RESEARCH BULLETIN 638 AUGUST, 1957

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

J. H. Longwell, *Director*

Control of Woody Vegetation

A REPORT ON TESTS USING 2,4,5-T, AMMATE, SODIUM ARSENITE AND CMU ON NINE COMMON MISSOURI TREE SPECIES

J. MILFORD NICHOLS

Division of Forestry
Missouri Conservation Commission
cooperating

(Publication Authorized August 27, 1957)

COLUMBIA, MISSOURI

SUMMARY

Four chemicals, 2,4,5-T, ammate, sodium arsenite, and CMU were tested in the treatment of several tree species, in several methods of application, and in different seasons. The following conclusions were drawn concerning the chemical treatments, species of trees, and size-classes of trees investigated in this study.

1. Root-kill, as evidenced by lack of sprouting, cannot be appraised accurately at the end of the first growing season following chemical treatment. Root-kill determined even after three growing seasons may not be conclusive, but satisfactory predictions of the actual root-kill can probably be made at that time.

2. Trees with root systems that are large in proportion to their stems (a common situation in frequently-burned woodlands) are difficult to root-kill; the small stems cannot absorb enough of chemicals to kill the roots.

3. None of the treatments tested can be guaranteed to effect 100 percent root-kill of any of the species investigated during any season of the year.

4. The 2,4,5-T basal bark treatment, (16.70 pounds a.h.g. in kerosene) applied at any season of the year to stems under 2 inches d.b.h., will probably result in 100 percent stem-kill of any species investigated. Increasing the concentration of 2,4,5-T above 16 pounds a.h.g. is probably of no value in increasing the percentage of stem-kill.

5. In stump treatments and frill treatments, ammate is generally inferior to 2,4,5-T.

6. All of the chemicals tested are most effective when applied during the growing season.

7. Root systems that are not killed by chemical applications produce sprouts that are less vigorous than where no chemical is applied; ammate appears to be slightly more effective than 2,4,5-T in this respect.

8. The direct application of ammate crystals to freshly cut stumps is not as effective as application of ammate in solution. Ammate solutions with less than 3 pounds of ammate per gallon of water are ineffective in stump treatment of hickory and would probably be ineffective in stump treatment of other resistant species.

9. Under most conditions persimmon probably can be controlled effectively with a 2,4,5-T stump treatment at any season of the year.

10. Foliage spraying of one-year-old sprouts of oak and hickory with either ammate or 2,4,5-T will produce excellent stem-kill; neither will produce satisfactory root-kill.

11. Trees 4 inches d.b.h. and larger with thick bark, such as post oak, are difficult to stem-kill with the basal bark treatment.

12. Hickory, sassafras, and persimmon rank in that order in their resistance to 2,4,5-T stump treatment.

13. In chemical treatment of oak and hickory sprouts under 2 inches d.b.h., the differences in susceptibility of species are small; the sizes of their respective root systems have a much greater effect on the ultimate root-kill.

14. In killing unwanted trees in stand improvement, 2,4,5-T and sodium arsenite applied to frills can be expected to effect almost 100 percent top-kill at any season of the year. Trees in the larger size classes (over 9 inches d.b.h.) produce fewer sprouts following treatment than do trees in the smaller size classes (under 9 inches d.b.h.).

15. CMU cannot be used in selective treatment of trees in stand improvement because of the danger of killing adjacent trees which are to be retained in the stand.

16. Of the species treated in timber stand improvement, hickory is most resistant to chemical applications, post oak is intermediate in resistance, and the black oaks have the least resistance.

TABLE OF CONTENTS

This bulletin is a report on Department of Forestry Research Project 166, Inferior Species. The project is financed, in part, by the Division of Forestry, Missouri Conservation Commission.

Control of Woody Vegetation

A REPORT ON TESTS USING 2,4,5-T, AMMATE, SODIUM ARSENITE AND CMU ON NINE COMMON MISSOURI TREE SPECIES

J. MILFORD NICHOLS

THE PROBLEM

Woody vegetation is a tough land management problem in many areas of Missouri. Cutting with hand or power tools, burning, and intensive grazing were the common controls a few years ago. These methods were generally unsuccessful, even when repeated frequently. Roots were not killed and vigorous sprouting almost always resulted.

Research workers have developed several chemical preparations during the past 15 years that show promise of easing this chore. This report covers the results from tests of two of these chemicals, 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T) and ammonium sulfamate (ammate). The tests were conducted at the University of Missouri Forest in Butler County, beginning in 1949. Also included are results of limited tests of sodium arsenite and 3-p-chlorophenyl-1-1-dimethylurea (CMU).

The study was limited to the following species: sassafras *(Sassafras albidum* Nutt.), common persimmon *(Diospyros virginiana* L.), hickory *(Carya* spp.), post oak *(Quercus stellata* Wengenh.), white oak *(Quercus alba* L.), black oak *(Quercus velutina* Lam.), scarlet oak *(Quercus coccinea* Muench.), southern red oak *(Quercus falcata* Michx.) and blackjack oak *(Quercus marilandica* Muench.)

Explanation of Measurements and Terms

Concentrations of herbicides may be expressed in different ways. In this report, the concentration of ammate is expressed as the number of pounds of ammate crystals per gallon of water. Manufacturers of 2, 4, 5-T specify on the labels of their products the acid equivalent, by weight, per gallon of product.

In this report, concentrations of chemicals are expressed in terms of the acid equivalent, as **pounds of acid per hundred gallons of diluent**, hereafter referred to as "**a.h.g.**"

Terms referring to "kill" are defined as follows:

Stem-kill—complete kill of the above-ground parts.

Root-kill—absence of new growth when examination was made two years or more following treatment.

Apparent root-kill—absence of new growth when examination was made less than two years following treatment.

STUMP APPLICATION OF 2, 4, 5-T AND AMMATE TO PERSIMMON, SASSAFRAS AND HICKORY

The purpose of this experiment was to compare the effectiveness of 2, 4, 5-T[1] and ammate applied in different concentrations to freshly cut stumps of persimmon, sassafras, and hickory. The sassafras and persimmon trees were growing on a level to gently rolling field which had been abandoned as agricultural land for approximately 10 years. Both of these species occurred in poorly stocked pure stands. The hickory occupied an intermediate crown position in a sapling-pole stand of oak and hickory located on a ridge-top site. Stem diameters, at a stump height of 6 inches, ranged from 1 to 3 inches and averaged 1.7 inches for sassafras, 2.2 inches for persimmon and 2.3 for hickory.

Treatments were made from March 29 to April 1, 1949. The stems were cut horizontally with a saw at a height of approximately 6 inches, and all chemicals were applied immediately following cutting. Chemicals used in liquid form were applied with a paint brush; stumps were saturated to the ground line. Ammate salt crystals were measured and applied with a measuring spoon. The following treatments were assigned by random selection to 210 individual stumps, 10 stumps per treatment per species: (1) 2,4,5,-T, 16.70 pounds a.h.g. kerosene[2], (2) 2,4,5-T, 3.34 pounds a.h.g. kerosene, (3) 2,4,5-T 16.70 pounds a.h.g. water, (4) ammate, 4 pounds per gallon of water,[3] (5) ammate, 1 pound per gallon of water, (6) ammate, 1 tablespoon of salt placed on stump, and (7) no chemical application.

Examinations were made in September, 1949, September, 1950, September, 1951, and August, 1954. Table 1 shows, by chemical application and by species, the percentage of stumps without living sprouts at the time of each examination.

The results clearly demonstrate the danger in drawing conclusions on the basis of apparent root-kill following only one growing season. In this

[1]Isopropyl ester formulation, 3.34 pounds of acid equivalent per gallon, 37 percent acid equivalent.

[2]Equivalent to a concentration of 5 percent, by volume of 2,4,5-T, 37 percent acid equivalent; acid equivalent 17,500 parts per million.

[3]32.5 percent solution.

TABLE 1. EFFECT ON PERSIMMON, SASSAFRAS, AND HICKORY OF SEVEN STUMP TREATMENTS AT THE END OF ONE, TWO, THREE, AND FIVE GROWING SEASONS

Treatment	Percent of Stumps Without Living Sprouts											
	Persimmon				Sassafras				Hickory			
	1949	1950	1951	1954	1949	1950	1951	1954	1949	1950	1951	1954
2,4,5-T, 16.70 lb. a.h.g.* kerosene	100	100	80	80	100	80	70	50	90	50	20	80
2,4,5-T, 3.34 lb. a.h.g. kerosene	100	90	70	80	90	60	50	10	70	30	20	60
2,4,5-T, 16.70 lb. a.h.g. water	70	30	30	30	50	20	10	0	90	50	30	70
Ammate, 4 lb. per gal. of water	80	80	40	40	80	60	50	30	80	40	30	60
Ammate, 1 lb. per gal. of water	30	20	20	30	20	10	10	10	20	10	10	70
Ammate, 1 tablespoon salt per stump	10	10	10	20	60	30	10	10	40	10	20	60
No chemical application	10	0	0	10	0	0	0	0	0	0	0	20

*a.h.g. = pounds acid equivalent per hundred gallons of water.

experiment the true effects of the different chemical applications were not apparent even after two growing seasons. Apparently, not even a three-year period is sufficient to judge the effectiveness of chemicals on sassafras. The average percentage of stumps without living sprouts for all treatments decreased from 55 percent in September, 1949, to 37 percent in September, 1950, and to 28 percent in September, 1951. The apparent increase in effectiveness on hickory in 1954 was probably due to the severe drouth conditions in 1953 and 1954. The hickory, located in a well-stocked sapling and pole stand, was under more severe competition for moisture than the old-field sassafras and persimmon. It is possible, however, that the chemical applications lowered the vigor of the root systems and thus made them more susceptible to drouth kill.

All chemical applications, except the 1-pound ammate solution and the dry salt of ammate, resulted in good repression of sprouting for one growing season.

The increase in sprouting during the second growing season following treatment was twice as great as the increase during the third growing season. From the third to the fifth growing seasons, only sassafras produced new sprouts after appearing to be root-killed. Carlson (1952) states that species which readily produce root sprouts, such as sassafras, may easily be killed back to the ground only to sprout from the roots the following year. Egler (1951) stated that the percentage of root-kill from any one spray treatment probably could not be judged until at least two full years had passed.

The highest concentration of 2, 4, 5-T in kerosene was effective the most consistently, but the lower concentration was equally effective on persimmon. In the use of 2, 4, 5-T, kerosene was superior to water as a diluent except in the case of hickory. This inconsistency is not surprising since none of the treatments was effective in preventing sprouting of this species, assuming drouth damage to be chiefly responsible for the good results after the fifth growing season. None of the ammate treatments was very effective.

Persimmon was killed more effectively than either sassafras or hickory. However, different investigators have not had consistent results with persimmon. Darrow and Frey (1951), who made dormant applications of 2, 4, 5-T on persimmon at College Station, Texas, stated, "Cut-surface applications of 2, 4, 5-T have given complete control of sprouting within the range of carriers and concentrations used." On the other hand, Gassaway and Elder (1951) reported, after testing treatments with 2, 4, 5-T in diesel oil, "Stump treatments have been relatively ineffective on persimmon at concentrations ranging from 0.5 percent to 5 percent."

TABLE 2. EFFECT OF SIX CHEMICAL TREATMENTS IN REDUCING GROWTH OF SPROUTS

	Average Height in Feet		
Treatment	Persimmon	Sassafras	Hickory
2,4,5-T 16.70 lb. a.h.g. kerosene	5.0	3.7**	3.5
2,4,5-T 3.34 lb. a.h.g. kerosene	5.5	4.1**	4.3
2,4,5-T 16.70 lb. a.h.g. water	5.1	6.5*	1.7*
Ammate, 4 lb. per gal. of water	4.8	3.1**	4.3
Ammate, 1 lb. per gal. of water	3.9*	5.2**	3.7
Ammate, 1 tablespoon salt per stump	4.1	4.1**	3.0
No chemical application	5.9	9.0	4.3

Note: Measurements taken in August, 1954.

* Significant at 5% level
** Significant at 1% level

Table 2 gives the average height, by treatment and species, of the tallest sprouts from the stumps which sprouted. To compare the differences in average sprout height the data were subjected to the "t" test. All chemical applications resulted in statistically significant reductions in sprout height of sassafras. Only one chemical application, ammate at a rate of 1 pound per gallon of water, had a significant effect on the height of persimmon sprouts. Likewise, only one application, 2, 4, 5-T at a rate of 16.70 pounds a.h.g. water. had a significant effect on the height of hickory sprouts. It should be noted that treatment of these two species were generally more successful than of sassafras and there were fewer stems on which to base statistical significance. It is doubtful that there is any practical significance to any of the reductions in sprout height, although the reduction in vigor might improve the effectiveness of any retreatment.

EFFECTS OF 2,4,5-T AND AMMATE WHEN APPLIED TO STUMPS AND TO THE BASES OF STANDING STEMS EACH MONTH OF THE YEAR

Tests to determine whether the time of application (season) would be a factor in the results attained with 2,4,5,-T[4] and ammate on persimmon, sassafras, hickory and mixed oak-hickory were carried out during 1950. Treatments were made at approximately the fifteenth of each month, beginning in January, 1950. Ammate was used at the rate of 4 pounds per gallon of water in stump applications and 2,4,5-T was used at the rate of 16.70 pounds a.h.g. kerosene for both stump and basal bark applications. The basal bark method of application, saturation of the trunks of standing stems to a height of approximately 18 inches, was used only on sassafras and mixed oak-hickory.

[4]Isopropyl ester formulation, 3.34 pounds of acid equivalent per gallon, 37 percent acid equivalent.

Persimmon

The persimmon trees used in this test were located on a level to gently rolling field which had been abandoned from agricultural use for approximately 20 years. Persimmon was the dominant woody species, growing in an almost pure stand. Individual stems ranged in diameter from 3 to 5 inches at the stump height of 6 inches. The three stump treatments described above were randomly assigned to 360 trees, 10 trees per treatment per month. Applications were made by brushing the chemical solutions on the stumps with a paint brush.

Stumps were examined in August of 1951, 1952, and 1954. Table 3 gives the results.

TABLE 3. EFFECT OF THREE KINDS OF STUMP TREATMENTS AND TIME OF TREATMENT ON THE DEVELOPMENT OF PERSIMMON SPROUTS

Month of 1950 Application	Percent of Stumps Without Sprouts								
	2,4,5-T, 16.70 lb. a.h.g. kerosene			Ammate, 4 lb. per gal. of water			No chemical application		
	1951	1952	1954	1951	1952	1954	1951	1952	1954
January	100	80	80	10	20	20	0	0	10
February	100	90	90	50	30	50	0	0	10
March	100	60	50	30	20	20	0	0	0
April	100	90	70	80	40	50	10	0	0
May	100	80	80	50	40	50	10	0	0
June	100	100	90	60	50	60	0	0	0
July	100	100	100	70	10	50	20	30	30
August	100	100	90	100	40	50	0	10	10
September	100	100	90	90	10	30	10	10	0
October	100	90	90	20	10	20	0	10	10
November	100	100	90	80	30	50	10	0	10
December	100	100	100	60	20	20	0	0	0

Season of application was not an important factor in the results attained with 2,4,5-T. The average effectiveness for the summer applications of 2,4,5-T was 87 percent and for the dormant applications, 83 percent. However. there was a considerable difference in the effectiveness of ammate, with 48 percent during the summer and 30 percent during dormancy.

Relatively poor results could be expected from dormant applications because of the way in which ammate must enter the plant. Since it cannot be used in an oil diluent, absorption through the bark is limited. Practically all material entering the plant must pass through the small area of freshly cut surface. Without movement of water and food materials in the plant during dormancy, only a small amount of ammate can be absorbed during this period.

Because of the difference between ammate and 2,4,5-T in killing action, larger quantities of ammate are required to effect the same degree of kill. Coulter (1950) states, "Again, in contrast to the phenoxyacetic acid herbicides. much larger amounts of ammonium sulphamate must be used to obtain the same results. On a concentration basis the ratio of the amount of material used is about 30 to one."

Consistently better results were attained with 2,4,5-T than with ammate which conforms with the results from 1949 tests. However, it is interesting to note that many sprouts from stumps treated with ammate which appeared vigorous in 1952, were dead in 1954. It is possible that the severe drouths in 1953 and 1954 may have killed some of these sprouts, but sprouts from stumps treated with 2,4,5-T and from check stumps showed no mortality during this period.

Hickory

The hickory trees in this experiment ranged in diameter from 2 to 4 inches, at a stump height of approximately 6 inches. The 360 trees were intermediate or codominant in crown class within a sapling-pole stand of oak and hickory in which the hickory comprised about 30 percent of the total number of trees. The procedure for conducting the experiment was the same as that used in the monthly treatment of persimmon. Table 4 gives the results.

TABLE 4. EFFECT OF THREE KINDS OF STUMP TREATMENTS AND TIME OF TREATMENT ON THE DEVELOPMENT OF HICKORY SPROUTS

Month of 1950 Application	Percent of Stumps Without Sprouts					
	2,4,5-T, 16.70 lb. a.h.g. kerosene		Ammate, 4 lb. per gal. of water		No chemical application	
	1951	1952	1951	1952	1951	1952
January	90	90	10	10	11	22
February	78	89	30	40	10	20
March	90	100	40	60	0	10
April	80	90	56	89	0	0
May	100	90	67	67	70	70
June	100	90	20	40	10	60
July	70	80	30	70	0	0
August	89	100	67	67	0	0
September	89	78	40	50	0	0
October	89	78	11	33	11	11
November	100	89	50	40	0	0
December	100	100	11	11	0	0

Note: Several of the treated stems were destroyed by right-of-way clearing, accounting for the uneven percentage figures.

The area burned in 1954, so examination was limited to August of 1951, and 1952. There was little seasonal difference in results from 2,4,5-T. As in the tests with persimmon, summer applications of ammate worked better than dormant applications and 2,4,5-T was superior to ammate each month of the year.

Cutting of the stems without chemical treatment resulted in profuse sprouting of practically all stumps except those which were cut in May and June. Sixty percent of the stumps cut in May and 70 percent of those cut in June failed to produce sprouts following three growing seasons. These figures were superior to the ammate treatment. In view of the small sample involved, this apparent suppression of sprouting is probably of no practical significance. However, Clark and Liming (1953) in girdling sapling and pole size blackjack oak, found less sprouting from stems which were girdled during the growing season than from those girdled during dormancy; the effectiveness in prevention of sprouting was as high as 80 percent as a result of June girdling.

The average height of the tallest sprouts from stumps was 2.4 feet for those treated with ammate, 2.3 feet for those treated with 2,4,5-T, and 3.1 feet for the untreated stumps. Although both chemical treatments resulted in statistically significant reductions in sprout height, the reductions had little practical significance.

Sassafras

The sassafras trees were in a field which had been abandoned from agricultural use for approximately 15 years. The terrain was level to gently rolling. Sassafras was the dominant woody species. The sprout clumps, with one to four individual stems per clump, were uniformly three years old. The original stems, which averaged approximately 2 inches in diameter at breast height, were killed by fire in 1947. Thus the treated stems, which did not exceed 1 inch in diameter at breast height were growing from well-established root systems that were large in proportion to the stems.

Four treatments, the three stump treatments used on persimmon and hickory plus the basal bark treatment, were assigned at random to 480 sprout clumps, 10 clumps per treatment per month. The stems were cut at a height of 6 to 10 inches and chemical applications were made by brushing solutions on stumps of stems with a paint brush.

Table 5 gives the results based on examination in September, 1951, August, 1952, and August, 1954. Treatments of sassafras were from 10 to 16 percent more effective during the summer than during dormancy. None of the treatments were as consistent or as effective on sassafras as they were on persimmon and hickory. This was in agreement with the 1949 tests. The smaller size of the stems in proportion to their root systems may have lowered the effectiveness of the treatments. Less treating surface was available in proportion to roots.

The stump application of 2,4,5-T gave the best control and it was the most consistent, giving good root-kill in all months but March and April. Average effectiveness for the 12 monthly treatments, when results were measured in 1954, was 55%. The 2,4,5-T basal treatment was next in effectiveness with an average of 50%. Least effective was the ammate stump treatment with an average of 33%. It is interesting to note that the basal treatment showed better results in 1954 than at the time of previous examinations. This was likewise true for the stumps which were not treated.

TABLE 5. EFFECT OF FOUR KINDS OF TREATMENTS AND TIME OF TREATMENT ON THE DEVELOPMENT OF SASSAFRAS SPROUTS

Month of 1950 Application	Percent of Clumps Without Sprouts											
	2,4,5-T, 16.70 lbs. a.h.g. kerosene-stump			2,4,5,-T, 16.70 lbs. a.h.g. kerosene-basal			Ammate, 4 lb. per gal. water-stump			No Chemical Application		
	1951	1952	1954	1951	1952	1954	1951	1952	1954	1951	1952	1954
January	40	40	40	10	20	10	0	20	30	10	10	10
February	50	40	50	10	10	50	30	50	40	0	0	20
March	10	20	30	30	50	50	20	20	30	10	10	10
April	10	40	10	10	20	40	30	30	40	0	0	10
May	70	70	60	50	70	80	40	60	30	10	10	30
June	80	90	60	60	60	80	50	70	60	0	10	30
July	90	90	90	40	40	60	30	40	60	0	10	40
August	70	80	70	50	40	50	20	20	20	0	0	20
September	80	80	70	40	50	40	30	60	30	10	0	0
October	90	100	70	30	20	20	20	20	20	20	0	0
November	60	60	40	40	50	70	10	20	20	0	0	10
December	80	80	70	60	50	50	10	10	10	10	0	0

Mixed Oaks and Hickory

The species in this portion of the monthly tests included white oak, post oak, black oak, scarlet oak, southern red oak, and hickory, growing together in a mixed stand. All stems were of sprout origin, ranging in diameter at a stump height of 6 inches from 0.5 inch to 2.5 inches. They were approximately 10 years of age. Each sprout clump included from 1 to 10 individual stems. The area at one time had been cleared for agricultural use, but it had been abandoned for approximately 20 years. The mixed stand of oak and hickory sprouts originated when fire killed original stems which had developed following abandonment. As a result of frequent killing back of successive crops of sprouts by fire and cutting, the root systems were large in proportion to the stems and foliage.

Treatments were made on a plot basis, using circular plots, each 30 feet in diameter and having an area of 0.016 acre. There were from 20 to 50 sprout clumps per plot. The four treatments used on sassafras were assigned at random to 48 plots, one plot per treatment per month. Stems to be used for stump treatments were cut at a height of from 6 to 10 inches. Both stump and basal bark applications were made with a low-pressure garden sprayer. The stumps and basal 18 inches of uncut stems were saturated thoroughly to the ground line with the chemical solutions.

Excellent stem-kill was obtained with the 2,4,5-T basal bark treatment. Stem-kill was 95 percent or greater for all months except April, September, November, and December. The poorest stem-kill was 78 percent in April. Differences in stem-kill between the different size classes were very small. Stem-kill was 92 percent or greater for each species.

Fisher (1952), speaking of basal spraying, stated, "Excellent top kills of most woody species have been obtained during the growing season or in dormancy, but root kills have been less consistent. The greater variation in root kills is probably due to the variation of different species in the location, depth and nature of sprouting tissues below ground level."

There was profuse sprouting on practically all plots when they were examined in September, 1951. Additional sprouting was noted at the time of examination in August, 1952 (Table 6).

TABLE 6. EFFECT OF THREE KINDS OF TREATMENTS AND TIME OF TREATMENT ON THE DEVELOPMENT OF OAK AND HICKORY SPROUTS

Month of 1950 Application	Percent of Sprout Clumps Apparently Root-Killed by August, 1952: 2,4,5,-T, 16.70 lb. a.h.g. kerosene-stump	2,4,5,-T, 16.70 lb. a.h.g. kerosene-basal	Ammate, 4 lb. per gal. water -stump	No Treatment
January	18	5	59	0
February	0	27	21	7
March	32	7	0	11
April	12	7	0	0
May	24	48	12	0
June	6	20	46	0
July	11	48	0	0
August	45	44	0	11
September	0	17	0	0
October	11	8	4	0
November	18	0	29	0
December	20	19	41	6

The apparent root-kill resulting from each of the treatments was poor; the 2,4,5-T basal treatment was best with an average of 21 percent for the year. There was little consistency for successive months. Dormant and summer treatments yielded similar results. All treatments appeared considerably less effective in 1952 than they had in 1951. This conforms with the 1949 results on persimmon, sassafras, and hickory. (see Table 1).

Another means of measuring effectiveness of applications is to determine the extent to which the basal area of the sprouts is reduced as a result of chemical action. Table 7 gives the percentage reduction in basal

TABLE 7. EFFECT OF DIFFERENT TREATMENTS AND TIMES OF TREATMENT ON REDUCTION OF BASAL AREA OF OAK AND HICKORY SPROUTS

Month	Percent Reduction in Basal Area by August, 1952		
	2,4,5,-T, 16.70 lb. a.h.g. kerosene - stump	2,4,5,-T, 16.70 lb. a.h.g. kerosene - basal bark	Ammate, 4 lb. per gal. water-stump
January	32	33	65
February	31	58	61
March	33	48	0
April	13	0	43
May	45	84	41
June	0	30	59
July	43	30	0
August	50	61	0
September	12	44	0
October	79	64	0
November	15	32	57
December	68	62	48

area[5] of sprouts in the Oak and Hickory test plots by different chemical applications and by different months of application. In computation of these percentages, the basal areas existing in 1952 for chemically treated plots and for untreated control plots were compared on a proportional basis to the basal area of the original stems on each plot in 1950. The final basal area figures included the basal area of original stems which were not completely killed by the chemical application.

The 2,4,5-T basal bark application gave the most consistent results from month to month, averaging 46 percent reduction in basal area for the year compared to 35 and 31 percent, respectively, for 2,4,5-T and ammate stump applications. This difference is particularly significant since the basal area figures include original stems not completely killed by the basal treatment. Because these stems were severely affected even though not killed, the results of the basal treatment are believed to be conservative. Twenty-two percent of stems treated basally in April, accounting for 46 percent of the total basal area, were not stem-killed; thus the April treatments did not cause reduction in total basal area over the check plot on which all stems were removed by cutting. Only the May basal treatment resulted in 100 percent stem-kill. Reduction in basal area was also greatest from the May treatment with 84 percent.

The stump applications were highly inconsistent, particularly those with ammate. Ammate treatments made in March, July, August, Septem-

[5]Computed from diameter measurements taken at a height of 6 inches above the ground line.

ber, and October did not reduce basal area. Results from summer applications were poorer than those from dormant applications, just opposite the results from ammate stump treatment of persimmon, sassafras, and hickory. However, in view of the generally poor results from all ammate stump applications and the lack of consistency for successive months, this difference in summer and dormant applications was not considered significant.

Table 8 gives comparisons of species in percentage reduction in basal area and percentage of clumps apparently root-killed. Southern red oak

TABLE 8. EFFECT OF CHEMICALS ON SPROUTING OF SIX TREE SPECIES

Species	Percentage Reduction in Basal Area	Percent of Sprout Clumps Apparently Root-Killed
White Oak	52	29
Post Oak	42	19
Black Oak	30	10
Scarlet Oak	44	34
Southern Red Oak	37	41
Hickory	45	18

Note: Above figures include 3 chemical treatments and 12 months of application.

and scarlet oak showed the best apparent root-kill, with black oak the least susceptible to chemical applications. However, the original black oak clumps were generally dominant over the clumps of other species; they included a greater number of stems per clump and they had larger individual stems. This may have accounted for the poorer kill of black oak, rather than an inherent resistance of the species.

Sprouts from chemically treated clumps were smaller than those from control clumps. However, even though these differences were statistically significant, there was little practical difference. When the plots were given an extensive examination in 1955, there was little difference in appearance between the treated plots and the control plots. The sprouts on the plots were rapidly approaching the appearance of the original stand surrounding them.

FOLIAGE TREATMENT OF OAK AND HICKORY SPROUTS

The purpose of this experiment was to test the effectiveness of ammate and 2,4,5-T, each in two concentrations, in foliage treatment of first-year sprouts of scarlet oak, post oak, black oak, and hickory. The sprouts ranged in height from 1.5 to 4.0 feet and averaged approximately 2.5 feet. The area chosen for the study was a right-of-way which had been cleared in February, 1950, in preparation for power line construction. The treatments were made during the summer of 1950.

Ammate was used in concentrations of 1.0 pound and 0.5 pound per gallon of water. The butyl ether ester of 2,4,5-T[6] was used in concentrations of 4.00 pounds a.h.g.[7] and 2.00 pounds a.h.g., both in water diluent. Three hundred twenty sprout clumps, each from a parent stump under 4 inches in diameter, were chosen for treatment. The treatments were assigned at random, 20 clumps of each species per treatment. Scarlet oak, post oak, and hickory were treated July 25, 1950. Rain followed approximately 4 hours after the ammate applications and approximately 2 hours after the 2,4,5-T applications. Black oak was treated on August 3, 1950. There was no rain immediately after treatment on this date. All applications were made with a low-pressure garden sprayer; both foliage and stems were saturated.

The results were evaluated in September, 1951. The percentages of sprout clumps which were stem-killed are shown in Table 9 by species and treatments. All treatments were effective in this respect, the 68 percent stem-kill of scarlet oak by the lesser concentration of ammate being the least effective. The higher concentrations of both 2,4,5-T and ammate were only slightly more effective than the lower concentrations of each. The occurrence of rain following the treatment of three species obviously affected the stem-killing ability of the different chemical applications very little if at all.

Although all treatments resulted in a high percentage of stem-kill of all species, none gave complete kill of the root systems. Table 9 gives the percentages of sprout clumps apparently root-killed by species and treatments. During the 1951 growing season more than 80 percent of the sprout clumps which had been stem-killed resprouted. The higher concentration of 2,4,5-T was most effective, resulting in an average apparent root-kill of approximately 35 percent, compared to less than 20 percent for each of the other applications. The higher concentration of 2,4,5-T was almost twice as effective as the lower concentration of 2,4,5-T. The 1-pound ammate application was less effective than the lower concentration of 2,4,5-T and the 0.5 pound ammate application was almost totally ineffective. The fact that the 1-pound ammate treatment was relatively effective on black oak when no rain followed, but was completely ineffective on the other 3 species when rain followed the applications, indicates that the rain may have reduced the root-killing effectiveness of ammate. For this reason, an accurate comparison of species susceptibility is impossible.

[6]Four pounds acid equivalent per gallon, 43 percent acid equivalent.

[7]Equivalent to a concentration of 1 percent, by volume, of 2,4,5-T, 43 percent acid equivalent, butyl ether ester; 4,300 parts per million.

It appears, however, that post oak was the most resistant species. The occurrence of rain apparently had less effect on the 2,4,5-T applications than it did on the ammate applications.

Although none of the treatments resulted in good root-kill the new sprouts which developed following treatment were less numerous than the original sprouts. Table 9 gives the percentage reductions in numbers of sprouts, by species and treatments, comparing the number of living sprouts in September, 1951, with the number of sprouts which were treated. Again, the foliage spray with 2,4,5-T at a concentration of 4.00 pounds a.h.g. was superior, reducing the number of sprouts 65 percent. The other treatments caused reductions of 45 percent to 52 percent. There was less reduction in the number of post oak sprouts than in the number of sprouts of other species.

TABLE 9. EFFECT OF AMMATE AND 2,4,5-T IN DIFFERENT CONCENTRATIONS IN FOLIAGE TREATMENT OF OAK AND HICKORY SPROUTS

Treatment	Black Oak	Scarlet Oak	Post Oak	Hickory
	Percentage of Sprouts Stem-killed			
2,4,5-T, 2.00 lb. a.h.g. water	98	96	91	100
2,4,5-T, 4.00 lb. a.h.g. water	100	95	94	100
Ammate, 0.5 lb. per gal. of water	99	68	96	89
Ammate, 1.0 lb. per gal. of water	100	85	95	100
	Percentage of Sprouts Apparently Root-killed			
2,4,5-T, 2.00 lb. a.h.g. water	20	18	15	26
2,4,5-T, 4.00 lb. a.h.g. water	30	41	20	50
Ammate, 0.5 lb. per gal. of water	5	0	0	11
Ammate, 1.0 lb. per gal. of water	30	6	5	10
	Percentage Reduction in Number of Sprouts			
2,4,5-T, 2.00 lb. a.h.g. water	54	60	40	56
2,4,5-T, 4.00 lb. a.h.g. water	68	74	48	59
Ammate, 0.5 lb. per gal. of water	55	48	45	68
Ammate, 1.0 lb. per gal. of water	56	59	22	35

Note: Results evaluated one year following treatment.

STUMP TREATMENT OF HICKORY WITH FOUR CONCENTRATIONS OF AMMATE

Four concentrations of ammate were used in treating freshly cut stumps of hickory to determine the relative effectiveness of the different concentrations. The hickory trees treated in this test were a component of a sapling-pole stand of mixed oak and hickory located on a level to gently rolling ridge-top site. The trees selected for treatment ranged from 2 to 4 inches in diameter at a 6-inch stump height.

Ammate was used in solutions of 1, 2, 3, and 4 pounds per gallon of water. The four ammate treatments and the check treatment were assigned at random to 75 trees, 15 trees per treatment. Treatments were made February 22, 1950.

Trees were examined in September, 1950, and September, 1951. Table 10 gives the results. None of the treatments resulted in good root-kill. A Comparison of 1950 and 1951 percentages of stumps without sprouts shows that the first-year observations did not give an accurate indication of root-kill. Previous results from the 1949 tests (see Table 1) indicate that some stumps which appeared to have been root-killed the second year would still sprout. There was an obvious breaking point in effectiveness within the range of the 1-pound concentration and the 3-pound concentration, with the two lower concentrations giving 7 percent apparent root-

TABLE 10. THE EFFECTS ON HICKORY OF FIVE STUMP TREATMENTS AFTER ONE AND TWO GROWING SEASONS

Treatment	Percent of Stumps Without Sprouts		Average No. of Sprouts per Stump in Sept., 1951	Average Height in Feet of Tallest Sprout per Stump in Sept., 1951
	Sept., 1950	Sept., 1951		
No chemical application	0	0	3.5	3.6
Ammate, 1 lb. per gal. of water	13	7	3.7	2.4
Ammate, 2 lb. per gal. of water	27	7	3.1	2.5
Ammate, 3 lb. per gal. of water	40	20	2.4	1.7
Ammate, 4 lb. per gal. of water	40	20	2.4	1.7

kill and the two higher concentrations, 20 percent.

By application of the "t" test, it was determined that there were statistically significant reductions in numbers of sprouts per stump and in the average height of the tallest sprout per stump. The 3- and 4-pound concentrations of ammate resulted in significant reductions in the average number of sprouts per stump. The greater number of sprouts per stump for the 1-pound concentration was not significantly different from the check treatment. This tendency toward abundant sprouting has not been observed for other stump applications made in 1949 and 1950. In comparing the average heights of the tallest sprout per clump for different treatments, the breaking point in effectiveness is again apparent. All ammate applications resulted in significant reductions in sprout height. Both the 3- and 4-pound concentrations resulted in significantly greater reductions in sprout height than did the two lesser concentrations.

BASAL BARK AND FRILL TREATMENT OF POLE-SIZE POST OAK AND HICKORY

The purpose of this experiment was to test the effectiveness of ammate in frill[8] treatment and 2,4,5-T[9] in both frill and basal bark treatment of post oak and hickory. Treatments were made in both summer and winter on trees ranging in size from 4 to 10 inches d.b.h. The area chosen for the study was level to gently rolling and was moderately stocked with a sapling-pole stand of oak and hickory.

The following treatments were assigned at random to 200 trees, 10 trees per treatment per species per season: (1) ammate at the rate of four pounds per gallon of water, applied in frills, (2) 2,4,5-T, 20.00 pounds a.h.g. kerosene, applied in frills, (3) 2,4,5-T, 20.00 pounds a.h.g. kerosene, as a basal bark treatment, and (4) 2,4,5-T, 40.00 pounds a.h.g. kerosene, as a basal bark treatment. In the basal bark treatments the trunks were saturated to a height of approximately 3 feet. Frills were made at a height of approximately 3 feet; both the frills and immediately adjacent trunk areas were saturated with treating solution.

Summer treatments were made August 10, 1950 on hickory and September 11, 1950 on post oak. Both species were given winter treatments on February 10, 1951. Evaluation of results was made in August, 1952. Table 11 shows the percentage of trees stem-killed by different treatments and different seasons. There was a lack of consistency in the results, making detailed comparisons impossible. Too great a range in diameters of treated trees accounted for some of the inconsistency; stem-kill of trees 4 to 6 inches d.b.h. was twice as great as stem-kill of trees 8 to 10 inches

[8]Cutting through the bark and cambium around the circumference of a tree with overlapping axe cuts.
[9]Butyl ether ester, four pounds acid equivalent per gallon, 43 percent acid equivalent.

d.b.h. Also, no measure was made of the quantity of chemical solution applied to each tree. Coulter (1952) performed an experiment on white oak during 1951 in which 2,4,5-T was applied in several concentrations, each at different volumes per inch of tree circumference. He found that the low-volume high-concentration tests were inferior to the high-volume low-concentration tests in causing stem-kill.

The data in Table 11 does not take into account the effect of chemicals on trees which were partially stem-killed. It was noted that all trees which were frill-treated with either ammate or 2,4,5-T were severely affected. Many of the trees in this category in 1951 were dead in 1952.

It is apparent that frill treatments were superior to the basal bark treatments. This was particularly true of post oak. The thick bark of this species apparently absorbed the 2,4,5-T solutions and prevented the chemical from reaching the cambium. Many of the trees which received the basal bark treatment appeared to be entirely normal at the time of examination. 2,4,5-T frill treatment consistently gave better stem-kill than the ammate frill treatment.

TABLE 11. EFFECT OF AMMATE AND 2,4,5-T, IN BASAL BARK AND FRILL TREATMENT ON POST OAK AND HICKORY

	Percent of Trees Stem-Killed			
	Post Oak		Hickory	
Treatment	Summer	Winter	Summer	Winter
Ammate (4 lb. per gal. of water)-Frill	40	70	50	30
2,4,5-T, (20.00 lb. a.h.g. kerosene) - Frill	80	80	100	90
2,4,5-T, (20.00 lb. a.h.g. kerosene) - Basal Bark	0	60	30	70
2,4,5-T, (40.00 lb. a.h.g. kerosene) - Basal Bark	0	50	100	90

COMPARISON OF SEVERAL TREATMENTS IN TIMBER STAND IMPROVEMENT

Eleven treatments were compared for their effectiveness in the removal of undesirable trees for timber stands in 1953 and 1954. Using plots one acre in size, undesirable trees were selected for removal with the object of leaving the stand of timber in the best possible growing condition. Species treated included post oak, blackjack oak, black oak, and hickory.

From 25 to 70 trees were treated on each plot with an average of 53 trees per plot. Treatments were made in May, 1953, October, 1953, and February, 1954. The treatments were assigned at random, one plot per treatment per season, except as noted in the tabular information to follow.

Girdles and frills were made with axes. Low frills were made approximately 6 inches from the ground; high frills were made approximately 30 inches from the ground. Half-frills were made by spacing the axe cuts, leaving approximately 3 inches of uncut cambium between them. Chemicals were applied to frills with a can fitted with a ⅛-inch copper tube spout, using sufficient chemical solution to saturate the frill. Soil treatments were made within one foot of the bases of treated trees.

Table 12 gives the percentage of trees in each of four condition classes by treatments, species, size classes, and seasons of treatment. Examination was made in September, 1955. In computing the average effectiveness of treatments on the different species and for the different seasons of treatment, only those results from the six treatments which were made at all three seasons were used.

All summer treatments were highly effective with an average of 85 percent of trees completely top-killed and with no sprouting. Fall and winter treatments were much less effective, averaging 60 percent and 56 percent top-kill, respectively. Arend (1954) found that frill treatments with 2,4,5-T in oil carrier effectively top-killed all species tested at all seasons of the year. He also found summer treatments to be more effective than dormant treatments and oil to be superior to water as a diluent.

The most consistently effective treatments for all seasons were sodium arsenite in low frills and 2,4,5-T in kerosene in high frills, averaging 87 and 85 percent, respectively. The least effective treatment was 2,4,5-T in water in low frills. CMU applied to the soil was reasonably effective but also killed some good trees which were closely adjacent to treated ones. CMU was applied directly to low frills on one plot; none of the treated trees showed any noticeable effect. The frill treatments with sodium arsenite in a 20 percent concentration were effective in giving good top-kill but there was much sprouting of smaller trees. Girdling was as effective in top-killing as most of the chemical applications, but sprouting was greater on the small size classes.

Hickory was the most difficult species to top-kill, considering all treatments. However, both 2,4,5-T in high frills and sodium arsenite in low frills were at least 90 percent effective in top-killing hickory, with some sprouting of the smaller trees. Black oak and blackjack oak were easiest to top-kill and sprouted the least.

Since top-killing of cull trees is sufficient to afford release of desirable

TABLE 12. THE EFFECT OF SEVERAL TREATMENTS IN KILLING UNDESIRABLE TREES IN TIMBER STAND IMPROVEMENT

	Percent of Trees in Each Condition Class in September, 1955							
	Trees 3 - 9 inches d.b.h.				Trees 9 inches d.b.h. and larger			
Treatment	A	B	C	D	A	B	C	D
	Summer Application-May, 1953							
Girdle	--	--	23	77	--	5	--	95
2,4,5-T in kerosene, high frills	--	--	17	83	--	--	--	100
2,4,5-T in kerosene, low frills	--	4	19	77	--	37	--	63
2,4,5-T in water, low frills	6	--	9	85	18	6	6	70
Sodium Arsenite, low frills	--	--	11	89	--	--	7	93
Ammate, low frills	--	--	7	93	--	--	9	91
Sodium Arsenite, high half frills	--	3	45	52	--	7	--	93
	Fall Application-October, 1953							
Girdle	--	6	51	43	--	9	27	64
2,4,5-T in kerosene, high frills	4	7	29	60	--	7	--	93
2,4,5-T in kerosene, low frills	4	2	31	63	--	35	--	65
2,4,5-T in water, low frills	75	13	3	9	59	9	--	32
Sodium Arsenite, low frills	--	--	12	88	--	6	--	94
Ammate, low frills	--	8	71	21	--	10	5	85
Sodium Arsenite (diluted) low frills	--	--	41	59	--	--	--	100
Sodium Arsenite (diluted) high frills	--	5	57	38	--	--	--	100
CMU, soil application	31	3	--	66	6	38	--	56
	Winter Application-February, 1954							
Girdle	--	15	51	34	--	25	25	50
2,4,5-T in kerosene, high frills	--	--	18	82	--	20	--	80
2,4,5-T in kerosene, low frills	--	--	41	59	--	25	--	75
2,4,5-T in water, low frills	18	24	29	29	62	13	--	25
Sodium Arsenite, low frills	--	--	38	62	--	--	--	100
Ammate, low frills	12	23	27	38	57	14	--	29
Sodium Arsenite (diluted) low frills	--	8	39	53	--	--	6	94
Sodium Arsenite (diluted) high frills	--	--	67	33	--	--	20	80
CMU, soil application	38	9	--	53	38	12	--	50
	Summary of Six Treatments by Seasons							
Summer	1	1	14	84	3	8	4	85
Fall	14	6	33	47	10	13	5	72
Winter	5	10	34	51	20	16	4	60
	Summary of Six Treatments by Species							
Post Oak	3	5	22	70	14	15	4	67
Hickory	8	6	31	55	23	8	4	65
Black Oak and Blackjack Oak	3	--	29	68	2	6	2	90

Note: Condition Classes: (A) No apparent effect, (B) Partial top-kill, (C) Complete top-kill with new sprouts, and (D) Complete top-kill without sprouts.
Concentration of Chemicals: 2,4,5-T - 8 lb. a.h.g. diluent in all treatments, Ammate - 4 lb. per gal. of water in all treatments, Sodium Arsenite - 40% solution, Sodium Arsenite (diluted) - 20% solution, and CMU - 1 teaspoon per inch of tree d.b.h.

trees in a stand, sprouting may not be immediately important in stand improvement work. Also, larger trees which are of greatest importance in stand improvement, sprout less vigorously than smaller trees. In securing rapid release, sodium arsenite was superior to all other treatments. This chemical affected top-kill within two weeks following treatment. Following other treatments, the crowns continued to live for the greater portion of one growing season. All treatments, except the 20 percent solution of sodium arsenite in high frills, repressed sprouting more than did girdling. Sodium arsenite in a 20 percent solution resulted in less sprouting when applied to low frills than when applied to high frills. The reverse was true for 2,4,5-T in kerosene; there was more sprouting from the low frill treatment. This could have been because the cambium was not completely severed in the low frill treatment, low frills being more difficult to make than high frills. Also, complete frills were not required to effect top-kill with sodium arsenite; 95 percent of trees which were half-frilled and treated with sodium arsenite were top-killed. It should be noted that 2,4,5-T with kerosene in low frills failed to completely top-kill 34 percent of trees 10 inches d.b.h. and larger.

BIBLIOGRAPHY

Arend, John L. 1954. "Effects of Season in Michigan on Control of Hardwoods With Frill Girdles and 2,4,5-T," Research Report, North Central Weed Control Conference, 1954. pp. 130.

Carlson, A.E. 1952. "Application of Chemicals," Summary Report Short Course and Conference, Chemical Control of Brush, conducted at University of Missouri College of Agriculture, Columbia, Missouri, January 17 and 18, 1952. Report prepared by Missouri State Rural Electrification Association, Jefferson City, Missouri.

Clark, F. Bryan, and Franklin G. Liming. 1953. "Sprouting of Blackjack Oak in the Missouri Ozarks," Technical Paper No. 137, Central States Forest Experiment Station, Columbus, Ohio, 1953. pp. 8.

Coulter, L.L. 1950. "Herbicidal Action of Chemicals in Weed and Sprout Control," Weed and Sprout Control Short Course and Conference Proceedings, University of Missouri Agricultural Experiment Station Progress Report, Columbia, Missouri, March, 1950. pp. 4-6.

Coulter, L.L. 1952. "Two Primary Factors Influencing Results in the Control of Oak During the Dormant Period," *Down to Earth,* Spring, 1952.

Darrow, R. A., and W. K. Frey. 1951. "Dormant Season Treatment of Persimmon," Research Report, North Central Weed Control Conference, 1951. pp. 150.

Egler, Frank E. 1951. "Herbicide Effects in Connecticut Vegetation, 1950," *Journal of Forestry* 50:198-204.

Fisher, C. E. 1952. "Control of Woody Plants With Herbicides," *Agricultural Chemicals* 7:49.

Gassaway, James E., and W. C. Elder. 1951. "Effects of 2,4-D and 2,4,5-T on Persimmon," Research Report, North Central Weed Control Conference, 1951. pp. 154.

Grano, Charles X. 1952. "How Do Sulfamate Poisons Kill Trees?," *Journal of Forestry* 50:318.

Mills, Frederick Cecil. 1938. *Statistical Methods Applied To Economics and Business.* (Revised edition; New York: Henry Holt and Company), 746 pages.

APPENDIX

Explanation of Statistical Treatment of Data

When appropriate, the data were analyzed by the "t" test as described by Mills (1938). The symbol "t" is defined as the difference between the means divided by the standard error of the difference. An example of the computation, as used on the data in the 1949 stump treatment of sassafras, is shown in the Appendix Table.

STATISTICAL EXAMPLE

Treatment	No. Stumps With Sprouts	Mean Ht. Tallest Sprout per Stump	Standard Error of Mean	Standard Error of Difference Between Check Mean and Treatment Mean	Check Mean Minus Treatment Mean	"t"	Degrees of Freedom	Probability
Check	10	7.1	.458	----	----	---	---	---
245,3,700 p.p.m. in kerosene	5	3.4	.748	.878	3.7	4.21	13	**
245,18,500 p.p.m. in kerosene	3	3.7	1.203	1.287	3.4	2.64	11	*
245,18,500 p.p.m. in water	9	5.6	.444	.638	1.5	2.35	17	*
Ammate, 1 lb. per gal. of water	9	4.8	.466	.653	2.3	3.52	17	**
Ammate, 4 lb. per gal. of water	5	4.2	1.020	1.118	2.9	2.59	13	*
Ammate crystals, 1 tablespoon per stump	9	3.6	.444	.638	3.5	5.49	17	**

NOTE: ** - significant at the 1 percent level
* - significant at the 5 percent level