Soil Moisture

Although not included in the original experimental plan, it was deemed advisable to make soil moisture determinations as a basis for comparison between the most effective treatment (CMU), clean cultivation and no treatment. On October 26, 1953 soil samples were secured at three different locations in the shelterbelt for each depth and treatment. These samples were thoroughly mixed, weighed, and placed in an

electric oven for 19 hours at a temperature ranging between 103° - 107° F. The samples were then removed and weighed and moisture percentage was calculated on a dry weight basis. Results of these soil moisture determinations are presented in Table 13.

TABLE 13. SOIL MOISTURE PERCENTAGES FOR CHEMICAL TREATMENT, CLEAN CULTIVATION AND NO TREATMENT AT SIX-INCH, 12-INCH AND 24-INCH DEPTHS.

Treatment	Depth-Inches	Per cent Moisture
Check	6	10.71
Check	12	10.06
Check	24	9.28
CMU	6	18.84
CMU	12	19.74
CMU	24	17.79
Clean Cultivation	6	16.34
Clean Cultivation	12	18.37
Clean Cultivation	24	17.64

These data clearly indicate the depleting effect of weed growth on soil moisture and also indicate that effective chemical weeding conserved soil moisture slightly better than clean cultivation.

Visual Effects

Observations made on June 24 on plots sprayed two weeks earlier revealed slight yellowing of the foliage of Hackberry and American elm in one plot sprayed with CMU. Plots treated with CMU on June 20, did not show this symptom. None of the trees in plots treated with the other herbicides showed any evidence of injury at the time of the June 24 observations.

On July 4, an inspection revealed burned foliage on Honeysuckle and Hackberry in one plot sprayed with CMU two weeks earlier. Burning of the foliage on Honeysuckle, Green ash and Hackberry was also noted in one plot treated with Ammate on June 20.

Survival counts made in the fall revealed that the foliage injury caused no mortality.

It was observed that plots treated with CMU remained practically free of weed growth throughout the season. This was not true in the case of any of the other herbicides tested.

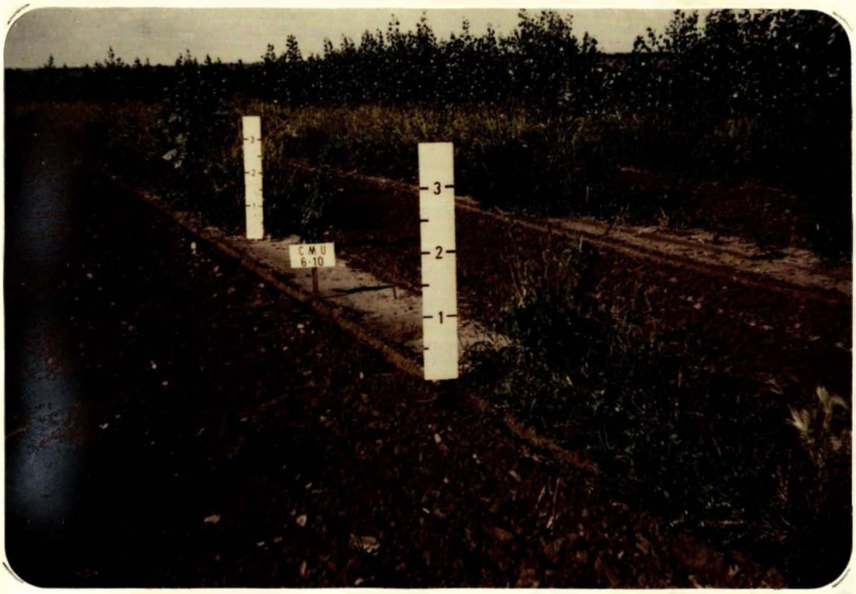

PLATE 1. Plot in Crosser shelterbelt treated with CMU on June 10. Picture taken August 18.

PLATE 2. Untreated plot in Crosser shelterbelt. Picture taken August 18.

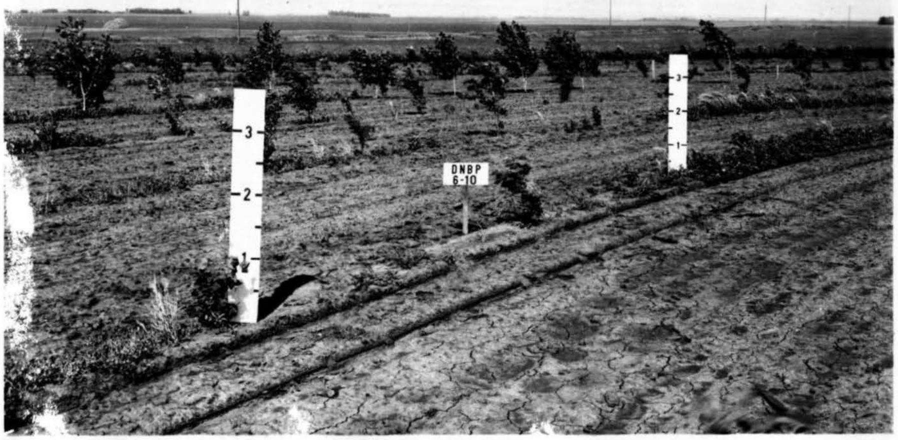

PLATE 3. Plot in Crosser shelterbelt treated with DNBP on June 10. Picture taken June 29.

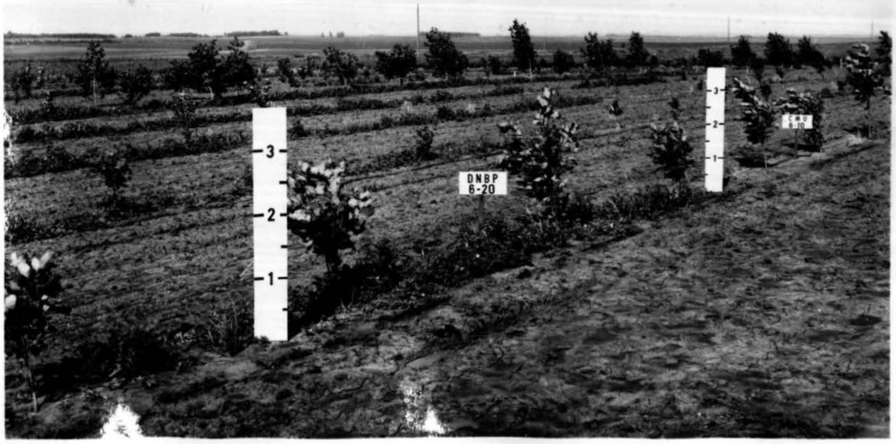

PLATE 4. Plot in Crosser shelterbelt treated with DNBP on June 20. Picture taken June 29.

PLATE 5. Plot in Crosser shelterbelt treated with Stoddard Solvent on June 10. Picture taken June 29.

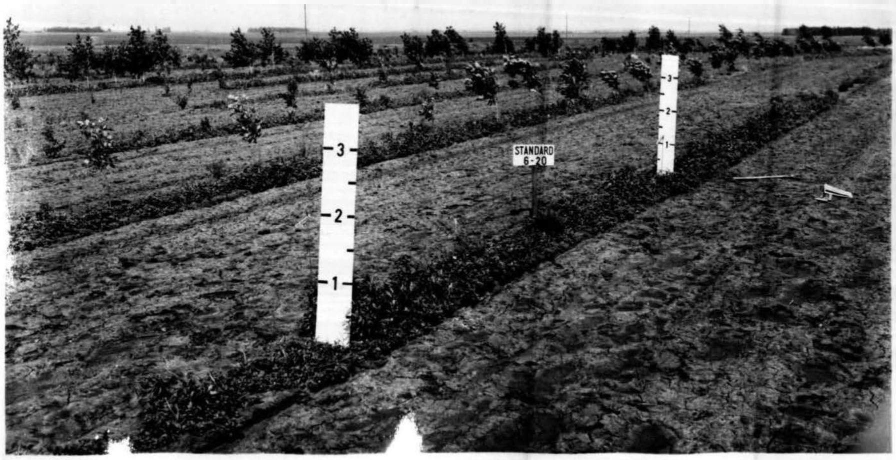

PLATE 6. Plot in Crosser shelterbelt treated with Stoddard Solvent on June 20. Picture taken June 29.

Camp Lakodia Shelterbelt

In contrast with the Crosser shelterbelt, no machine cultivation was performed in the Camp Lakodia shelterbelt during the 1953 season. As a result, a heavy stand of weeds developed between the rows.

The spraying technique and equipment employed in the Camp Lakodia shelterbelt was the same as that used in the Crosser shelterbelt. Each herbicide was applied on five 18-foot plots in each of the three replications, making a total of 15 plots treated with each herbicide. Since the shelterbelt was not of sufficient length to permit treatments on two dates, each herbicide was applied on a single date. Five untreated 18-foot check plots were included in the experiment, but were not replicated because of insufficient length. The check plots were not included in the statistical analyses.

Effect on Weed Growth

The average number of broad-leaved and grassy weeds per square foot for each treatment is shown in Table 14. The analysis of variance is recorded in Table 15. It will be noted that a highly significant difference due to treatments is established. Least significant differences obtained

reveal that CMU was the most efficient weed killer, followed closely by Ammate. DNBP was the least effective herbicide in this experiment. The advanced state of weed growth when DNBP was applied probably accounts for the unsatisfactory results obtained with this herbicide. This corresponds with results obtained in the Grosser shelterbelt where the late application of DNBP was much less satisfactory than the early application.

TABLE 14. AVERAGE NUMBER OF WEEDS PER SQUARE FOOT AFTER TREATMENT WITH FIVE HERBICIDES APPLIED ON FIVE DATES.

Treatment	Date Applied	Average number of weeds per square foot[1] June 27, 1953	Compared with untreated
Untreated	-----	81.0	-----
DNBP	6/18/53	70.1	-10.9*
Stoddard Solvent	6/3/53	54.6	-26.4**
Ammate	6/12/53	6.9	-74.1**
CMU	5/19/53	3.1	-77.9**
Crag Herbicide I	5/7/53	41.6	-39.4**

**Significant at 1% level.

*Significant at 5% level.

[1]Level required for significance at .05=9.5 weeds; at .01=13.9 weeds.

TABLE 15. THE ANALYSIS OF VARIANCE OF WEEDS PER SQUARE FOOT WHEN TREATED WITH FIVE HERBICIDES APPLIED ON FIVE DATES.

Source of variation	d.f.	Mean Square
Replications	2	38.94
Treatments	4	2601.24**
Error	8	25.63
Total	14	---

**Significant at 1% level.

Stoddard solvent, although applied before the weeds exceeded three inches in height, failed to give satisfactory control. Weather conditions may have been responsible for this failure. A temperature of 83° F and wind velocity of 12 miles per hour prevailing at the time of application was conducive to rapid evaporation and may have dissipated some of the oil before it could exert a toxic effect upon the plants. The wind also resulted in some spray drift.

Crag Herbicide I controlled slightly less than half of the weeds. While this is somewhat better weed control than was obtained with the early application of this herbicide in the Crosser shelterbelt, it cannot be considered satisfactory. Average soil moisture percentage at the time of application was 13.7. This is 1.8% more moisture than existed in the Crosser shelterbelt at the time of the first application of this herbicide.

The average number of grassy weeds per square foot for each treatment is shown in Table 16. The analysis of variance is shown in Table 17.

TABLE 16. AVERAGE NUMBER OF GRASSY WEEDS PER SQUARE FOOT AFTER TREATMENT WITH FIVE HERBICIDES.

Treatment	Date Applied	Average number of weeds per square foot[1]	
		June 27, 1953	Compared with untreated
Untreated	----	65.0	----
DNBP	6/12/53	68.0	+ 3.0
Stoddard Solvent	6/3/53	49.8	-15.2**
Ammate	6/12/53	6.3	-58.7**
CMU	5/19/53	2.5	-62.5**
Crag Herbicide I	5/7/53	33.1	-31.9**

**Significant at 1% level.

[1]Level required for significance at .01=13.5 weeds.

TABLE 17. THE ANALYSIS OF VARIANCE OF GRASSY WEEDS PER SQUARE FOOT AFTER TREATMENT WITH FIVE HERBICIDES APPLIED ON FIVE DATES.

Source of variation	d.f.	Mean square
Replications	2	13.48
Treatments	4	2355.77**
Error	8	16.69
Total	14	563.74

**Significant at 1% level.

It will be noted that a significant difference due to treatments is established. As indicated in Table 16, statistically significant differences were obtained with all treatments except DNBP. Failure to secure control of grassy weeds with this herbicide was quite likely due to at least two factors: (1) At the time of application grassy weeds had reached an advanced stage of growth, averaging 12 inches in height. As a result, most of the spray contacted only the upper parts of the plants. (2) Broad-leaved weeds, while slightly shorter in average height than the grassy weeds, contained some individuals in the population up to 24 inches high. These large specimens shielded the understory of grassy weeds from the spray.

Both CMU and Ammate gave excellent grassy weed control. Analysis of the data from both experiments indicates that date of application of CMU is not important, at least under the conditions which prevailed during 1953.

Since Crag Herbicide I controlled slightly less than half of the grassy weeds and Stoddard Solvent controlled less than one fourth of them, neither herbicide gave satisfactory weed control.

Table 18 shows the average number of broad-leaved weeds per square foot for each treatment. The analysis of variance is shown in Table 19.

TABLE 18. AVERAGE NUMBER OF BROAD-LEAVED WEEDS PER SQUARE FOOT AFTER TREATMENT WITH FIVE HERBICIDES.

Treatment	Date Applied	Average number of weeds per square foot: June 27, 1953	Average number of weeds per square foot: Compared with untreated
Untreated	----	16.0	----
DNBP	6/18/53	2.1	-13.9**
Stoddard Solvent	6/3/53	4.8	-11.2**
Ammate	6/12/53	0.5	-15.5**
CMU	5/19/53	0.5	-15.5**
Crag Herbicide I	5/7/53	8.5	- 7.5*

**Significant at 1% level.

*Significant at 5% level.

[1]Level required for significance at .05=5.9 weeds; at .01=9.8 weeds.

TABLE 19. THE ANALYSIS OF VARIANCE OF BROAD-LEAVED WEEDS PER SQUARE FOOT AFTER TREATMENT WITH FIVE HERBICIDES.

Source of variation	d.f.	Mean square
Replications	2	14.81
Treatments	4	34.85*
Error	8	6.89
Total	14	----

*Significant at 5% level.

As indicated in Table 18, statistically significant differences were obtained with all treatments. Highly efficient broad-leaved weed control was obtained with both CMU and Ammate. DNBP also gave good control of broad-leaved weeds in contrast with its complete failure to control grassy weeds in this shelterbelt. This appears to be due to the fact that broad-leaved weeds, mainly lambsquarters and rough pigweed, averaged almost as tall as the grassy weeds and exposed more surface to the spray. Also, a number of specimens in the broad-leaved population ranged up to two feet in height and received a thorough drenching with the spray. Much better results were obtained with Stoddard solvent on broad-leaved weeds in this shelterbelt than was the case in the Crosser shelterbelt. This appears to be due to the same reasons cited for the efficiency of DNBP in broad-leaved weed control. Results obtained with Crag Herbicide I in controlling broad-leaved weeds are almost identical to results obtained with grassy weeds. Slightly less than half of the broad-leaved weeds were controlled.

Effect on Tree Growth

When an analysis of variance was applied to heights of each species in the experiment, a significant F-test was secured only in the case of Eastern redcedar. The analysis is shown in Table 20.

TABLE 20. ANALYSIS OF VARIANCE OF HEIGHT GROWTH OF EASTERN REDCEDAR (JUNIPERUS VIRGINIANA) AFTER TREATMENT WITH FIVE HERBICIDES.

Source of variation	d.f.	Mean square
Replications	2	5.07
Treatments	4	10.03*
Error	8	2.40
Total	14	---

*Significant at 5% level.

Check plots were not replicated and were not included in the statistical analysis. A comparison of average height growth of Redcedar for all treatments revealed that only trees in the plots treated with Ammate fell below the average by more than one inch. Trees in the plots treated with Ammate averaged 3.7 inches less in height growth than trees in the plots treated with the other four herbicides. This trend was also noted in the case of Redcedar treated with Ammate in the Crosser shelterbelt. Since an average of only eight Redcedar trees were included in the plots treated with each herbicide in the Camp Lakodia shelterbelt, the sample is considered too small to be conclusive. It appears, however, that the effect of Ammate on the height growth of Eastern redcedar may warrant further investigation. Height growth of the other species included in the experiment was neither increased or retarded by the herbicides tested.

Effect on Tree Survival

All live trees in the experimental plots were counted at the beginning of the growing season and again at the end of the season. As indicated in Table 21, no losses were sustained in any of the plots except those containing Harbin pear treated with Ammate.

TABLE 21. AVERAGE TREE SURVIVAL PERCENTAGES AFTER TREATMENT WITH FIVE HERBICIDES APPLIED ON FIVE DATES.

Treatment	Average Survival Percentages					Average for all species
	Nanking cherry	Red-Cedar	Green ash	Harbin pear	Chinkota elm	
Check	100.0	100.0	100.0	100.0	100.0	100.0
DNBP	100.0	100.0	100.0	100.0	100.0	100.0
Stoddard Solvent	100.0	100.0	100.0	100.0	100.0	100.0
Ammate	100.0	100.0	100.0	87.5	100.0	97.5
CMU	100.0	100.0	100.0	100.0	100.0	100.0
Crag Herbicide I	100.0	100.0	100.0	100.0	100.0	100.0
Average survival per cent by species excluding check	100.0	100.0	100.0	97.5	100.0	99.5

Effect on Soil Moisture

Soil samples were secured on November 8, 1953 in the same manner as those obtained in the Crosser shelterbelt. Since no cultivation was performed in the Camp Lakodia shelterbelt during the 1953 season, no comparison could be made between the effects of clean cultivation and chemical treatment on soil moisture.

Results of the soil moisture determinations are presented in Table 22.

TABLE 22. SOIL MOISTURE PERCENTAGES FOR CHEMICAL TREATMENT AND NO TREATMENT AT SIX-INCH, 12-INCH, AND 24-INCH DEPTHS.

Treatment	Depth-Inches	Percent moisture
Check	6	12.47
Check	12	11.42
Check	24	9.45
CMU	6	15.85
CMU	12	13.70
CMU	24	11.77

These data show that effective chemical weed control, although confined to a band only one foot wide, conserved soil moisture to some extent. The heavy growth of weeds that

existed between the rows throughout the growing season undoubtedly caused a heavy drain on soil moisture both in and between rows. Comparison of the check plots with the CMU treated plots in the two shelterbelts shows a much greater difference in the Crosser shelterbelt. This is attributed to the removal of weed growth by cultivation.

Visual Effects

Observations made on June 18 revealed some foliage burned in two American elm plots sprayed with Ammate. No other species appeared to be affected. Further observations made on July first failed to reveal any further evidence of injury. Burned leaves observed on June 18 had dried up and fallen from the trees by July first. Survival counts made in the fall showed that no mortality resulted from this foliage injury.

It was noted that CMU treated plots remained almost entirely free of weed growth throughout the growing season. None of the other herbicides tested produced this result.

SUMMARY

This study was undertaken for the purpose of finding a herbicide that would effectively destroy competing vegetation in shelterbelt tree rows without damaging the trees. An

attempt was also made to determine the effect of chemical weeding on growth and survival of shelterbelt trees and shrubs and to determine the optimum date for application of the herbicides tested.

Two one-year old shelterbelts were used in the study. The herbicides tested were CMU, Stoddard Solvent, DNBP, Ammate and Crag Herbicide I. Each herbicide was applied to plots one foot wide and 18 feet long in five tree rows in each shelterbelt using a five-gallon hand pressure knapsack sprayer. In both shelterbelts the experimental design was a randomized block with three replications. In the Crosser shelterbelt each herbicide was applied to 30 plots, half of these being treated on one date and half on a later date. In the Camp Lakodia shelterbelt each herbicide was applied to 15 plots and each treatment was made on a different date. A total of eight species of trees and shrubs were included in the experiments in the two shelterbelts.

The number of broad-leaved and grassy weeds were counted in square foot samples selected at random in each test plot. These counts were compared with untreated check plots to determine which herbicide was most effective. Heights and diameters of trees and shrubs in the test plots were secured at the beginning and end of the growing season and compared to determine whether the herbicides under test exerted any effect on growth. Survival counts were made at

the beginning and end of the growing season to determine what effect chemical treatment might have on survival. Soil moisture determinations were made in the fall to compare the effects of the most effective chemical treatment, clean cultivation and no treatment on soil moisture content.

CMU was the most effective weed killer in both shelterbelts, regardless of date applied. The early application of DNBP ranked next to CMU in weed killing effectiveness in the Crosser shelterbelt, followed closely by the early application of Ammate. In the Camp Lakodia shelterbelt Ammate ranked close to CMU in effectiveness. DNBP, in contrast with good results obtained in the Crosser shelterbelt, was the least effective herbicide tested in the Camp Lakodia shelterbelt. This was undoubtedly due to the advanced state of weed growth at the time application was made.

Analysis of the data from the Crosser shelterbelt reveals that DNBP and Stoddard Solvent were the only herbicides tested that gave significantly better weed control when applied early.

With the exception of CMU, none of the herbicides tested had a significant effect on height growth. CMU exerted a beneficial effect on height growth of Redcedar in the Crosser shelterbelt. No significant difference in diameter growth was obtained for any of the species tested.

None of the herbicides under test exerted a significantly beneficial or harmful effect on survival.

Effective weed control obtained with CMU conserved soil moisture. This was especially evident in the Crosser shelterbelt.

CONCLUSIONS

1. CMU was the most effective weed killer of the five herbicides tested. CMU gave excellent control of both broad-leaved and grassy weeds regardless of date applied.
2. Date of application is important when using DNBP and Stoddard Solvent. Early applications of these two herbicides gave far better results than later applications. Both should be applied before weed growth reaches six inches in height.
3. CMU was the only herbicide tested which ~~exerted~~ a significantly beneficial effect on height growth and this was evident only in the case of Redcedar. None of the other herbicides tested exerted a beneficial or harmful effect on height growth of any of the species tested.
4. None of the herbicides tested exerted a significantly beneficial or harmful effect on survival.

5. Effective chemical weed control conserved soil moisture somewhat better than clean cultivation.

CMU is known to be a potent soil sterilant. While no tree losses were sustained in any of the plots treated with CMU, the experiment covered only one growing season and it is recognized that losses might still occur. Follow-up inspections will be made during the 1954 growing season to determine whether trees in plots treated with CMU suffer any mortality.

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