Final Report

HIGHWAY RESEARCH PROJECT 15

EROSION CONTROL

ON HIGHWAY RIGHTS-OF-WAY IN ARKANSAS

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IN
ARKANSAS

Highway Research Project No. 15
Final Report

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in Cooperation with the

U.S. Department of Transportation
Federal Highway Administration
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TABLE OF CONTENTS

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The opinions, findings and conclusions expressed in this report are those of the author and not necessarily those of the Arkansas Department of Highways or the Bureau of Public Roads.

Those who worked on this project other than the authors were:

Dr. Max M. Sckerl, Research Assistant
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FORWARD

The following is the final report for Research Project No. 15, Erosion Control on Highway Rights-of-Way in Arkansas. Results of individual experiments are reported by experiment number. Experiment numbers were coded as follows: the first number represents the Arkansas Highway District in which the experiment was conducted; laboratory and greenhouse experiments had L and G respectively for the first number. The second number represents the individual experiment number. Establishment and maintenance experiments were numbered 1 through 10 and herbicide experiments were numbered 11 through 20. The third number represents the year in which the experiment was established.

Each of the experiments reported here has been reported in greater detail in annual reports of this project. If more detail about individual experiments is desired, the annual report for the year in which the experiment was established should be consulted.

This project was initiated in 1963. The proposal and detailed work plan were developed by Dr. A. E. Spooner, who served as Project Director until 1967. Dr. C. L. Murdoch was named Project Director at that time and served until the study was completed in 1970.

ABSTRACT

The results of tests conducted by personnel of this project during the period 1963-1970 are discussed in this report. Laboratory and greenhouse experiments were conducted in facilities at the Main Branch of the Arkansas Agriculture Experiment Station, Fayetteville. Field experiments were conducted on highway rights-of-way throughout the state.

Laboratory and field experiments indicate that mulch during establishment of vegetation on rights-of-way is necessary to conserve moisture and prevent erosion. Wheat straw mulch as well as wood cellulose products are effective for this purpose.

The need for adequate fertility during establishment was established. The response of vegetation previously established to maintenance fertility was studied.

The results of species trials indicate that tall fescue, common bermuda, weeping lovegrass and bahiagrass are among the species best adapted for use on highway rights-of-way in Arkansas. Tall fescue and weeping lovegrass are adapted throughout the state. Common bermudagrass can be grown throughout the state, but is best adapted to the southern two-thirds. Bahiagrass is adapted only to the southern one-half of the state.

Demonstration experiments to compare the effectiveness of various vegetation control methods indicate that chemical weed control can be used to replace mowing on many areas. When unsightly weeds are controlled, the need for mowing is eliminated. Mowing is more expensive than effective weed control with chemicals in many instances.

Greenhouse and field experiments indicate that growth retardants can be used effectively to control growth of certain grasses. Unsightly seedhead production of tall fescue can also be controlled by proper rates of Maleic Hydrazide.

Laboratory studies of the mode of action of organic arsenical herbicides on Johnsongrass indicate that absorption and translocation occurs quite rapidly, both through leaves and roots. Translocation from leaves to all parts of the plant was shown to occur within 24-48 hours after application. Translocation from roots to the upper portions of the plant was also shown to occur within this time. Evidence indicates that, in Johnsongrass, organic arsenical herbicides are metabolized by the plant and complex with certain organic compounds (probably amino acids). This complexing was not found in cotton which is more resistant to damage from these compounds.

Field studies with organic arsenical herbicides for Johnsongrass control indicate that excellent control of Johnsongrass can be obtained with 2 to 3 applications at rates of 2 to 4 lbs/acre each. No injury to bermudagrass was observed from these applications. Stage of growth of Johnsongrass appears to influence the effectiveness of control with organic arsenical herbicides. On rights-of-way with good stands of common bermudagrass, control of Johnsongrass was effective for two growing seasons from 3 applications made the first year. In locations where Johnsongrass was the primary species present, excellent control of initial stands was obtained, but reinfestation from germinating seed occurred rapidly.

Numerous experiments were conducted with soil sterilants for control of vegetative growth in certain areas. A large number of chemicals were found to be quite effective in controlling vegetation. Excessive damage to desirable vegetation by movement of soil sterilants in runoff water was found to be a problem. Certain chemicals were found to move to a greater extent than others. Cost of certain soil sterilants for controlling vegetation around delineator posts showed that a wide range in costs of materials exists. Some of the least effective materials were found to also cost more. It is thought that soil sterilants would be much cheaper than hand mowing to control unwanted vegetation in certain areas.

Brush control experiments were conducted at several locations throughout the state. Compounds containing 2,4-D, 2,4,5-T and Tordon were found to be most effective for controlling most of the woody species present at these locations.

RECOMMENDATIONS

These recommendations are based on findings of experiments conducted during the course of this project. While it is recognized that plant responses to certain maintenance practices require longer time periods for complete evaluation, trends can be established upon which sound recommendations can be made. Certain practices, such as establishment procedures, growth regulators, and herbicides, can be evaluated with a good degree of confidence over much shorter periods. It is hoped that practical use of the findings of these experiments be made.

Practical implementation of research findings is sometimes more difficult than researchers realize, for this reason no attempt will be made here to lay down iron-clad rules for the establishment and maintenance of grasses on highway rights-of-way. It is suggested that, after study by persons responsible for implementing establishment and maintenance specifications, those practices which can be implemented practically be incorporated into the specifications for establishment and maintenance of grasses on highway rights-of-way in Arkansas.

An interim guide for seeding rates and dates, use of herbicides, soil sterilants and growth regulators was prepared in 1964 and revised in 1967 as new findings were made. Many of the suggestions included in the interim guide were incorporated into Arkansas State Highway Department specifications. This guide is shown in the appendix. The recommendations given here are intended to supplement those in the interim guide.

SPECIES OF GRASS: Several species of grasses have been evaluated for vegetative cover throughout the state. Those species which appear best adapted include: weeping lovegrass (throughout the state), tall fescue (throughout the state), common bermudagrass (southern 2/3 of state), and bahiagrass (southern 1/2 of state).

ESTABLISHMENT PRACTICES:

A. Fertilizers and Lime

The best recommendation for fertilizers could be made by soil test. Generalized recommendations tend to be wasteful in certain areas. In absence of a soil test, it is recommended that 800 lbs/acre of 10-20-10 fertilizer (or the equivalent plant nutrients in other fertilizer grades) be applied at establishment. Agricultural limestone or dicalcium silicate (brown mud) should also be applied at rates of 2 to 4 tons/acre. Fertilizers and lime can be applied in slurry with hydroseeders or disked into the top 3-4 inches of soil at time of seedbed preparation.

B. Mulches:

The use of mulches is necessary to insure establishment. Mulches aid in preventing erosion and also conserve moisture. Wheat straw at the rate of two tons/acre tied down with emulsifiable asphalt has been equal to or better than other mulches in tests conducted here. Wood cellulose products have been adequate and can be applied with seed and fertilizer in hydroseeding operations.

MAINTENANCE FERTILITY: The need for maintenance fertilizers for adequate vegetative cover has been demonstrated. It is suggested that 500-700 lbs/acre of 10-20-10 fertilizer (or the equivalent in plant nutrients) be applied every 2 to 3 years after establishment. Savings in replacing weakened turf and erosion control would more than pay for application of this amount of fertilizer.

GROWTH RETARDANTS: Maleic Hydrazide (MH-30) can be used successfully to retard growth of tall fescue and common bermudagrass. Use of this material should be limited to selected areas, however, where hand mowing is required to control vegetation and it is desirable to maintain ground cover. Relatively pure stands of these grasses should also be present when MH-30 is used, as uneven growth will result if mixtures of species are present. MH-30 will successfully retard growth and reduce unsightly seedhead formation in tall fescue at rates of 4-5 lbs/acre and in common bermudagrass at 6 lbs/acre. Suggested areas for use of MH-30 include: delineator posts, guard rails, fence lines, and other difficult to mow areas in urban areas where optimum appearance is desired.

SOIL STERILANTS: Soil sterilants can be used to good advantage to reduce the need of costly hand mowing of areas which are inaccessable to mechanical mowing equipment and where ground cover is not absolutely necessary. A large number of soil sterilants are available which are quite effective, all move downslope in runoff water and cause damage to vegetation below the point of application. Simazine, of the materials tested here, moved downslope less than other materials. It is suggested that large savings could be made by use of soil sterilants on areas such as delineator posts, guard rails, rip-rap areas on ditch banks, etc., where it is not necessary to have ground cover and where runoff water will not damage vegetation downslope.

SELECTIVE CHEMICAL HERBICIDES: The value of chemicals for control of undesirable vegetation lies in savings for mowing costs, less damage to steep slopes from mowing equipment and the fact that chemicals can be applied to control unwanted vegetation on areas which are inaccessable to mowing equipment. When cost of controlling vegetation by mowing is computed it readily becomes apparent that reduced mowing is highly desirable. Since most grasses recommended for highway rights-of-way are fairly low growing, mowing should be restricted to selected areas such as medians and backslopes. If good stands of desirable grasses are established and weeds are controlled, the need for mowing can be eliminated.

Johnsongrass is controlled quite readily by 2 to 3 applications of DSMA or MSMA at rates of 3 to 4 lbs/acre. The first application should be made when Johnsongrass is in the root stage and subsequent applications approximately two weeks apart. These materials can be used to control Johnsongrass in bermudagrass and tall fescue but not in weeping lovegrass. Other "grassy" weeds such as crabgrass, barnyardgrass, etc. will also be controlled by these materials.

Most broadleaf weeds can be readily controlled by one application of 2,4-D at 2 lbs/acre shortly after they emerge. Care must be taken not to spray near susceptible crops such as cotton or soybeans, since this material is quite volatile and can cause damage. Most broadleaf weeds will emerge before crops are planted, however, and this presents no problem

Brush control can be accomplished with materials containing 2,4-D, 2,4,5-T, Tordon or mixtures of these materials, Care must also be exercised in applying these materials to avoid injury to susceptible crops in the area. Tordon is less volatile than 2,4-D and 2,4,5-T but is quite damaging to crops if it comes in contact with them.

SECTION I

GREENHOUSE AND LABORATORY EXPERIMENTS CONCERNING ESTABLISHMENT AND MAINTENANCE OF VEGETATION ON HIGHWAY RIGHTS-OF-WAY

1. Experiment No. L-1-63. The effect of fertilizer solution of different concentrations on viability of grass seed.

INTRODUCTION: A water slurry containing seed, fertilizer and mulch is applied in one operation when a hydroseeder is used to seed highway rights-of-way. Since fairly high rates of fertilizer are often required, there is a possibility that germination of seed might be reduced due to high salt concentration of the slurry.

OBJECTIVE: The objective of this experiment was to determine the effect of soaking seed of various grasses in fertilizer solutions of different concentrations for different lengths of time.

MATERIALS AND METHODS: Fifty seed each of Kentucky 31 tall fescue, Common bermudagrass, Pensacola bahiagrass, Common ryegrass, German millet, and Common sudangrass were soaked for two different lengths of time (15 and 60 minutes) in fertilizer solutions of different concentrations. Fertilizer concentrations were equivalent to 0, 500, 1000, 2000 and 3000 pounds per acre applied in 3750 gallons of water. This amount of water is normally used in hydroseeding operations.

After soaking for the required time period, the seed were removed from the solutions and placed on moist filter paper in petri dishes. The petri dishes were placed in a germinator at 85°-95° F and percent germination determined. There were three replications of each treatment.

RESULTS AND DISCUSSION: There was no visual difference in speed of germination between the concentrations. However, considerably more mold was noticed at the higher concentrations of fertilizer toward the end of the germination test.

Concentration and time had no effect on germination of millet (Table 1). Little or no effect was found on sudangrass except at concentrations above 1000 pounds per acre and this was noticed more at the 60 minute period. This was also true of tall fescue, but 2000 pounds per acre produced germination injury at both the 15 and the 60 minute periods. Germination of bermuda and bahiagrass was slightly affected by concentration, only at the 60 minute period. Ryegrass was not injured at any concentration or time. All data from this experiment is summarized in Table 1.

TABLE 1. Percentage germination of 6 grass species in 5 fertilizer concentrations for 2 different lengths of time. (Average of 3 replications of 50 seed each)

Concentration lbs/A	Time in min.	Species					
		Millet	Sudan	Fescue1/	Bermuda2/	Bahia2/	Ryegrass
0	15	82.7	65.4	38.0	48.0	28.7	72.6
	60	86.0	64.7	87.0	58.4	49.6	90.3
500	15	86.7	64.0	34.0	32.0	34.7	93.3
	60	82.7	56.0	83.3	53.0	45.6	93.4
1000	15	86.6	59.3	30.0	52.4	28.6	82.6
	60	78.7	54.0	47.3	27.0	90.7	
2000	15	86.6	66.6	26.7	36.0	34.6	78.0
	60	84.0	53.4	53.3	38.7	31.3	92.0
3000	15	84.0	52.6	10.7	44.7	36.0	78.0
	60	80.0	44.0	49.3	38.0	23.0	92.0

1/ Fresh fescue seed that was in a period of after-ripening domancy was used for the 15 minute test. Dormancy was broken for the 60 minute test by placing in refrigerator at 35° F for five days before test was initiated. Therefore, a higher constant germination at the 60 minute period resulted.

2/ Seed for the 60 minute period was placed in a 0.2 percent potassium nitrate solution instead of distilled water as an aid in germination. This procedure was not followed with the 15 minute period.

CONCLUSIONS: Rates above 1000 pounds per acre of 10-20-10 fertilizer at one application is not very common on highway rights-of-way. Very little or no germination injury was observed up to this concentration except with bermuda and bahiagrass, and that was with the 60 minute time period. This is a much longer period of time than it normally takes to fill a hydroseeder with a slurry and spray on highway rights-of-way. There appears to be no reduction of viability of grass seed from normal fertilizer concentrations use and in hydroseeding operations.

2. Experiment G-1-63. Effect of water stress for different lengths of time after seeding with a hydroseeder on germination and seedling vigor of various plant species.

INTRODUCTION: During periods of drought, the soil may not contain sufficient moisture for germination and growth of species seeded on highway rights-of-way. Under certain conditions the water applied in the slurry when hydroseeding might be sufficient to inititate germination, but not adequate to maintain subsequent seedling growth.

OBJECTIVE: The objective of this experiment was to determine the effect of water stress of different lengths after seeding on germination and vigor of different species.

MATERIALS AND METHODS: Kentucky 31 tall fescue, Crimson clover, bahiagrass and white clover were seeded in air dry soil in the greenhouse. The seed were mixed with a wood cellulose mulch and spread evenly over the surface of the soil. A measured amount of water equivalent to that normally applied in hydroseeding operations (3750 gal/acre) was sprinkled over each flat after seeding. One set of flats was seeded late in the afternoon and a second set early the following morning.

The soil in one treatment (check) was watered to field capacity the day of seeding and kept moist throughout the experiment. Other treatments were watered at 2, 7, 14 and 21 days after seeding to simulate drought periods of these lengths. After watering, all treatments were kept moist until germination was complete in that treatment. Each treatment was replicated three times.

RESULTS AND DISCUSSION: There were no observed differences in seedling vigor within each species among the different treatments. In all but two cases there was only a slight variation in germination compared to the check. Germination was reduced with Crimson clover that had been seeded in the early morning and watered seven days later. However, flats watered at a later date did not continue this trend. This was also true with bahiagrass but at a different rate and not to such a great degree (Table 2).

TABLE 2. Germination of two species of clovers and two species of grasses when seeded in early morning vs. late afternoon. The percentage germination is an average of three replications.

		Species			
Number of days until watering	Seeding Time	White Clover	Crimson Clover	Ky. 31 Fescue	Bahia
		Percent			
0 (check)		88.3	81.3	90.3	57.6
2	P.M.	91.6	82.3	95.0	58.3
2	A.M.	90.6	79.3	87.0	51.0
7	P.M.	92.6	79.3	94.6	48.6
7	A.M.	90.6	61.0	90.3	48.6
14	P.M.	93.3	75.6	94.0	41.7
14	A.M.	94.3	73.6	93.6	52.3
21	P.M.	91.3	69.0	94.0	49.9
21	A.M.	91.3	78.6	88.6	50.3

Less variation usually occurs with high viable seeds than seeds low in viability. The low germination of bahiagrass and Crimson clover seems to further point this out.

CONCLUSIONS: When combining mulch and seed for seeding in a water slurry, the time of day of seeding and the number of days until watering had little or no effect on final total germination. There was no noticeable difference in seedling vigor within each species among the different treatments.

3. Experiment GH-4-63. Effects of water stress at time of seeding on germination and survival of seedlings.

INTRODUCTION: Sufficient soil moisture must be present at time of seeding to initiate germination and maintain the seedlings until further moisture is received in rainfall. If moisture is available to initiate germination but not sufficient to maintain seedling growth, then the seeding may fail before additional rainfall is received.

OBJECTIVE: The objective of this experiment was to determine the effect of different amounts of water at time of seeding on germination and seedling survival of different species.

MATERIALS AND METHODS: One hundred seed each of Kentucky 31 tall fescue, Crimson clover, white clover, and bahiagrass were seeded in sterilized topsoil in metal flats in the greenhouse. The seed were distributed over the surface and wood cellulose mulch was used at a rate equivalent to 1000 lbs/acre. Water was sprinkled over the soil at a rate normally used in hydroseeding operations (3750 gal/acre). The following water treatments were made: (1) kept moist (check), (2) 0.10 inches, (3) 0.25 inches, (4) 0.50 inches, (5) 0.75 inches, (6) 1.00 inches, and (7) 1.25 inches. Two weeks after the different amounts of water were applied all flats were watered and kept moist until the experiment was terminated. Seedling counts were made at the end of the two-week period. Additional counts were made after the flats had been uniformly watered and additional seedlings had emerged. Each treatment was replicated three times.

<u>RESULTS AND DISCUSSION</u>: No visible germination occurred with any species tested when 0.5 inches or less water was added. However, when 0.75 inches was added some germination occurred with all species except bahia. As the amount of added water increased, the percent germination increased with the exception of bahia which did not germinate at any treatment level (Table 3).

TABLE 3. Percentage germination of four species at various moisture levels. The figures shown are an average of three replications.

Inches of Water Added	White Clover	Ky. 31 Fescue	Crimson Clover	Bahia
0.10	0.0	0.0	0.0	0.0
0.25	0.0	0.0	0.0	0.0
0.50	0.0	0.0	0.0	0.0
0.75	22.0	2.0	37.0	0.0
1.00	75.7	4.7	67.0	0.0
1.25	81.7	7.3	74.3	0.0
Kept moist (check)	88.7	77.7	78.3	24.7

White clover and Crimson clover seed germinated much faster when compared to fescue or bahia. Fescue germinated much faster than bahia.

The soil was dry two weeks after the treatments were made and all vegetative growth was dead. All the flats were watered at this time and kept moist for approximately two weeks. The percentage germination that occurred as a result of this treatment is shown in Table 4.

TABLE 4. Percentage germination of four species with adequate moisture after an initial treatment at various moisture levels. The figures shown are an average of three replications.

Inches of water added initially	White Clover	Ky. 31 Fescue	Crimson Clover	Bahia
0.10	83.0	88.0	73.0	25.7
0.25	84.0	87.3	76.0	20.3
0.50	82.0	85.7	69.7	22.0
0.75	55.7	81.7	21.0	25.3
1.00	13.3	66.0	3.6	18.7
1.25	6.7	66.0	0.6	14.3
Kept moist (check)	96.0	84.0	71.3	22.0

CONCLUSIONS: Of the four species tested no germination occurred when less than 0.75 inches of water was added as a treatment. Crimson clover and white clover germinated much faster than fescue, and fescue germinated faster than bahia. Results of this test indicate that sufficient moisture must be maintained over a longer period of time for the germination of fescue and bahia when compared to Crimson clover or white clover.

4. Experiment GH-3-63. Effects of different types of mulch on germination of two different grasses.

INTRODUCTION: Different types of mulch are becoming available which lend themselves to use with hydroseeders. The uniformity of application of these materials is a very desirable attribute when efficiency of seeding large areas with specialized equipment is concerned. Not enough is known, however, about the mulching characteristics of these different types of mulch.

OBJECTIVE: The objective of this experiment was to compare the germination of two grasses with various mulching materials.

MATERIALS AND METHODS: Kentucky 31 tall fescue and Common bermudagrass were seeded in sterilized topsoil in metal flats in the greenhouse. Four mulch treatments were used for each of the grasses: (1) wheat straw at 2000 lbs/acre, (2) a coarse natural colored wood cellulose mulch material (silvicel) at 1400 lbs/acre, (3) a finely ground green colored wood cellulose mulch material (Turfiber) at 1000 lbs/acre, and (4) no mulch (check). All flats were watered at time of seeding and watered as needed until germination was complete. Each treatment was replicated three times.

RESULTS AND DISCUSSION: No difference was noted in the rapidity of germination or vigor of the seedlings between the different treatments. Flats that received no mulch required watering more frequently than mulched flats. The erosion as a result of watering was not considered in this experiment.

There were no statistically significant differences between the three mulches in the number of emerged fescue seedlings. The no mulch treatment resulted in a significantly lower percentage germination (Table 5). No significant difference was found between the two wood cellulose materials with bermudagrass seedlings or between the straw and no mulch flats.

TABLE 5. Percentage germination of bermudagrass and Ky. 31 fescue with four mulch treatments. Figures shown are an average of three replications.

		% Germination	
Mulch	Rate #/A	Fescue	Bermudagrass
Wood Cellulose (coarse)	1400	89.7a*	46.0a*
Wood Cellulose (fine)	1000	82.3a	34.7ab
Wheat Straw	2000	80.3a	24.7b
No Mulch	0	67.7b	27.0b

* In Each Column: Any two values not followed by the same small letter are significantly different at the 5% level of probability.

CONCLUSIONS: There was no difference in percent germination of Ky. 31 fescue among the three mulches tested. A much lower germination did result where no mulch was used. No differences were found in germination of bermudagrass between the coarse and finely ground wood cellulose mulch. The finely ground wood cellulose, straw, and no mulch treatments were not significantly different in germination of bermudagrass. The no mulch treatments required watering more frequently than the mulched plots.

5. Experiment GH-1-65. Effectiveness of different mulching materials for controlling erosion.

INTRODUCTION: Different types of mulch have been used successfully in establishing seedlings on highway rights-of-way. One of the primary purposes of mulch is to prevent erosion until seedlings can become established.

OBJECTIVE: The objective of this experiment was to compare the effectiveness of various mulch materials at preventing erosion when subjected to simulated heavy rainfall.

MATERIALS AND METHODS: Three different mulch materials and a check (no mulch) were compared for controlling erosion in flats of soil in the greenhouse. The treatments were: (1) check (no mulch), (2) wheat straw at 4000 lbs/acre, (3) wood cellulose A (Turfiber) at 1000 lbs/acre, and (4) wood cellulose B (silvicel) at 1400 lbs/acre. The flats were divided into half and two mulch treatments were evaluated simultaneously in the same flat. A measured amount of soil was placed in each flat and packed uniformly before each mulch treatment was applied. Each flat containing the mulch treatment was placed at an angle simulating a 3:1 slope under an artificial rainfall machine and subjected to an equivalent of 6.3 inches of rainfall for a two-hour period. Ratings were made for erosion control. There were two replications.

RESULTS AND DISCUSSION: The effects of no mulch and three commonly used materials on erosion control are presented in Table 6.

TABLE 6. Ratings following the 6.3 inches of simulated rainfall as effected by the different mulch treatments. Average of two replications.

Treatment No.	Type Mulch	Rating*		Type Mulch	Rating*
1	Straw	0.5	+	No Mulch	10.0
2	Straw	0.4	+	Wood Cellulose A	2.8
3	Straw	0.2	+	Wood Cellulose B	1.8
4	Wood Cellulose A	5.0	+	Wood Cellulose B	1.8
5	Wood Cellulose A	2.2	+	No Mulch	10.0
6	Wood Cellulose B	2.0	+	No Mulch	10.0

* Ratings are for one-half of the flat for the particular mulch treatment. Rating scale: 0 - no erosion; 1-3 slight; 4-6 moderate; 7-9 heavy; 10 - severe.

The use of straw mulch at 4000 lbs per acre resulted in less erosion than the other two types of mulch used. Wood cellulose B (silvicel), using the manufacturers' recommendation of 1400 lbs per acre, resulted in less erosion than wood cellulose A (Turfiber) at 1000 lbs per acre. This difference between the two wood cellulose products was attributed more to the use of different rates than to the difference in the two products. Severe erosion occurred where mulch was not used.

CONCLUSIONS: An application of straw at the recommended rate controlled erosion significantly better than the two wood cellulose materials when subjected to rapid rates of simulated rainfall. This experiment points out the fact that some type of mulch must be used where new seedings are to be made on highway slopes with a 3:1 slope or greater.

6. Experiment GH-1-64. The loss of moisture due to evaporation is often the cause of poor seedling survival on highway rights-of-way. Mulch has a twofold purpose: (1) to control erosion until seedlings can become adequately established, and (2) to retard evaporation of soil moisture so that seed can germinate and become established.

OBJECTIVE: The objective of this experiment was to compare the effectiveness of different mulching materials for retarding moisture loss.

MATERIALS AND METHODS: Metal flats were filled with a measured amount of soil and packed uniformly. Five different mulch treatments were used with five replications of each treatment. Mulch treatments are listed below:

Treatment No.	Mulch	Rate (lbs/acre)
1	No Mulch (check)	----
2	Wood Cellulose A (Turfiber)	1,000
3	Wood Cellulose B (Silvicel)	1,400
4	Crushed Corn Cobs	10,000
5	Wheat Straw	4,000

Each mulch material was distributed evenly over the surface of the soil. A measured amount of water, sufficient to completely saturate the soil, was added to each flat. Care was taken not to disturb the layer of mulch. Weights were taken of each flat one day after initiation of the experiment and every two days thereafter until no additional loss in weight was recorded. Weight losses were recorded in grams.

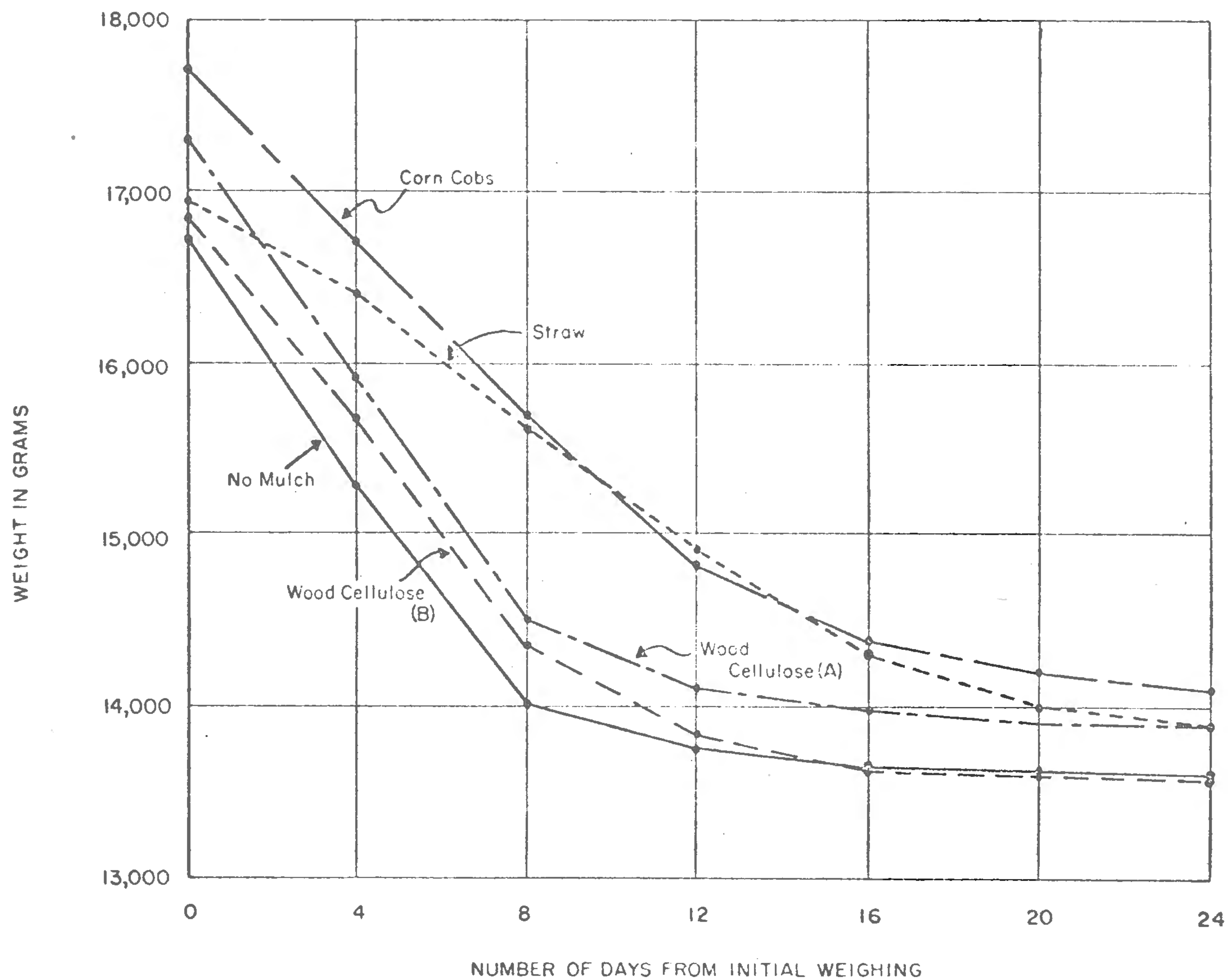
RESULTS AND DISCUSSION: The results of this experiment are reported by four-day intervals in Figure 1. There was very little difference in the evaporation rates from the flats that were not mulched and those that were mulched with either type of wood cellulose. Corn cobs and wheat straw were the best of all treatments with respect to conserving moisture. Wheat straw reduced the loss of moisture the first four days more than any other treatment. Both corn cobs and wheat straw were effective in conserving moisture for the first sixteen days which would allow time for germination and partial establishment of most species of grasses and legumes.

CONCLUSIONS: Mulching materials used in this experiment conserved soil moisture during the first fourteen days but had very little effect beyond this point. This period of time would be adequate for good germination and partial establishment of most grasses and legumes used on highway slopes in Arkansas.

FIGURE I

LOSS IN WEIGHT OF DIFFERENT MULCHES OVER A PERIOD OF 24 DAYS

AVERAGE OF FIVE REPITITIONS



7. Experiment L-1-67. Nitrogen release from different nitrogen sources.

INTRODUCTION: When soluble nitrogen fertilizer sources are applied to highway rights-of-way, rapid growth stimulation occurs. Since the nitrogen is readily available, it is quickly used by the plants or lost by leaching. In long term effects a nitrogen source might be more desirable which would release its nitrogen slowly over a long period of time.

OBJECTIVE: The objective of this experiment was to compare the rate of release of four different nitrogen sources.

MATERIALS AND METHODS: Four different nitrogen sources, ureaformaldehyde, urea, activated sewage sludge, and ammonium nitrate, were incubated at 95° F for 6 weeks to determine the rate of release of nitrogen. The materials were mixed with 10 grams of soil and placed in plastic tubes with a small hole in the bottom. The plastic tubes were plugged with glass wool to prevent soil loss. Each nitrogen fertilizer material was added at the rate of .02 grams of actual N per tube. A check treatment was included to determine original soil nitrogen levels. The soils were leached with 25 ml of distilled water at the beginning of the experiment and every two weeks afterward for a total of four leachings. Nitrates and nitrites were determined colorimetrically after each leaching. The nitrogen released was expressed as a percent of total nitrogen added (minus the check treatment). There were four replications of each treatment.

RESULTS AND DISCUSSION: As was expected, the nitrogen from ammonium nitrate and urea was practically all released within two weeks (Table 7). The nitrogen from ureaformaldehyde was released at a slower and more uniform rate than from activated sewage sludge. These data indicate that for nitrogen application where long-lasting effects are desired ureaformaldehyde would probably be desirable.

TABLE 7. Percent of total nitrogen released by 4 nitrogen sources at different incubation periods.

	Percent nitrogen released				
	Incubation time				
Nitrogen source	0	2 wks	4 wks	6 wks	Total
Ammonium nitrate	80	10	2	2	94
Urea	77	11	1	1	91
Ureaformaldehyde	6	11	12	14	43
Sewage sludge	5	10	25	30	70

CONCLUSIONS: Although ureaformaldehyde and sewage sludge were slower in their release of nitrogen and might be more desirable in terms of more uniform growth distribution, they are also much more expensive than soluble nitrogen sources. In selecting a nitrogen source for fertilizing highway rights-of-way the cost of lighter, more frequent applications of soluble nitrogen sources might not exceed that of the less soluble sources applied once.

8. Experiment GH-1-68. Effects of soil type, nitrogen fertilizer levels and clipping frequency on weeping lovegrass.

INTRODUCTION: Weeping lovegrass has shown great promise for use on highway rights-of-way. Its rapid germination and quick establishment results in excellent erosion control. More information is needed on adaptation of this species to different soil types, fertilizer rates and clipping frequency.

MATERIALS AND METHODS: A greenhouse study was initiated in 1968. A factorial treatment set was used in which the following treatments were applied:

A. Soils
   1. A sandy topsoil from Mississippi County on Arkansas Highway 119
   2. A silty subsoil from Lawrence County on Arkansas Highway 25

B. Starter fertilizers
   1. None (check)
   2. 400 lbs 10-20-10/acre
   3. 800 lbs 10-20-10/acre

C. Nitrogen fertilizer
   1. None (check)
   2. 80# N as ammonium nitrate
   3. 160# N as ammonium nitrate

D. Clipping
   1. Clipped to 4" every 3 weeks
   2. Clipped to 4" every 6 weeks
   3. Not clipped (check)

The soil test data for the two soils were as follows:

soil	pH	% OM	P (lbs/A)	K (lbs/A)	Ca (lbs/A)
sandy topsoil	6.8	1.5	49	155	1400
silty subsoil	6.6	0.8	7	140	1150

Two and one-half pounds of soil were placed into plastic pots. Starter fertilizer at the proper rates was mixed with the soil in each pot.

Thirty-five weeping lovegrass seed were placed in each pot and covered lightly with soil. Nitrogen topdressings of 0, 20 and 40 lbs/A were made monthly for 4 months to give nitrogen rates of 0, 80 and 160 lbs/A total N. Clippings were started 5 weeks after planting and all clipping treatments were clipped to a height of 4 inches.

After 21 weeks the final clipping was made just above the surface. The crowns were then clipped from the roots and the roots washed free of soil. Roots and tops were dried and dry weights recorded.

RESULTS AND DISCUSSION: Root and top weights of weeping lovegrass on the two different soils are shown in Table 8.

TABLE 8. Root and top weights means of weeping lovegrass as influenced by different soils.

	Grams Dry Weight	
Soils	Root	Top
Sand	2.71	5.94
Silt	2.11	3.96

Root and top weights of weeping lovegrass were greater in the sandy topsoil than the silty subsoil. This might be expected in light of the higher soil test values for the sandy topsoil.

Effect of different rates of starter fertilizer on weight of roots and tops is shown in Table 9.

TABLE 9. Root and top weight means as influenced by starter fertilizers.

	Grams Dry Weight	
Starter Fertilizer lbs/A	Root	Top
0	1.71	2.87
400	2.57	5.39
800	2.95	6.59

Top and root weights of weeping lovegrass were increased with each increase in starter fertilizer. The largest increase, however, was from the first increment of starter fertilizer.

Nitrogen topdressing of 80 and 160 lbs/A also resulted in increases in root and top weight (Table 10).

TABLE 10. Root and top weight means as influenced by nitrogen topdressing fertilizers.

	Grams Dry Weight	
Nitrogen lbs/A	Root	Top
0	1.68	2.62
80	2.68	5.33
160	2.92	6.90

Top weights of weeping lovegrass receiving 160 lbs N/acre were greater than those of weeping lovegrass receiving 80 lbs N/acre. There were no significant differences in root weights between the 80 and 160 lbs/acre treatments.

Clipping at all frequencies reduced both root and top weights of weeping lovegrass in comparison with the unclipped treatment (Table 11).

TABLE 11. Root and top weight means as influenced by clipping frequencies.

	Grams Dry Weight	
Clipping frequency in weeks	Root	Top
0	3.32	8.57
6	2.25	3.51
3	1.66	2.78

Weight reductions were greater as clipping frequency increased. This result is to be expected as more photosynthetic surface is removed the plant becomes weaker.

There were differences in response of weeping lovegrass to starter fertilizers on the two different soils used (Table 12).

TABLE 12. Root and top weight means of weeping lovegrass as influenced by soils and starter fertilizers.

	Starter Fertilizer lbs/A					
	0		400		800	
	gms dry wt		gms dry wt		gms dry wt	
Soils	Root	Top	Root	Top	Root	Top
Sand	2.30	4.50	2.78	6.08	3.05	7.25
Silt	1.12	1.24	2.37	4.69	2.84	5.94

In both soils top and root weights increased as starter fertilizer levels increased. The magnitude of increase was greater on the silty subsoil than on the sandy topsoil. Again differences in soil test data for the two soils might explain this difference in response on the two soils.

Response to nitrogen topdressing was also different on the two soils (Table 13).

TABLE 13. Root and top weights means as influenced by soils and nitrogen topdressings.

	Nitrogen lbs/A					
	0		80		160	
	gms dry wt		gms dry wt		gms dry wt	
Soils	Root	Top	Root	Top	Root	Top
Sand	1.69	2.91	3.12	6.52	3.32	8.40
Silt	1.57	2.32	2.25	4.15	2.51	5.40

Root and top weights of weeping lovegrass were increased by increased levels of nitrogen topdressing on both soils. The magnitude of increase was greater on the sandy topsoil since soil test values for P, K and Ca were greater on this soil additional nitrogen may have been utilized better.

Clipping at frequent intervals reduced root and top weight on both soils, the reduction was less on the silty subsoil than on the sandy topsoil (Table 14).

TABLE 14. Root and top weight means as influenced by soils and clipping frequencies.

	Clipping frequencies in weeks					
	0		6		3	
	gms dry wt		gms dry wt		gms dry wt	
Soils	Root	Top	Root	Top	Root	Top
Sand	3.76	10.31	2.48	4.12	1.88	3.40
Silt	2.87	6.82	2.02	2.89	1.43	2.16

Since total growth was less on the silty soil than the sandy soil it is thought that adverse effects of clipping would not be as noticeable.

The reduction in weight of roots and tops due to increasing frequency of clipping was less in treatments receiving no starter fertilizer. However, at each respective clipping interval, root and top weights were greater in the treatments receiving starter fertilizer (Table 15).

TABLE 15. Root and top weight means as influenced by starter fertilizers and clipping frequencies.

		Clipping frequencies in weeks					
		0		6		3	
		gms dry wt		gms dry wt		gms dry wt	
		Root	Top	Root	Top	Root	Top
Starter Fertilizer lbs/A	0	2.16	4.42	1.69	2.31	1.28	1.89
	400	3.69	9.35	2.39	3.88	1.64	2.93
	800	4.11	11.93	2.68	4.34	2.05	3.52

Top weights of weeping lovegrass were reduced less by increased clipping frequency in the treatment which received no nitrogen topdressing. It should also be pointed out in this case that top weights were greater at each respective clipping frequency as nitrogen levels increased. There was no interaction between nitrogen topdressing and clipping frequency for root weights (Table 16).

TABLE 16. Root and top weight means as influenced by nitrogen topdressing and clipping frequency.

		Clipping frequencies in weeks					
		0		6		3	
		gms dry wt		gms dry wt		gms dry wt	
		Root	Top	Root	Top	Root	Top
Nitrogen topdressing lbs/A	0	2.48	4.74	1.46	1.76	0.95	1.36
	80	3.72	9.15	2.50	3.82	1.83	3.03
	160	3.77	11.81	2.79	4.94	2.19	3.95

CONCLUSIONS: Weeping lovegrass responded differently to different fertilizer, nitrogen topdressing and clipping treatments on different soils. Soil test data were used to explain these differences in response.

Top growth of weeping lovegrass increased with each additional increment of nitrogen topdressing. Root growth increased with addition of nitrogen topdressing, however, there was no additional increase in root growth when 160 lbs N/acre were added when compared to 80 lbs N/acre. Since additional top growth might not be desirable on highway rights-of-way, 80 lbs of N/acre might be sufficient.

Clipping reduces top and root weight of weeping lovegrass. Best management of this grass would probably be to leave it unmowed.

9. Experiment GH-2-68.

INTRODUCTION: A problem area exists along Interstate 30 approximately two miles south of the Pulaski-Hot Springs County line. Establishment of vegetation on these acid, infertile slopes has been unsuccessful with a resulting soil erosion problem.

OBJECTIVE: The objective of this experiment was to determine the effects of different lime and fertilizer levels on establishment and growth of weeping lovegrass and bermudagrass on this soil.

MATERIALS AND METHODS: A factorial treatment set was initiated on this soil in the greenhouse. Treatments were as follows:

A. Lime

1. None (check)
2. 4 tons/A agriculture limestone
3. 8 tons/A agriculture limestone
4. 12 tons/A agriculture limestone

B. 10-20-10 fertilizer

1. None (check)

2. 500 lbs/A

3. 1000 lbs/A

C. Species

1. Weeping lovegrass

2. Bermudagrass

Approximately 20 lbs of soil was placed in each 3 gallon crock and respective amounts of lime and fertilizer were mixed throughout the soil. The soil was kept moist for 2 weeks and then seeded with the equivalent of 10 lbs/A of either weeping lovegrass or Common bermudagrass. There were two replications of each treatment.

Soil test data for this soil were as follows: pH - 3.8, P_2O_5 - 8 lbs/A, K_2O - 50 lbs/A, Ca - 750 lbs/A. In addition aluminum content of this soil was found to be greatly above the level normally detrimental to plant growth.

Dry weight of tops were recorded and used as an indication of plant response to different lime and fertilizer treatments.

RESULTS AND DISCUSSION: Top weights of weeping lovegrass as influenced by different lime and fertilizer levels are given in Table 17.

TABLE 17. Effects of lime and complete fertilizer on top weights of weeping lovegrass.

		Fertilizer lbs/A 0	500	1000	
		gms dry wt	gms dry wt	gms dry wt	Lime means
Lime Tons/A	0	2.0	10.0	15.0	9.0
	4	1.5	9.0	16.0	8.8
	8	0.7	7.2	11.2	6.3
	12	1.0	6.7	10.7	6.1
Fertilizer means		1.3	8.2	13.2	

Top weights of weeping lovegrass increased with added fertilizer. As lime rates increased, top weights decreased. The reason for this is not clear. It was thought that lime would be needed very badly on this extremely acid soil. There was no significant interaction between lime and fertilizer.

Effects of lime and fertilizer on growth of bermudagrass are shown in Table 18.

TABLE 18. Effects of lime and complete fertilizer on top weights of bermudagrass.

		Fertilizer lbs/A 0	500	1000	
		gms dry wt	gms dry wt	gms dry wt	Lime means
Lime Tons/A	0	0.2	10.5	11.0	7.2
	4	0.2	14.7	21.5	12.1
	8	0.5	7.5	9.5	5.8
	12	0.5	9.5	13.5	7.8
Fertilizer means		0.3	10.5	13.9	

Top weights of bermudagrass were also increased as rate of fertilizer increased. Lime at 4 tons per acre resulted in an increase in growth over the check, however, additional lime above 4 tons again resulted in a decrease in top weights.

Lime had no effect on top weights of plants receiving no fertilizer.

CONCLUSIONS: Growth of weeping lovegrass and bermudagrass increased on this problem soil with increased levels of complete fertilizer.

The effects of lime on this extremely acid soil were not understood. Lime reduced growth of weeping lovegrass. Common bermudagrass yields were increased when 4 tons of lime were added but decreased with further addition of lime.

SECTION II

FIELD EXPERIMENTS CONCERNING ESTABLISHMENT AND MAINTENANCE OF VEGETATION ON HIGHWAY RIGHTS-OF-WAY

1. Experiment 6-1-63. Effects of mulch and a rapidly germinating annual grass on establishment of vegetation on exposed subsoil slopes.

INTRODUCTION: It is sometimes difficult to establish vegetation on slopes of exposed subsoil. The seeding of a rapidly germinating annual species, such as annual ryegrass, might afford erosion protection until slower perennial species could become established. Mulch is almost always beneficial in preventing erosion.

MATERIALS AND METHODS: The site of this experiment was on Interstate 40 near North Little Rock. The soil was an exposed subsoil with an approximate 2.5:1 slope. Soil was prepared by disking to about 3 inches. A factorial treatment set was used. Treatments were:

A. Species

   1. 60 lbs Ky. 31 tall fescue and 10 lbs white clover/acre
   2. 30 lbs Ky. 31 tall fescue, 50 lbs annual ryegrass and 10 lbs white clover/acre

B. Mulch

   1. 1000 lbs turfiber/acre
   2. No mulch

The plot size was 25 x 30 feet and there were 3 replications. The plots were seeded with a hydroseeder on September 23, 1963. One thousand pounds of 10-20-10 commercial fertilizer was applied at time of seeding.

RESULTS AND DISCUSSION: The soil was very dry at time of seeding and for approximately 2 months after seeding when a rain was received. The plots were evaluated on December 10, 1963, and on January 27, 1964.

Plots in which ryegrass were seeded had much better coverage than did those without ryegrass. There was no white clover in any of the plots. No differences were observed between the mulched and unmulched plots. Erosion was not a serious problem.

CONCLUSIONS: A sufficient stand of fescue was established on all plots, however, plots with ryegrass in the mixture had much better coverage. Mulch had no effect on establishment or erosion on these plots. White clover was not established on these plots.

2. Experiment 6-2-63. Effects of different fertilizer rates on establishment of Kentucky 31 tall fescue.

INTRODUCTION: Exposed subsoils, low in nutrients and organic matter, are quite common along highway rights-of-way. Establishment of vegetation is often difficult under these conditions. Large amounts of fertilizer must often be applied to such slopes to meet requirements for plant growth.

OBJECTIVE: The objective of this experiment was to compare various rates of fertilizer for establishment of Ky. 31 tall fescue on an exposed subsoil.

MATERIALS AND METHODS: This experiment was located on I-40 near North Little Rock. Soil samples were taken on upper and lower portions of the slope. Results of the soil tests are shown in Table 1.

TABLE 1. Soil test results of North Little Rock test site.

Slope position	pH	% O.M.	lbs/A P	lbs/A P_2O_5	lbs/A K	lbs/A Ca
Upper	4.9	0.70	22	50	200	400
Lower	5.0	0.60	23	54	150	350

Five treatments consisting of different rates of 10-20-10 fertilizer were applied in this experiment. The rates of fertilizer were: (1) no fertilizer (check), (2) 250 lbs/acre, (3) 500 lbs/acre, (4) 750 lbs/acre, and (5) 1000 lbs/acre. All plots were seeded with Kentucky 31 tall fescue at the rate of 60 lbs/acre. The plots were mulched with 1000 lbs/acre Turfiber. The mulch, fertilizer and seed were applied as a slurry with a hydroseeder on September 25, 1963. There were three replications.

RESULTS AND DISCUSSION: The soil was very dry at time of seeding and for a two month period after seeding. The plots were checked on December 10, 1963, and January 27, 1964, and germination had occurred but the seedlings were very small.

On March 26, 1964, an attempt was made to check the plots but they had been covered with topsoil.

CONCLUSION: Germination was delayed due to an extended drought and did not occur until cold weather. The plots were destroyed the following spring by being covered with topsoil.

3. Experiment 6-3-63. Effects of different rates of fertilizer on establishment of Ky. 31 tall fescue on shale subsoils.

INTRODUCTION: In certain areas of Arkansas shale outcroppings are quite common on highway rights-of-way slopes. Exposed shale is extremely difficult to establish vegetation on due to low nutrients and water holding capacity.

OBJECTIVE: The objective of this experiment was to determine the effect of different fertilizer rates on establishment of Ky. 31 tall fescue.

MATERIALS AND METHODS: This experiment was located on I-30 in Little Rock. The slope consisted primarily of shale. Soil samples were taken on upper and lower portions of the slope. Results of soil tests are shown in Table 2.

TABLE 2. Soil test results of Little Rock test site.

Slope position	pH	% O.M.	lbs/A P	lbs/A P_2O_5	lbs/A K	lbs/A Ca
Upper	4.0	0.50	2	5	445	910
Lower	3.5	0.90	14	32	650	1000

The different rates of 10-20-10 fertilizer used in this experiment were: (1) none (check), (2) 250 lbs/acre, (3) 500 lbs/acre, (4) 750 lbs/acre, and (5) 1000 lbs/acre.

All plots were seeded with Ky. 31 tall fescue at the rate of 60 lbs/acre. The plots were mulched with 1000 lbs/acre Turfiber. The mulch, fertilizer, and seed were applied as a slurry with a hydroseeder. Each plot was 25' x 30' and replicated 3 times. Plots were seeded on

September 25, 1963. The soil was very dry and no rain was received for about two months after seeding.

RESULTS AND DISCUSSION: Dry weather at and before seeding delayed germination until cold weather. The plots were observed on December 10, 1963, and January 27, 1964. Although some germination had occurred, the grass was growing very slowly due to low temperatures. On March 26, 1964, the plots were observed again and it was found that most of the seedlings which had germinated were killed by low temperatures. The dry fall which delayed germination as well as the shale soil which holds very little moisture were thought to be responsible for failure to obtain stands in these plots.

CONCLUSION: Dry weather after seeding until cold weather resulted in failure to establish stands in these plots. It is thought that the addition of topsoil on exposed slopes is necessary for satisfactory seedling establishment.

4. Experiment 8-1-63. Effects of rate of fertilizer on establishment of Ky. 31 tall fescue on cut and fill slopes.

INTRODUCTION: In preparing highway rights-or-way, it is often necessary to cut certain areas and fill others. Differences in soils in these kinds of areas may make a difference in the ease of establishment of vegetation.

OBJECTIVE: The objective of this experiment was to compare the effects of fertilizer levels on establishment of Ky. 31 tall fescue on cut and fill slopes.

MATERIALS AND METHODS: A cut and fill area on I-40 west of Russellville was chosen for this experiment. The slope was prepared by grading with a bulldozer which left the soil very firm. Soil samples were taken from upper and lower portions of both the cut and fill areas. Results of the soil tests are given in Tables 3 and 4.

TABLE 3. Soil test results of the cut test site at Russellville, Arkansas

Slope position	pH	% O.M.	lbs/A P	lbs/A P_2O_5	lbs/A K	lbs/A Ca
Upper	5.6	0.20	13	30	185	875
Lower	5.6	0.10	5	12	170	800

TABLE 4. Soil test results of the fill test site at Russellville, Arkansas

Slope position	pH	% O.M.	lbs/A P	lbs/A P_2O_5	lbs/A K	lbs/A Ca
Upper	5.1	0.00	14	32	150	225
Lower	5.2	0.30	16	37	205	285

The different rates of 10-20-10 fertilizer used on both the cut and fill areas were: (1) none (check), (2) 250 lbs/acre, (3) 500 lbs/acre, (4) 740 lbs/acre, (5) 1000 lbs/acre. All plots were seeded with Ky. 31 tall fescue at the rate of 60 lbs/acre. One thousand lbs/acre of Turfiber mulch was used. The mulch, fertilizer and seed were applied as a slurry with a hydroseeder. Each fertilizer plot was 25' x 35' and replicated 3 times on each of the cut and fill areas. The plots were seeded on September 26, 1963. The soil was very dry at time of seeding and no rainfall occurred for approximately 2 months after seeding.

RESULTS AND DISCUSSION: The soil test results point out the low fertility of both areas. With the exception of pH and calcium, there were little differences in soil test analysis between the cut and fill areas.

Dry weather prevented germination in these plots until cold weather. Some germination occurred during the winter but only a few plants survived the winter.

CONCLUSIONS: Soil test results indicated very little differences in analysis of the different elements between the cut and fill areas. Dry weather after seeding prevented germination until cold weather and the seedlings were winter killed.

5. Experiments 5-1-64, 2-1-64, and 7-1-64. Effects of lime on establishment of various plant species at different locations.

INTRODUCTION: Major differences occur in soils and climate in different areas of the state. The northern one-third of the state generally has much colder weather than the southern part. For this reason, certain species are not sufficiently winter hardy to become established in the northern one-third of the state.

OBJECTIVE: The objectives of this experiment were to compare different species of plants and different amounts of limestone at different locations throughout the state.

MATERIALS AND METHODS: Four species were seeded at each of three locations (Highway Districts 2, 5, and 7). These species were Pensacola bahiagrass, Ky. 31 tall fescue, sericea lespedeza, and common bermuda. One plot of each species at each location received 1000 lbs/acre agriculture limestone while a second received no lime. All plots received 1000 lbs/acre of 10-20-10 fertilizer. One thousand lbs/acre of Turfiber mulch was applied on all plots. A hydroseeder was used to seed, fertilize and mulch the plots in one operation. Plots at all locations were 25 x 30 ft and replicated 3 times.

RESULTS AND DISCUSSION:

Experiment 5-1-64 (District 5 - Batesville).

Soil test results are given in Table 5.

TABLE 5. Soil test results for the Batesville location.

pH	% Organic matter	lbs/A P	lbs/A K	lbs/A Ca	lbs/A Mg	lbs/A Na
5.2	0.20	12	140	640	750	40

This experiment was seeded on March 30, 1964. Observations were made on April 23, 1964. At this time very little sericea lespedeza, bermudagrass or bahiagrass had germinated. The fescue had germinated fairly well. The plots were checked again in August 1964 and all species had germinated but growth was slight because of an extremely dry summer. The plots were observed again in June 1965 and rated for percent ground cover. Results are shown in Table 6.

TABLE 6. Percent ground cover of four species with two levels of lime application. (Average of three replications)

Treatment No.	Species	Rating*	
		Limed (1,000 #/A)	Not Limed
1	Pensacola Bahia	10	17
2	Sericea Lespedeza	75	45
3	Ky. 31 Tall Fescue	17	17
4	Common Bermuda	0	0
L.S.D. at 5% level		13.8	11.6

Sericea lespedeza with lime was the only plots showing satisfactory ground cover. Common bermuda and Pensacola bahiagrass are not well adapted to the northern one-third of the state. The dry summer probably accounted for the failure of Ky. 31 tall fescue to establish satisfactory stands. Lime was essential for good establishment of sericea lespedeza.

Experiment 2-1-64 (District 2 - Cleveland Co.)

Table 7 gives the soil test results at this site.

TABLE 7. Results of soil analysis test.

pH	% Organic Matter	#/A P	#/A K	#/A Ca	#/A Mg	#/A Na
4.4	0.5	12	237	80	287	93

The plots were seeded on April 1, 1964. Plots were rated for percent cover on August 27, 1964 (Table 8).

TABLE 8. Percent ground cover of four species at different lime application levels. (Average of three replications)

Species	1000 lbs/A Lime	No Lime
Bahiagrass	75	37
Bermudagrass	47	15
Ky. 31 Tall Fescue	1.7	1.5
Sericea Lespedeza	25	10

Only bahiagrass with lime provided sufficient ground cover at this location. Bermudagrass with lime was better than without lime. Ky. 31 tall fescue and sericea lespedeza did not produce satisfactory ground cover regardless of lime treatment.

Experiment 7-1-64 (District 7 - El Dorado)

This test was seeded on April 2, 1964. Since all treatments would not fit on one slope in the area chosen, a west facing slope was used for the treatments receiving lime and a east facing slope for the treatments receiving no lime. Soil test results for the two slopes are shown in Table 9.

TABLE 9. Result of soil analysis test.

Slope	pH	%Organic Matter	#/A P	#/A K	#/A Ca	#/A Mg	#/A Na
West facing (limed)	4.7	0.00	32	125	325	150	120
East facing (not limed)	4.7	0.00	29	135	500	150	63

The plots were observed on June 1, 1964, and a fair stand of fescue, bahia and sericea lespedeza were present. When the plots were checked again July 31, these seedlings were all dead due to extremely dry weather. The bermuda plots had approximately 20% stand.

CONCLUSIONS: Dry weather limited germination and establishment in at least two of the three locations. Lime was found to be beneficial in locations where satisfactory stands of any species was obtained. Sericea lespedeza was superior in District 5 and Pensacola bahiagrass in District 2.

6. Experiment 6-1-64. Effects of different rates of wood cellulose mulch on establishment of common bermudagrass and Ky. 31 tall fescue.

INTRODUCTION: The advantages of mulch during seedling germination has been well established. On extreme slopes, higher rates of mulch than normal may be advantageous to prevent erosion.

OBJECTIVE: The objective of this experiment was to compare different rates of wood cellulose mulch in establishment of common bermudagrass and Ky. 31 tall fescue.

MATERIALS AND METHODS: This experiment was established on a shale slope on I-30 in Little Rock. The area had been established as Experiment 6-3-63 (reported previously) in 1963 but a stand was not obtained. Approximately 3 inches of topsoil was spread over the area to be seeded.

Two different rates of Turfiber wood cellulose mulch were used: 1000 and 2000 lbs/acre. Kentucky 31 tall fescue was seeded at the rate of 45 lbs/acre and common bermudagrass at 15 lbs/acre were the species seeded. All plots received 1000 lbs/acre of 10-20-10 fertilizer. A hydroseeder was used to apply the mulch, fertilizer and seed in one operation. Each plot was 25 by 30 feet and there were 3 replications. Seeding was on March 31, 1964.

RESULTS AND DISCUSSION: Plots were observed on June 2, 1964. A good stand of both common bermuda and tall fescue was obtained. The fescue was lighter green on the plots receiving 2000 lbs mulch/acre, indicating that the heavy rate of mulch was tying up nitrogen. On July 28, 1964, the plots were observed again and it was found that all bermudagrass plots had essentially 100% coverage. It was found that the topsoil used to cover the area contained viable bermudagrass stolons and rhizomes and that these had contributed to ground coverage. The fescue plots also had good coverage, but had stopped vegetative growth with the hot weather. There was a great deal of bermudagrass in the fescue plots from sprigs in the topsoil.

CONCLUSIONS: Topsoil was considered essential for satisfactory establishment of vegetation on this shale slope. The 2000 lbs/acre rate of wood cellulose mulch was thought to be tying up nitrogen. The 1000 lbs/acre rate was sufficient for erosion control and seedling development in this experiment.

7. Experiment 6-2-64. Effects of lime and mulch on establishment of bermudagrass.

INTRODUCTION: This experiment was conducted on a slope in which a previous experiment had failed (Experiment 6-2-63). Topsoil was used in this experiment which was not used in the previous experiment. In addition the effects of lime and mulch were studied.

OBJECTIVE: To determine the effects of lime and mulch on the establishment of common bermudagrass.

MATERIALS AND METHODS: The slope was covered with approximately 3 inches of topsoil containing common bermudagrass sprigs. One series of plots received Turfiber wood cellulose mulch at 1000 lbs/acre and a second series no mulch. One-half of each mulch treatment received 1000 lbs lime/acre and one-half no lime. Common bermudagrass was seeded on March 31, 1964. Each plot received 1000 lbs/acre of 10-20-10 fertilizer. Seed, fertilizer, lime and mulch were applied by hydroseeder. There were 3 replications.

RESULTS AND DISCUSSION: Excellent ground cover of common bermudagrass was obtained on all plots. There were no differences due to mulch or lime treatment. There was a large amount of bermudagrass sprigs in the topsoil which was used to cover this slope and this was thought to have prevented erosion to some extent.

CONCLUSIONS: No differences between any of the mulch or lime treatments were observed. All plots provided essentially perfect ground cover. The amount of bermuda sprigs in the topsoil was thought to have aided in establishment and also reduced the effectiveness of mulch in preventing erosion.

8. Experiments 7-2-64, 2-2-64, 5-2-64, and 4-1-64. Effects of lime and fertilizer applications on deteriorated stands of rights-of-way vegetation.

INTRODUCTION: Often a good stand of vegetation is established on highway rights-of-way but maintenance fertility is not practiced and stands become thin. It is thought that this problem could be solved with the application of adequate fertilizer and/or lime.

OBJECTIVE: The objective of these experiments was to determine the effect of different lime and fertilizer application rates on thin stands of rights-of-way vegetation.

MATERIALS AND METHODS: A separate lime and fertilizer test was conducted at each of 4 locations in the state. These experiments were located in Districts 2, 4, 5, and 7. The treatments used at each location are shown in Tables 10 and 11.

TABLE 10. Treatment number and fertilizer rate in pounds per acre.

Treatment No.	#/A Lime	#/A 10-20-10 Fert.
1	1000	0
2	1000	100
3	1000	250
4	1000	500
5	1000	1000

TABLE 11. Treatment number and lime rate in pounds per acre.

Treatment No.	#/A Lime	#/A 10-20-10 Fert.
1	0	500
2	500	500
3	1000	500
4	2000	500
5	4000	500

The plot size at each location was 25 x 30 feet. Lime and fertilizer was applied broadcast by hand. There were three replications at each location.

Each location will be discussed separately.

Experiment 7-2-64 (District 7 - El Dorado)

An east and a west facing slope was used in this District. The experiment in which a constant rate of 2000 lbs lime/acre was applied and fertilizer rates varied was on the east facing slope. The experiment with varied rates of lime and a constant rate of 10-20-10 fertilizer was on the west facing slope. Soil analysis of the two slopes are given in Table 12.

TABLE 12. Analysis of soil test from east and west facing slopes.

Slope	pH	% Organic Matter	#/A P	#/A K	#/A Ca	#/A Mg	#/A Na
West facing	5.1	0.10	97	100	175	100	84
East facing	5.2	1.00	51	120	500	100	85

The vegetation present on these slopes was mainly spring annual weeds and grasses. There was some bermudagrass and annual lespedeza on both slopes but not enough to be considered a satisfactory stand. Treatments were made on May 4, 1964.

RESULTS AND DISCUSSION: A guard rail running parallel to an auxillary road bordered the top of the east facing slope. A heavy application of soil sterilant was made by personnel of the Arkansas State Highway

Department to kill the vegetation under this guard rail. The soil sterilant leached down the slope and damaged many of the plots on this slope. It was observed in the plots which were not damaged that ground cover was increased greatly in plots which received 500 lbs/acre or more of 10-20-10 fertilizer.

Ratings of the plots were made in the fall of 1965. No differences were found in ground cover between different lime rates. The results of the different fertilizer levels are shown in Table 13.

TABLE 13. Ratings of vegetative response to different fertility levels. (Average of three replications)

Treatment No.	#/A 10-20-10*	Rating**
1	0	4.0
2	250	4.5
3	500	6.5
4	1000	5.8
L.S.D. at 5% level		2.3

* All plots received 2000 #/A lime.
** A 0 rating means no increase due to treatment.
A 10 rating means vigorous growth with complete cover.

The treatment which received 500 lbs/acre 10-20-10 was significantly better than the check. The effects of the soil sterilant may have resulted in lower ratings in certain of these plots.

Experiment 2-2-64 (District 2 - Pine Bluff)

The location of this experiment was such that both the lime and fertilizer experiments were included on the same slope. Soil test results for this site are given in Table 14.

TABLE 14. Soil test results for the Pine Bluff test.

pH	% Organic Matter	#/A P	#/A K	#/A Ca	#/A Mg	#/A Na
4.4	0.40	5	105	225	175	85

The lime and fertilizer were applied on May 5, 1964. A thin cover of vegetation consisting mostly of spring annual weeds and grasses was present with a limited amount of bermudagrass.

RESULTS AND DISCUSSION: The plots were observed during 1964 then rated for ground cover in 1965 (approximately one year after application of fertilizers). Ratings are presented in Table 15.

TABLE 15. Ratings of response to fertilizer and lime treatments. (Average of three replications)

Treatment No.	Fertility Test* #/A 10-20-10	Rating***
1	0	4.2
2	250	5.6
3	500	7.3
4	1000	7.0
L.S.D. at 5% level		1.22

Treatment No.	Lime Test** #/A Lime	Rating***
1	0	7.4
2	500	7.3
3	1000	8.2
4	2000	8.4
5	4000	7.8
L.S.D. at 5% level		NS

* All plots received 2000 #/A lime.
** All plots received 500 #/A 10-20-10.
*** A rating of 0 means no increase due to treatment.
A rating of 10 means vigorous growth with complete cover.

Increases in rate of 10-20-10 fertilizer up to 500 lbs/acre resulted in increased ground cover. There was no significant increase in ground cover due to different rates of lime application.

Experiment 5-2-64 (District 5 - White County)

The area selected for this experiment had been seeded to tall fescue the previous fall and a fairly good stand was present. Results of the soil test for this area are given in Table 16.

TABLE 16. Results of soil analysis test.

pH	% Organic Matter	#/A P	#/A K	#/A Ca	#/A Mg	#/A Na
4.6	0.10	5	150	400	225	135

The fertilizer and lime treatments were made on May 7, 1964. Plots were observed through 1964 and rated for ground cover in 1965 approximately one year after fertilizer and lime applications.

RESULTS AND DISCUSSION: There was a positive response to both increased fertilizer and lime rates in this experiment (Table 17).

TABLE 17. Ratings of vegetative response to different fertilizer and lime treatments. (Average of three replications)

Treatment No.	Fertility Test* #/A 10-20-10	Rating***
1	0	3.5
2	250	4.8
3	500	6.8
4	1000	9.3
L.S.D. at 5% level		1.75

Treatment No.	Lime Test** #/A Lime	Rating***
1	0	3.8
2	500	4.5
3	1000	6.5
4	2000	6.2
5	4000	5.3
L.S.D. at 5% level		1.83

* All plots received 2000 #/A lime.
** All plots received 500 #/A 10-20-10.
*** A 0 rating means no increase due to treatment.
A 10 rating means vigorous growth with complete cover.

The fertilizer test showed an increase in ground cover with each additional increment of 10-20-10 fertilizer with near perfect cover at 1000 lbs/acre.

Better ground cover was obtained when 1000 or 2000 lbs/acre of lime were applied.

Experiment 4-1-64 (District 4 - Y City)

The lime and fertilizer in this experiment was not applied until October 1, 1964. The predominant species in this site was tall fescue, although annual grasses and weeds had invaded somewhat. Results of the soil test for this site are given in Table 18.

TABLE 18. Analysis of soil test from fertility and lime test plots.

Test	pH	% Organic Matter	#/A P	#/A K	#/A Ca	#/A Mg	#/A Na
Fertility	5.1	1.3	23	135	400	150	105
Lime	4.8	1.0	26	175	300	175	110

RESULTS AND DISCUSSION: Plots were rated on July 1, 1965. Increases in ground cover were found with each additional increment of 10-20-10 fertilizer (Table 19). No differences were found between any of the levels of lime applied.

TABLE 19. Ratings of vegetative response to fertilizer and lime treatments. (Average of three replications)

Treatment No.	Fertility Test* #/A 10-20-10	Rating***
1	0	3.0
2	250	4.7
3	500	7.5
4	1000	8.8
L.S.D. at 5% level		1.75

Treatment No.	Lime Test** #/A Lime	Rating***
1	0	7.3
2	500	6.5
3	1000	6.3
4	2000	6.7
5	4000	6.8
L.S.D. at 5% level		Ns

* All plots received 2000 #/A lime.
** All plots received 500 #/A 10-20-10.
*** A rating of 0 means no increase due to treatment.
A rating of 10 means vigorous growth with complete cover.

CONCLUSIONS: Increases in ground cover with increased levels of 10-20-10 fertilizer on deteriorated stands resulted in each of the four locations studied. This points out the necessity for maintaining adequate fertility levels after establishment.

Increases in ground cover due to added lime was obtained in only one experiment, although soil test results showed that the pH was low in all soils. Differences in species present may have been the chief reason for the response to lime in only one location.

9. Experiment 4-1-65. Adaptation of various plant species.

INTRODUCTION: The comparison of different plant species in a given area is necessary in order to determine plants adapted to that area.

OBJECTIVE: The objective of this experiment was to compare various species for adaptation to northwestern Arkansas.

MATERIALS AND METHODS: Six species were seeded April 12, 1965, on I-40 near Van Buren. The seedbed was prepared by disking and harrowing. One thousand lbs/acre of 10-20-10 fertilizer was worked into the soil to a depth of approximately 3 inches at the time of seedbed preparation. Seeding was with a hydroseeder. One thousand lbs/acre of Turfiber mulch was applied in slurry with the seed. Each plot was 22 x 44 feet with two replications. The species and seeding rates are listed in Table 20.

TABLE 20. Species and seeding rates.

Treatment No.	Species	Seeding Rate-lbs/A
1	Pensacola Bahia	60
2	Weeping Lovegrass (*Eragrostis curvula*)	8
3	Sericea Lespedeza	90
4	Crown Vetch	45
5	Green Sprangletop (*Leptochloa dubia*)	4 P.L.S.*
6	Common Bermuda	15

* P.L.S. - Pure live seed.

Soil samples were taken from the area prior to fertilization. Results of soil tests are shown in Table 21.

TABLE 21. Soil analysis data.

pH	% Organic Matter	#/A P	#/A K	#/A Ca	#/A Mg	#/A Na
4.9	0.6	17	155	550	250	70

Visual ratings of stands of the different species were taken on July 1, 1965, and again during 1966, 1967, 1968 and 1969.

RESULTS AND DISCUSSION: The first rating made in July 1965 indicates that common bermuda, Pensacola bahiagrass, weeping lovegrass and green sprangletop were the only species providing acceptable stands (Table 22). No crown vetch was found on this date and seedlings of sericea lespedeza were very few.

TABLE 22. Ratings of species on July 1, 1965. (Average of two replications)

Treatment No.	Species	Rating*
1	Pensacola Bahia	5.8
2	Weeping Lovegrass	4.5
3	Sericea Lespedeza	1.8
4	Crown Vetch	0
5	Green Sprangletop	4.0
6	Common Bermuda	7.0
L.S.D. at 5% level		1.69

* A rating of 0 means no stand; a rating of 10 means an excellent stand.

Ratings in the fall of 1966 showed that only Pensacola bahia and weeping lovegrass had maintained satisfactory stands (Table 23).

TABLE 23. Stand ratings in fall 1966. (Average of two replications)

Treatment No.	Species	Rating*
1	Pensacola Bahia	8.3
2	Weeping Lovegrass	4.9
3	Sericea Lespedeza	0.5
4	Crown Vetch	0
5	Green Sprangletop	0.5
6	Common Bermuda	1.1

* A rating of 0 means no stand; a rating of 10 means an excellent stand.

Common bermuda, which had provided the most ground cover in 1965, had decreased until the stand was not satisfactory. The reason for the stand decrease was thought to be winter killing.

The plots were rated again in 1967, 1968 and 1969. No important changes in stands from the 1966 data were found. Sericea lespedeza had increased by 1968 and 1969 but was still not providing an acceptable cover.

CONCLUSIONS: Under the conditions of this experiment, Pensacola bahiagrass and weeping lovegrass provided good vegetative cover. Common bermuda was established the first year but was winter killed. None of the other species provided acceptable cover in this experiment.

10. Experiment 8-1-65. Comparison of various methods of establishing bermudagrass on highway rights-of-way slopes.

INTRODUCTION: Rapid establishment of vegetative cover is essential for erosion control on steep slopes. Common bermudagrass can be established vegetatively or from seed. In certain cases the additional expense involved in vegetative establishment may be necessary in order to establish stands of vegetative cover.

OBJECTIVE: The objective of this experiment was to compare different methods of establishing common bermuda on newly graded slopes.

MATERIALS AND METHODS: A newly graded area on I-40 west of Russellville was chosen for this experiment. The soil was very rocky. Soil test data indicated this soil was low in pH, P, K, and Ca. Two tons/acre of agricultural limestone were applied and disked into the soil at time of seedbed preparation. Two different fertilizer rates were compared: 500 and 1000 lbs/acre of 10-20-10 fertilizer. The fertilizer was also applied and disked in prior to establishing the plots. The plots were one-third acre in size and were established on April 20, 1965. The treatments used in this experiment are shown in Table 24.

TABLE 24. Methods of establishment of bermudagrass.

Treatment No.	Mulch & Rate	Seeding or Sprigging Rate of Bermuda
1	3-4 inches of sod mulch per acre	
2	Wood Cellulose - 1000 #/A	15 lbs/A (Seed)
3	Wood Cellulose - 1500 #/A	75 bu/A (Sprigs)
4	Straw 3000 #/A	15 lbs/A (Seed)

A hydroseeder was used to apply the wood cellulose mulch, sprigs and seed on those plots receiving them.

RESULTS AND DISCUSSION: Excellent cover was obtained by July 2, 1965, on the sod mulched and seeded plots. The seeded plots were showing water stress to a much greater extent. The sprigged plots had a poor stand at this date. It was thought that the sprigs applied through the hydroseeder did not become pegged down sufficiently.

The plots were rated again in 1966 and 1967. The 1967 ratings are given in Table 25.

TABLE 25. Percent ground cover of common bermudagrass established in four different ways.

Method of Establishment	% Ground Cover 500# 10-20-10/A	% Ground Cover 1000# 10-20-10/A
Bermuda Sod (3-4")	95	100
Bermuda Seed + Straw Mulch	85	90
Bermuda Sprigs + Wood Cellulose	50	75
Bermuda Seed + Wood Cellulose	30	50

By 1966 the plots established with sod mulch were clearly superior to other methods. The plots seeded and covered with straw were superior to those seeded or sprigged and covered with wood cellulose mulch. Plots which received 1000 lbs/acre of fertilizer were superior to those receiving 500 lbs/acre regardless of method of establishment.

By 1967 considerable erosion had occurred. The plots were partially destroyed by motorcycles using this area for a hill climb. Plots established from sod mulch still maintained practically 100% ground cover, other plots were badly eroded.

CONCLUSIONS: Sod mulch was greatly superior to other methods of establishment on this rocky slope. The water holding capacity of the topsoil added with the sod was thought to be contributing to this superiority. Straw mulch was superior to wood cellulose in plots which were seeded. One thousand lbs/acre of 10-20-10 fertilizer was better than 500 lbs/acre in producing acceptable cover regardless of the method of establishment.

11. Experiment 4-1-66. Adaptation of different seeding mixtures.

INTRODUCTION: Mixtures of species may sometimes be desirable in establishing vegetation cover on highway rights-of-way. Rapidly germinating species might provide cover until slower germinating species could become established. The inclusion of legumes in mixtures with grasses would also provide nitrogen for growth of the grasses.

OBJECTIVE: The objective of this experiment was to compare various seeding mixtures for erosion control.

MATERIALS AND METHODS: A slope on State Highway 288 approximately 10 miles south of Ozark was selected for this study. Four mixtures of perennial species were seeded in April 1966 on plots 50 x 10 feet. The area was disked and 700 lbs/acre of 10-20-10 fertilizer was worked into the top few inches of soil. The various species mixtures were broadcast on the plots by hand and covered with straw mulch at the rate of 2 tons/acre tied down with emulsifiable asphalt. Each treatment was replicated 3 times.

The species mixtures and rates per acre were as follows:

1. Blue grammagrass 12 lbs/acre, black grammagrass 12 lbs/acre, buffalograss 9 lbs/acre, and intermediate lespedeza 10 lbs/acre.
2. Prostrate dallisgrass 11 lbs/acre, weeping lovegrass 15 lbs/acre, and common lespedeza 10 lbs/acre.
3. Crown vetch 15 lbs/acre, green sprangletop 15 lbs/acre, and weeping lovegrass 15 lbs/acre.
4. Green sprangletop 15 lbs/acre, bahiagrass 15 lbs/acre and annual lespedeza 10 lbs/acre.

Visual ratings of the plots were made in 1966, 1967 and 1968.

RESULTS AND DISCUSSION: Satisfactory ground cover was obtained on all plots by the end of the first growing season. Annual weeds and grasses accounted for a large portion of the ground cover in many of the plots. Although very little difference was found the first year in total ground cover, the largest part of the cover in each mixture was provided by only 1 or 2 species (Table 26).

TABLE 26. Percent total ground cover, percent of each species and percent weeds for 4 different species mixtures. (Average of 3 replications)

Mixture No.	Species		% Ground Cover
1	Blue grammagrass		8.3
	Black grammagrass		8.3
	Buffalograss		5.0
	Intermediate lespedeza		35.0
		Weeds	33.0
		Total	89.6
2	Prostrate dallisgrass		6.6
	Weeping lovegrass		65.0
	Common lespedeza		3.3
		Weeds	23.6
		Total	98.5
3	Crown vetch		0.0
	Green sprangletop		26.6
	Weeping lovegrass		65.0
		Weeds	3.0
		Total	94.6
4	Green sprangletop		65.0
	Bahia grass		10.0
	Common lespedeza		0.0
		Weeds	18.3
		Total	93.3

The experiment was observed again in 1967 and 1968. The most important changes in these years was that intermediate lespedeza had increased in mixture 1 until it was providing approximately 100% ground cover.

CONCLUSIONS: There was no advantage in the mixtures of species used in this experiment. By the end of the first growing season one or two species in each mixture was providing most of the ground cover. Best species in this experiment were weeping lovegrass, intermediate lespedeza and green sprangletop.

12. Experiment 1-1-66. Establishment of various grasses on an erosion prone soil.

INTRODUCTION: Soils with a high silt content exist in Arkansas District 1 near Wynne. These soils are subject to severe erosion and are difficult to establish to good vegetative cover. Species which germinate rapidly and have good seedling vigor would be advantageous on these slopes.

OBJECTIVE: The objective of this experiment was to compare the establishment and erosion control of three adapted species on these highly erodable soils.

MATERIALS AND METHODS: This experiment was located on Highway 284 approximately 2 miles east of Wynne. Lime at the rate of two tons per acre and 750 lbs of 10-20-10 fertilizer were disked into the plots at time of seedbed preparation. The plots were seeded with a hydroseeder in April 1966. One thousand lbs/acre Turfiber mulch was applied in slurry with the seed. Species seeded were weeping lovegrass, Pensacola bahiagrass and common bermudagrass. Each species plot was approximately 1000 feet long and the width of the slope.

RESULTS AND DISCUSSION: Bahiagrass did not provide sufficient cover to prevent serious erosion. Common bermudagrass provided adequate coverage upon germination, however, by the end of the growing season plots of common bermuda were seriously eroded. Weeping lovegrass was very effective in providing cover and preventing erosion on this soil. A dense stand of weeping lovegrass was obtained and very little erosion had occurred by the end of 1968.

CONCLUSIONS: Weeping lovegrass was the only species seeded in this test which effectively provided vegetative cover and prevented serious erosion. The rapid germination and strong seedling vigor of this species is very desirable on soils which are subject to serious erosion.

13. Experiment 9-1-66. Vegetative planting of crown vetch.

INTRODUCTION: Failure to establish crown vetch from seed in other experiments has resulted in interest in establishing crown vegetatively.

OBJECTIVE: The objective of this experiment was to determine if crown vetch could be established under Arkansas conditions using vegetative plant material.

MATERIALS AND METHODS: This experiment was established on a steep slope of exposed subsoil on Highway 71 approximately 2 miles south of Greenland. Soil test analysis showed the soil to be low in pH, P, K and Ca. Two tons of agricultural limestone/acre and 800 lbs/acre 10-20-10 fertilizer was applied and disked into the soil. Crowns of crown vetch were obtained from a planting on the Agronomy Farm, Main Experiment Station, Fayetteville, Arkansas. Crowns were planted on 1 foot centers and firmed into the soil by hand. Planting was accomplished in April 1966.

RESULTS AND DISCUSSION: By fall 1966 no living crown vetch plants were visable. The plots were checked again in 1967 and it appeared that only a very few plants had survived. The failure of crown vetch to survive in this experiment further points out its weakness as a vegetative cover species in Arkansas.

CONCLUSIONS: Crown vetch planted vegetatively on soil limed and fertilized properly failed to survive. This species is thought to be unadapted to Arkansas climate and soils.

14. Experiment 6-1-66. Establishment of 3 species of grass and crown vetch using two different types of mulch.

INTRODUCTION: There is a soil along I-30 west of Lonoke which has a history of severe erosion on highway slopes. This soil is high in silt content and erodes quite easily. Mulches have been proven effective in controlling erosion. Certain species germinate and become established more rapidly than others making them more desirable on soils which are prone to rapid erosion.

OBJECTIVE: The objective of this experiment was to compare two different mulching practices in the establishment of four plant species.

MATERIALS AND METHODS: This experiment was located on a slope on I-30 approximately 6 miles west of Lonoke. Bahiagrass, bermudagrass, weeping lovegrass and crown vetch were seeded at recommended rates with a hydroseeder. Eight hundred lbs/acre 10-20-10 fertilizer was applied with the seed. Straw mulch at 2 tons/acre and Turfiber at 1000 lbs/acre were the two mulch materials used. Turfiber was applied with the seed and fertilizer in those treatments receiving Turfiber. Straw was applied by hand and tied down with emulsifiable asphalt.

RESULTS AND DISCUSSION: No crown vetch was visable in any of the plots in the fall of 1966. Later observations in 1967 and 1968 showed that only a very few crown vetch plants became established. Weeping lovegrass provided excellent cover from 1966 through 1968. Plots seeded to weeping lovegrass rated practically 100% ground cover with very little erosion. Common bermuda established fair stands in the plots mulched with straw. Common bermudagrass did not prevent serious erosion in plots mulched with Turfiber. Bahiagrass did not establish satisfactory stands in either of the mulch treatments. Serious erosion had occurred by the end of the first growing season on bahiagrass plots.

CONCLUSIONS: Weeping lovegrass provided excellent cover and erosion control with both types of mulch. Common bermuda provided acceptable cover and erosion control on plots mulched with straw but not with Turfiber. Crown vetch and bahiagrass did not establish cover or prevent erosion with either type of mulch.

15. Demonstration Experiments 6-1-69, 6-3-69 and 6-4-69.

INTRODUCTION: In a meeting between personnel of the Bureau of Public Roads, the Arkansas State Highway Department and this project in July of 1968 it was agreed that demonstration plots be established in Arkansas Highway District 6 in which methods of vegetation management be evaluated. These plots would be an attempt to demonstrate the value of practices which had proven to be beneficial in experiments conducted previously during this project.

Sites for the demonstration plots were chosen after consulting with the District Engineer for District 6. These sites represented areas in which difficulty had been encountered in establishing and/or maintaining adequate vegetative cover due to extremely steep slopes or adverse soil conditions.

This report covers the progress up to termination of this project. Personnel of the Arkansas State Highway Department, Division of Research and Planning, have agreed to continue evaluation of these plots and publish results of the second growing season as an addition to this report. It was thought that more meaningful recommendations could be obtained by observing these plots through the second growing season.

Experiment 1-6-69. Levy, interchange, I-40.

OBJECTIVE: The objective of this experiment was to evaluate the cost and desirability of controlling vegetation by chemical methods on slopes which are difficult to mow conventionally. It is thought that if unsightly weeds were controlled with selective herbicides, the need for mowing would be eliminated.

MATERIALS AND METHODS: This experiment is located on the south slope of the access ramp from Levy, Arkansas, to I-30. The slope is approximately 3 acres in total area. The steepness of this slope prevents the use of conventional mowing for vegetation control.

Half of the slope was treated with selective herbicides, as needed, to control weeds while the other half was left untreated. The first herbicide application was made on May 15, 1969. This was an application of 2,4-D at the rate of 2 lbs/acre active material for the control of broadleaf weeds. Spot treatments of DSMA for Johnsongrass control were made on July 25 and August 4, 1969. 2,4-D was again applied for broadleaf weed control on March 26, 1970. No Johnsongrass had emerged at the time this report was written, however, if applications of DSMA are made they will be reported later.

RESULTS AND DISCUSSION: Heavy infestations of broadleaf weeds were present in 1969 when the first application of 2,4-D was made. 2,4-D at 2 lbs/acre resulted in excellent control of most of the species in these plots.

Spot spraying with DSMA resulted in good control of the scattered Johnsongrass present in the plots in 1969. After the second spraying it was estimated that 75% of the Johnsongrass was controlled.

Appearance of the sprayed plots was much improved over the unsprayed ones in 1969. A good stand of common bermudagrass was present on these plots. Unsightly weeds were quite prevalent on the unsprayed plot.

Cost of the materials and labor used for weed control, computed on a per acre basis in 1969, were as follows:

1. 2,4-D at 2 lbs/acre active material - $2.00/acre
2. 1 lbs/acre DSMA as two spot sprays - $1.00/acre
3. 4½ man hours for applying herbicides - $6.75/acre
4. Total cost $9.75 per acre

Although the Arkansas State Highway Department did not hand mow this slope during the 1969 season, it is estimated that hand mowing would be much more expensive than chemical weed control and probably would have resulted in poorer appearance since weeds could regrow from mowing.

Itemized costs and results of applications of chemicals for 1970 will be reported by personnel of the Arkansas State Highway Department, Division of Research and Planning at the end of the growing season.

Experiment 6-3-69.

OBJECTIVE: The objectives of this experiment were to compare the response of three different grasses to different nitrogen fertility levels and different mowing treatments.

MATERIALS AND METHODS: This experiment was established on Highway 65 south at the Saline County line. The area has a history of difficulty in establishing and maintaining satisfactory vegetation. Soil test data showed a pH of 4.8, available P, 12 lbs/acre and water soluble K, 25 lbs/acre.

Three grasses, common bermuda, weeping lovegrass and Pensacola bahiagrass were seeded on June 16, 1969. Each species plot was 300 feet long and 40 feet wide. There were two replications. Total area in the experiment was approximately 1.7 acres. Eight hundred lbs/acre of 10-20-10 fertilizer and 4 tons of dicalcium silicate per acre were disked in at time of seedbed preparation.

Nitrogen fertilizer plots were imposed on each species plot. Three levels of nitrogen fertilizer were applied; 0, 40 and 80 lbs/acre. The 40 and 80 lbs/acre rates were made in two equal applications of 20 and 40 lbs each on July 24 and August 21, 1969. In 1970 it is planned that 0, 60 and 120 lbs/acre N be applied on these plots. Applications of 0, 20 and 40 lbs/acre were made on March 26 and April 20, 1970, for a total of 0, 40 and 80 lbs. One-half of each nitrogen plot was mowed as needed to control vegetation while the other half was unmowed and treated with selective herbicides to control weeds. One application of 2,4-D was made in 1969 and one mowing was all that was necessary, since growth was limited due to a severe drought. 2,4-D was again applied in 1970 on

March 25. Mowing will be started when sufficient growth is obtained.

RESULTS AND DISCUSSION: Although a drought delayed growth of grasses on these plots, common bermudagrass and weeping lovegrass had provided good stands by the end of the growing season. Pensacola bahiagrass did not become established on these plots.

The one mowing which was accomplished in 1969 did not affect growth or ground cover of the grasses. Since growth was limited by low soil moisture, very little growth above the 4 inch mowing height was present.

Nitrogen fertilizer at 40 and 80 lbs/acre increased ground cover of both weeping lovegrass and bermudagrass. There appeared to be no increase in ground cover when 80 lbs/acre was applied in comparison to the 40 lbs/acre treatment.

Broadleaf weeds were not a serious problem on these plots, therefore very little difference between the herbicide plots and those mowed could be observed in regard to weed infestation.

Cost of materials and labor for each of the different treatments in 1969 were computed on a per acre basis. The following is an itemized list of costs for treatments imposed after establishment.

1. Chemical weed control

a. 2 lbs/acre, 2,4-D @ $1.00 lb	= $2.00
b. Labor for applying 2,4-D, 1½ hrs @ $1.50 hr	= 2.25
Total cost of chemical weed control	= $4.25

2. Cost of mowing

a. 1½ man hours/acre @ $1.50 hr	= $2.25
b. 1½ tractor hours/acre @ $1.50 hr	= 2.25
Total cost of mowing	= $4.50

3. Nitrogen fertilization

a. 40 lbs N/acre at 10¢ lb	= $4.00
b. 2 hours labor @ $1.50 hr	= 3.00
Total for 40 lbs N/acre	= $7.00
c. 80 lbs N/acre @ 10¢ lb	= $8.00
d. 2 hrs labor @ $1.50 hr	= 3.00
Total for 80 lbs N/acre	=$11.00

These costs indicate that expenses were the same in 1969 for mowing and chemical weed control. It should be pointed out, however, that growth was limited due to severe drought and fewer mowings than normal were needed. Hand spray equipment and small mowing equipment might also make these figures unrealistic, however the cost of herbicide would remain the same regardless of the method of application and district engineers who are more familiar with conventional mowing costs should be able to determine what the relative merits of the two treatments are.

Cost of materials and results for 1970 will be reported later by personnel of the Arkansas State Highway Department, Division of Planning and Research.

Experiment 6-4-69.

OBJECTIVE: The objective of this experiment was to compare the response of weeping lovegrass and common bermudagrass to different nitrogen fertilizer levels and different methods of vegetation control.

MATERIALS AND METHODS: This experiment was established in an area with a history of difficulty in maintaining successful stands of vegetative cover.

Weeping lovegrass and common bermudagrass were seeded on June 10, 1969. Eight hundred lbs of 10-20-10 fertilizer and 4 tons of dicalcium silicate/acre were disked in at the time of seedbed preparation. Two plots 300 x 40 feet were seeded to each species. One plot of each species was to be mowed to control vegetation and one was left unmowed and weeds were controlled by application of selective herbicides.

As mentioned in the previous experiment, a severe drought shortly after these plots were seeded limited growth and only one mowing was made. One application of 2,4-D at 2 lbs/acre was made in 1969 for weed control. 2,4-D was also applied in 1970 at the same rate on March 25.

Three levels of nitrogen fertilizer were imposed on the species plots. Nitrogen levels in 1969 were 0, 40 and 80 lbs/acre. The 40 and 80 lbs/acre treatments being split into two applications of 20 and 40 lbs/acre. In 1970 nitrogen is to be applied at rates of 0, 60 and 120 lbs. Nitrogen has been applied in 1970 on March 25 and April 20 at the rates of 0, 20 and 40 lbs/acre for a total of 0, 40 and 80 lbs/acre.

RESULTS AND DISCUSSION: Good stands of weeping lovegrass and common bermudagrass were initially obtained on these plots, however, some loss of stand occurred, due to the drought. It was estimated that, over all treatments, ground cover of weeping lovegrass was 60% and that of common bermuda 70%.

Nitrogen fertilization was the only treatments imposed which influenced appearance and ground cover of the grasses in these plots. No increase in appearance and ground cover was noted from 80 lbs N/acre in comparison to 40 lbs/acre although both of these treatments were better than the check.

Costs were computed on a per acre basis for the various materials and labor and are as follows:

1. Cost of chemical weed control

a. 2 lbs/acre 2,4-D @ $1.00 lb	= $2.00
b. Labor 1½ hrs @ $1.50 hr	= 2.25
Total cost of chemical weed control	= $4.25/acre

2. Cost of mowing

a. Labor 1½ hrs @ $1.50 hr	= $2.25
b. 1½ tractor hrs @ $1.50 hr	= 2.25
Total cost of mowing	= $4.50/acre

3. Cost of nitrogen fertilizer

a. 40 lbs N/acre @ 10¢ lb	= $4.00
b. Labor 2 hrs @ $1.50 hr	= 3.00
Total for 40 lbs N/acre	= $7.00/acre
c. 80 lbs N/acre @ 10¢ lb	= $8.00
d. Labor 2 hrs @ $1.50 hr	= 3.00
Total for 80 lbs N/acre	=$11.00/acre

These costs again indicate that mowing once was equal to chemical weed control in cost.

Costs of nitrogen fertilizers indicate that 80 lbs/acre N is much more expensive than 40 lbs/acre and was probably not justified in plant response.

Costs of materials and results for 1970 will also be reported for this experiment by personnel of the Arkansas State Highway Department, Division of Research and Planning, at the end of the growing season.

CONCLUSIONS: No conclusions will be drawn from these experiments until results for 1970 are available.

SEEDING GUIDE, WITH VARIETIES, RATES, DATES, AND FERTILITY REQUIREMENTS FOR NORTHERN AND SOUTHERN ARKANSAS

Northern Arkansas*

Species and Variety 1/	Rate	Dates	Fertility #/A. **
Tall Fescue (Ky. 31)	45#/A.	Mar. 1-May 1 or Spet. 1-Oct. 15	800# 10-20-20 ***
Bermuda Speed (Common)	15#/A.	Apr. 15-June 15	800# "
Bermuda Sprigs (Common)	60-75 Bu./A.	Feb. 1-July 15	800# "
Redtop (Common)	20#/A.	Mar. 1-May 1 or Sept. 1-Oct. 15	800# "
Weeping Lovegrass	10#/A.	April 15-June 15	800# "
Ryegrass (Annual	90#/A.	Sept. 1-Oct. 15	800# "
Lespedeza (Sericea)	90#/A.	Mar. 15-May 15	500# 12-12-12
White Clover (Common)	10#/A.	In combination with above grasses if desired.	None if seeded with grasses. 800# 0-20-20 if seeded alone.

* Northern Arkansas - All areas in Districts 5, 8, 9, and 10 and the northern five counties in District 4.

** Obtain soil samples from each major soil area and send to Soil Testing Laboratory, Fayetteville, Arkansas, for pH analysis.

pH 5.0 or below, apply 3 tons lime per acre
pH 5.0 to 5.5, apply 2 tons lime per acre
pH above 5.5 - no lime needed

If no soil test is available, apply 2 tons of lime per acre as a general application.

*** Or equivalent total amount of plant food.

1/ All species should be seeded or sprigged on a well prepared seedbed (disked or broken 3-4 in.) with the establishment fertilizer and lime mixed with the soil.

Southern Arkansas *

Species and Variety 1/	Rate	Dates	Fertility #/A. **
Tall Fescue	45#/A.	Mar. 1-May 1 or Sept. 1-Nov. 1	800# 10-20-10 ***
Bermuda Seed (Common)	15#/A.	Apr. 1-June 1	800# "
Bermuda Springs (Common)	60-75 Bu./A.	Feb. 1-Aug. 1	800# "
Bahia (Pensacolia)	45#/A.	Apr. 1-June 1	800# "
Weeping Lovegrass	10#/A.	Apr. 15-June 15	800# "
Ryegrass (Annual)	90#/A.	Sept. 1-Nov. 1	800# "
Lespedeza (Sericea)	90#/A.	Mar. 15-May 15	500# 12-12-12
White Clover (Common)	10#/A.	In combination with above grasses if desired.	None if seeded with grasses. 800# 0-20-20 if seeded alone.
Crimson Clover (Dixie or Chief)	60#/A.	Sept. 1-Nov. 1	800# 0-20-20

* Southern Arkansas - All areas in Districts 1, 2, 3, 6, and 7 and the southern two counties in District 4.

** Obtain soil samples from each major soil area and send to Soil Testing Laboratory, Fayetteville, Arkansas, for pH analysis.

pH 5.0 or below, apply 3 tons lime per acre
pH 5.0 to 5.5 apply 2 tons lime per acre
pH above 5.5 no lime needed

*** Or equivalent total amount of plant food.

1/ All species should be seeded or sprigged on a well prepared seedbed (disked or broken 3-4 in.) with the establishment fertilizer and lime mixed with the soil.

SECTION III

GREENHOUSE AND LABORATORY EXPERIMENTS CONCERNING CHEMICAL GROWTH REGULATORS AND HERBICIDES

1. Experiment GH-11-63. Effects of MH-30 on growth retardation of grasses.

INTRODUCTION: Maleic Hydrazide (MH-30) is a chemical herbicide which acts as a growth retardant on grasses. When MH-30 is applied to grasses at an immature stage of growth very little subsequent growth occurs. This would be very desirable in controlling growth on hard to mow areas.

OBJECTIVE: The objective of this experiment was to determine a proper rate of MH-30 for growth inhibition of fescue and bermudagrass.

MATERIALS AND METHODS: Four inch plugs of bermuda and fesuce were taken from the field on November 26, 1963. The plugs were placed in 6 inch pots filled with soil. The greenhouse was held at a temperature range of 82-86° F. All plugs were clipped to ground level at the time they were placed into the pots.

Fertilizer (10-20-10) at a rate equivalent to 300 lbs/acre was added to each pot on December 2, 1963. On December 12, 1963, the equivalent of 50 lbs/acre NH_4NO_3 was added to each pot. On December 26 100 lbs/acre of NH_4NO_3 were added.

Fescue plugs were clipped to a height of 2 inches and bermudagrass to 3 inches prior to spraying with MH-30 on December 16, 1963. Rates of MH-30 equivalent to 0, ½ 1, 2, 4, 8, and 16 pounds of active ingredient per acre were applied. One series of pots was re-sprayed on January 23, 1963, while the second series was not re-sprayed. All treatments were replicated 3 times.

Due to variation in growth habit between fescue and bermudagrass a constant clipping date was not employed. Clipping weights were taken at each clipping and analyses of variance were performed on the green weight totals from each clipping date.

RESULTS AND DISCUSSION: MH-30 was quite effective in retarding the growth of fescue. The data in Table 1 show that 4 lbs/acre effectively retards growth for 12 weeks. Throughout the experiment the pots which received 4 lbs/acre MH-30 appeared to suffer no phytotoxicity from application of the growth retardant. Growth of fescue was approximately 8 inches in height compared to 16 inches in pots which received less than 4 lbs/acre MH-30. Fescue in pots which received the equivalent of 8 and 16 lbs/acre MH-30 suffered severe injury. In general, there were no differences in the response of fescue to different numbers of application of MH-30.

Data in Table 2 show the results of MH-30 on bermudagrass. Growth retardation of bermudagrass appeared to be less than that of fescue at comparable rates of MH-30. In general, effective growth retardation did not occur except when 8 or 16 lbs/acre MH-30 was applied. Some leaf necrosis occurred at these rates.

TABLE 1. Effects of various rates of MH-30 on the yield of fescue in the greenhouse after 1 and 2 sprayings.

Pounds MH-30 Per Acre	Average green weight of fescue per clipping date in grams						
	Series I. Sprayed Dec. 16			Series II. Sprayed Dec. 16 and Jan. 23			
	Clipped Feb. 4	Reclipped March 5	Total	Clipped Dec. 30	Reclipped Feb. 4	Reclipped March 5	Total
0	19.4 a*	9.3 a	28.7	4.8 b	12.6 b	5.2 a	22.6
½	17.9 a	8.3 a	26.2	4.7 b	13.9 b	6.1 a	24.7
1	19.4 a	10.3 a	29.7	7.9 a	17.9 a	7.2 a	33.0
2	14.7 a	8.2 ab	22.9	3.8 bc	12.5 b	6.3 a	22.6
4	8.9 b	5.9 bc	14.8	2.9 bcd	3.9 c	0.2 b	7.0
8	2.4 c	5.3 bc	7.7	2.3 cd	0.1 d	0 b	2.4
16	0.9 c	2.0 c	2.9	1.7 d	0 d	0 b	1.7

* Any two means followed by the same letter are not significantly different at the 5% probability level.

TABLE 2. Effects of various rates of MH-30 on the yield of bermudagrass in the greenhouse after 1 and 2 sprayings.

Pounds MH-30 Per Acre	Average green weight of bermudagrass per clipping date in grams							
	Series I. Sprayed Dec. 16				Series II. Sprayed Dec. 16 & Jan. 23			
	Clipped Dec. 30	Reclipped Feb. 4	Reclipped March 5	Total	Clipped Jan. 13	Reclipped Feb. 4	Reclipped March 5	Total
0	5.2 a*	17.1 a	10.7 a	33.0	14.2 ab	7.7 b	9.4 b	31.3
½	4.4 a	12.1 a	10.3 a	26.8	14.2 ab	8.0 b	9.8 b	32.0
1	5.0 a	21.4 a	12.2 a	38.6	16.4 a	12.0 a	14.9a	43.3
2	5.7 a	21.1 a	16.4 a	43.2	16.2 a	9.7 ab	9.0 b	34.9
4	5.0 a	20.1 a	12.5 a	37.6	13.8 ab	8.7 b	8.9 b	31.4
8	2.4 b	13.4 a	12.0 a	27.8	8.4 b	4.0 c	0.3 c	12.7
16	1.2 b	2.1 b	9.7 a	13.0	2.2 c	1.8 c	0 c	4.0

* Any two means followed by the same letter are not significantly different at the 5% probability level.

CONCLUSIONS: Four lbs/acre of MH-30 effectively retarded fescue growth in the greenhouse. Two applications were not necessary for satisfactory retardation. Four lbs/acre MH-30 did not effectively retard growth of bermudagrass. Eight and 16 lbs/acre of MH-30 resulted in effective retardation of bermudagrass, however, damage occurred at these rates.

2. Experiment No. GH-12-65. Effects of various growth retardants on bermudagrass and fescue.

INTRODUCTION: Several chemical compounds have shown growth retarding properties on grasses. Maleic Hydrazide (MH-30) is probably the oldest and most widely known of these compounds. Several new compounds have recently been released which have promise as growth regulating chemicals. More information is needed about the response of various grasses to these compounds.

OBJECTIVE: The objective of this experiment was to determine the effects of various growth regulating chemicals on bermudagrass and fescue in comparison with MH-30.

MATERIALS AND METHODS: Tall fescue and bermudagrass plugs were taken from the field on January 12, 1965. Plugs were placed in soil-filled 6 inch pots in a greenhouse which was held at 80-90^{o} F. Pots were fertilized initially with the equivalent of 300 lbs/acre of 10-20-10 fertilizer. Nitrogen was applied twice thereafter at the rate of 50 lbs/acre of ammonium nitrate. One week prior to spraying with the growth retardants, all pots were clipped to a height of 2 inches.

Growth regulators were sprayed on February 26, 1965. Materials used and their rates are given below:

1. Phosphon (Tributyl 2,4-dichlorobemzyl-phosphonium chloride) at 10, 25 and 40 lbs/acre.

2. Cycocel (2-chloroethyl trimethylammonium chloride) 10, 25 and 40 lbs/acre.

3. Hadacidin (N-hydroxy-N-formyl sodium glycinate) at 0.8, 4.0 and 8.0 lbs/acre.

4. MH-30 at 4 and 6 lbs/acre.

5. Check (no growth regulator).

Each treatment was replicated three times. Visual observations were made periodically and final observations made on April 6, 1965.

RESULTS AND DISCUSSION: Fescue and bermudagrass responded quite differently to the different growth regulators. Severe damage was observed on both grasses at all rates of Phosphon 3 days after application. Damage was still evident at termination of the experiment. In addition, very little growth inhibition on either grass was obtained with this compound.

The grasses responded quite differently to Cycocel and Hadacidin. Three weeks after application of Cycocel, fescue to which 10 and 25 lbs/acre were applied could not be distinguished from the checks. The 40 lbs rate did result in slight growth inhibition, but leaf chlorosis was severe. Cycocel's effect on bermudagrass was quite marked. Plots which received 10 lbs/acre were much thicker than the checks and growth retardation was evident. The 25 lbs/acre produced plants with extremely shortened internodes resulting in a very compact, lushy type growth. Forty lbs/acre of this compound on bermudagrass resulted in severe leaf damage with complete growth retardation. Six weeks after the application of Cycocel to fescue, no apparent growth retardation was evident at any rate of application. Bermudagrass, however, showed some growth in the pots treated with 10 lbs/acre. The 25 and 40 lbs/acre rates resulted in almost complete retardation of vertical growth.

Hadacidin at 4 lbs/acre resulted in effective growth retardation on fescue. Eight lbs/acre caused severe chlorosis on fescue while 0.8 lbs/acre had no effect. Bermudagrass was apparently unaffected by Hadacidin. Eight lbs/acre was damaging to this species but did not effectively retard growth.

MH-30 at 4 and 6 lbs/acre effectively reduced growth of fescue. Six lbs/acre was also effective on bermudagrass.

CONCLUSIONS: Results of this experiment indicate that Phosphon is unsatisfactory as a growth retardant on either bermudagrass or fescue. Cycocel was not satisfactory on fescue, but was very effective on bermudagrass. Hadacidin was ineffective on bermudagrass but was quite satisfactory on fescue. MH-30, as was previously determined, was quite effective on both grasses.

3. Experiment No. GH-11-66. Growth regulators for fescue and bermudagrass.

INTRODUCTION: Previous experiments with Cycocel and Hadacidin indicate their usefulness as growth retardants for bermudagrass and fescue respectively. The range of rates applied in previous experiments, however, were quite wide. It was thought that more precise information on rates was needed. It was also thought that perhaps toxic effects of the growth regulators to different grasses might be overcome by using combinations of the two compounds at reduced rates each.

OBJECTIVE: This experiment was initiated to determine optimum rates of Cycocel, Hadacidin and combinations of the two for growth regulation of fescue and bermudagrass.

MATERIALS AND METHODS: Four inch plugs of fescue and bermudagrass were collected and potted in 6 inch pots in the greenhouse on February 8, 1966. Each pot was fertilized with the equivalent of 500 lbs/acre of 10-20-10 fertilizer. The greenhouse was maintained at 80-90^{o} F. The grasses were clipped at a height of 2 inches 3 days prior to spraying with growth regulators.

Hadacidin alone was applied to fescue at rates of 0, 1, 3, 5, 7, 9, and 11 lbs/acre. Cycocel alone was applied to bermudagrass at rates of 0, 10, 20, 25, 30 and 40 lbs/acre. A mixture of 2.5 lbs/acre Hadacidin and 12.5 lbs Cycocel was applied to both fescue and bermuda. MH-30 was applied to fescue at the rate of 4 lbs/acre and to bermuda at the rate of 6 lbs/acre.

MH-30 treated plots were used as treated checks. All treatments were replicated three times.

RESULTS AND DISCUSSION: Hadacidin at 1 lb/acre resulted in increased growth of fescue when compared with the checks. Five lbs/acre was very effective in inhibiting growth of fescue with no apparent damage. Higher rates were damaging to the grass while lower rates were not satisfactory from the standpoint of growth inhibition.

Growth inhibition of bermudagrass by Cycocel was obtained at rates above 20 lbs/acre. There was no apparent differences between any of the higher rates. Growth inhibition of bermudagrass by Cycocel was not as striking in this experiment as in previous experiments.

The mixture of Cycocel and Hadacidin caused severe leaf necrosis on fescue and no growth inhibition of bermudagrass, therefore it appears that mixtures of these two chemicals are not advisable.

CONCLUSIONS: Five lbs/acre of Hadacidin appears to be the optimum rate for growth inhibition of fescue. Twenty lbs/acre of Cycocel on bermudagrass appears to be optimum. Mixtures of these two compounds for use on either bermuda or fescue are unsatisfactory.

4. Experiment No. GH-12-63. Effects of DSMA and dicryl herbicides on bermudagrass and fescue.

INTRODUCTION: The release of new herbicides (organic arsenicals) for selective control of Johnsongrass in certain other grasses holds great promise. The possibility of combining organic arsenical herbicides with other chemicals for broadleaf control would increase the range of weed control.

OBJECTIVE: The objective of this experiment was to determine the effect of two relatively new herbicides on fescue and bermudagrass. The herbicides were DSMA (Disodium methylarsonate) and dicryl N(3,4-dichlorophenyl) methacrylamide.

MATERIALS AND METHODS: Four inch plugs of fescue and bermudagrass were taken from the field in a dormant condition on December 27, 1963. The plugs were placed in 6 inch pots, packed with soil and placed in the greenhouse which was held at a temperature range of 82-86^{o} F. Fertilizer at rates equivalent to 300 lbs of 10-20-10 plus 100 lbs of ammonium nitrate per acre was applied to each pot. The vegetation in all pots was clipped back to near the soil surface to reduce uneveness of growth. DSMA and dicryl were applied separately and in combination at various rates after the grasses had begun active growth. Rates and combinations are given in Table 3.

TABLE 3. Rates of chemicals used on fescue and bermudagrass in the greenhouse.

Treatment No.	Pounds per acre active ingredient		
	DSMA	Dicryl	DSMA + Dicryl
1	0	0	0 0
2	1	1	1 + .50
3	3	3	2 + .75
4	5	5	3 + 1.00
5	7	7	4 + 1.25

All treatments were replicated three times. Visual estimations of grass damage were made 11 days after spraying. Analyses of variance were performed on visual ratings.

RESULTS AND DISCUSSION: Both species of grass were very resistant to damage from DSMA. Dicryl alone or in combination with DSMA caused damage to fescue. Dicryl alone at heavier rates resulted in damage to bermudagrass. The rates of dicryl used in combination with DSMA did not damage bermudagrass. (Table 4)

TABLE 4. Effect of DMA, Dicryl, and DMA-Dicryl combination on fescue and bermudagrass in the greenhouse.

	Average rating of 3 replications*					
	Fescue			Bermudagrass		
Treatment No.	DMA	Dicryl	Comb.	DMA	Dicryl	Comb.
1	0 a**	0 a	0 a	0 a	0 a	0 a
2	0 a	3.3 b	3.3 ab	0 a	0 a	0 a
3	0 a	5.3 bc	5.3 b	0 a	1.3 a	0 a
4	0 a	5.7 bc	6.3 b	0 a	4.3 b	0 a
5	0 a	8.0 c	5.3 b	0 a	6.7 c	0 a

* 0 means no grass damage; 10 means complete grass kill.
** Any two means followed by the same letter are not significantly different at the 5% probability level.

CONCLUSIONS: DSMA appears to be safe for use on bermudagrass and fescue. Dicryl caused excessive damage of fescue. At lower rates dicryl did not damage bermuda.

5. Experiment No. GH-13-65. Effects of spraying intervals and rates of application of DSMA on control of Johnsongrass.

INTRODUCTION: DSMA has been shown to be an effective herbicide for selectively controlling Johnsongrass in bermudagrass and fescue. Multiple applications have been found to be necessary for good control. More information is needed on the effects of timing of applications and proper rates for optimum Johnsongrass control.

OBJECTIVE: The objective of this experiment was to measure the effect of application rate and timing of DSMA on Johnsongrass control.

MATERIALS AND METHODS: Round 10 inch plastic pots containing a potting mixture (Taloka silt loam soil: sand: vermiculite in a 2:1:1 ratio) were utilized in this experiment. Johnsongrass rhizomes in a dormant condition were placed in the pots and covered with an additional 2 inches of the potting mixture. Three rhizomes, each having four nodes, were placed in each pot. The pots were maintained in the greenhouse at 80-90^{o} F until the plants had reached a height of approximately 12 inches. Nitrogen in the form of NH_4NO_3 was added periodically to facilitate growth.

A 4 x 6 factorial experiment was used with 4 application schedules and 6 rates of DSMA. Each treatment was replicated 3 times. Rates of DSMA were 0, 1, 2, 3, 4, and 5 lbs/acre. All pots received the first spraying on February 25, 1966. The four spray applications (hereafter called treatments) were as follows: 1) four days after the first spraying, 2) eight days after the first spraying, 3) twelve days after the first spraying, and 4) no additional spraying.

Three weeks after the initial spraying all pots were visually rated for herbicide damage to the Johnsongrass. Six weeks after the initial spraying a viable stem count was made and rhizomes were also inspected for viability. The data were subjected to analysis of variance.

RESULTS AND DISCUSSION: Johnsongrass control at all rates of DSMA on both sampling dates was superior to the check. There was little difference between the 2, 3, 4, or 5 lbs/acre rate of DSMA at either sampling date, however, 1 lb/acre was inadequate for control (Table 5).

TABLE 5. Effect of various rates of DSMA on Johnsongrass 7 and 9 weeks after initial application. Data shown are means of three replications.

lbs/acre DSMA	Visual rating* March 18	Stem count/pot April 30
0	0.0 a	9.3 a
1	5.4 b	4.2 b
2	7.9 c	1.5 c
3	7.9 c	1.4 c
4	8.0 c	1.4 c
5	7.8 c	2.2 c

* 0 meaning no effect; 10 meaning complete plant kill. Any two means in individual columns followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range.

Nine weeks after initial application many pots which received the higher rates of DSMA had no Johnsongrass stems present. Further investigation showed complete deterioration of the rhizomes in those pots.

One application of DSMA at any rate was not effective for good Johnsongrass control in this experiment (Table 6). This has generally been shown by other workers.

TABLE 6. Effect of a second application of DSMA on Johnsongrass 4, 8, and 12 days after initial applications of herbicide.

Dates of DSMA application	Visual rating* March 18	Stem count April 30
Feb. 25 only	3.8 a	5.6 a
Feb. 25 plus March 1	7.6 b	2.9 b
" " " " 5	7.0 bc	2.6 b
" " " " 9	6.3 c	2.3 b

* 0 meaning no effect; 10 meaning complete plant kill. Any two means in individual columns followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

The analysis of variance showed no interaction between the various rates and the number of days elapsed between the two applications. Perhaps if longer periods between applications had been used more information on this problem would have been obtained.

CONCLUSIONS: Two applications of DSMA at 2, 3, 4, or 5 lbs/acre resulted in satisfactory Johnsongrass control. One lb/acre was not sufficient for good control. One application of all rates was insufficient for control of Johnsongrass.

6. Experiment L-11-65. Mode of action of DSMA on Johnsongrass.

INTRODUCTION: The selectivity of organic arsenical herbicides have made their use for controlling Johnsongrass in other grass species very attractive. More information is needed on the mode of action of these herbicides in order to better utilize their selective properties.

OBJECTIVE: The objective of this experiment was to develop autoradiograph techniques for studying the movement of radioactive herbicides applied to Johnsongrass and to determine if MSMA is transported from the site of application to Johnsongrass and if so, to what extent.

MATERIALS AND METHODS: Johnsongrass seeds were planted in a sand culture and watered with half strength Hoagland's solution until the seedlings were 11 days old. The seedlings were then transferred to full strength Hoagland's solution in nutrient solution cultures. Seedlings were allowed to grow for approximately two weeks on nutrient solution before the experiment was initiated.

Tagged MAA (Methanearsonic acid) was applied as a spot to the center of the newest fully developed leaf of each Johnsongrass seedling.

The tagged MAA in this experiment was a 0.16 molar solution containing 21.9 mgs methanearsonic acid per ml and having a specific activity of 1.85 microcuries per ml. Ten microliters of this material was applied in each spot on the Johnsongrass leaves.

Three plants were treated initially and 3 days later 2 more plants were treated. The 4 treated plants along with 2 check plants were harvested 6 days after the first 2 plants were treated. Harvesting consisted of removing the plants from the nutrient solutions and rinsing the roots in distilled water. Plants were then freeze dried under vacuum until completely dry. After drying, the plants were moistened to atmospheric conditions to avoid excessive leaf shattering. The six plants were then mounted on separate sheets of white paper and glued down and pressed for 24 hours.

The plants were removed from the press and positioned against a sheet of Kodak Royal Blue Medical x-ray film in the darkroom. The plants along with the x-ray film were then placed in cardboard, lead-backed exposure film holders for 6 days after which they were removed and developed by a commercial photographer.

RESULTS AND DISCUSSION: Film negatives developed from the check plants were completely clear which indicates that the technique was satisfactory and that no natural radiation was being emitted from the check plants. Negatives from plants treated 3 days prior to harvest showed radioactivity only in those portions of the plants above the crowns. Plants treated 6 days prior to harvest showed radioactivity in both the roots and the above-crown portions. In all plants the degree of radioactivity decreased basipetal (inward and down) from the spot of application. There was always increased radioactivity acropetal (upward and out) from the spot of application of the tagged MAA. This indicates that movement of MAA is more pronounced in the xylum tissue of the plant as compared to the phylum. Some movement in the phylum did occur, however, as evidenced by the radioactivity in the lower portions of the plants.

CONCLUSIONS: From the negatives obtained in this experiment it is clear that MAA is translocated in the plant. Movement was shown to be both acropetal and basipetal although acropetal movement was greater.

7. Experiment L-12-65. Rate of movement of MAA in treated plants.

INTRODUCTION: Results of the previous experiment prompted the initiation of a time series experiment with tagged MAA to determine the movement of MAA in the plant in relation to time.

MATERIALS AND METHODS: Essentially the same procedures were used in this experiment as in Experiment L-11-65. The only differences being that tagged

MAA was applied at 72, 48, 24, 8, 4, 2, and 1 hours before harvesting plants and exposed time of the x-ray film was increased to 21 days due to the possibility that minute quantities of radiation would be present in the shorter time period treatments.

RESULTS AND DISCUSSION: All plants except the check produced images on the developed x-ray film indicating radioactivity in all treated plants. The 48 and 72 hour treated plants produced prominent images of the entire plant indicating movement of MAA throughout the plant by 48 hours after application. There were no observable differences between any of the 1 through 24 hour treated plants with respect to movement of the tagged material basipetal from the point of application. Acropetal to the site of treatment, however, there was increasing evidence of movement of the tagged material with increasing treatment time.

CONCLUSIONS: On the basis of this experiment it appears that MAA begins to move very rapidly within the plant when introduced. Movement appears to be acropetal from the point of application at first but by 48 hours movement has occurred throughout the plant.

8. Experiment L-11-66. Movement of MAA into Johnsongrass.

INTRODUCTION: Results of experiments previously reported show that MAA movement into Johnsongrass seedlings is fairly rapid. These experiments were conducted with seedling plants, however, and differences might exist between movement of MAA into rhizome propagated Johnsongrass.

OBJECTIVE: The purpose of this experiment was to determine how rapidly and to what extent MAA moves into rhizome Johnsongrass.

MATERIALS AND METHODS: Rhizome segments, each consisting of 3 nodes, were planted in sand culture in the greenhouse. Eight days later they were transplanted into nutrient solution cultures on Hoagland's solution. When the Johnsongrass plants reached a height of approximately 6 inches they were treated with radioactive MAA. The MAA was applied to a spot at the center of the 2 newest fully developed leaves of each plant at the rate of 10 microliters per leaf. The radioactive MAA was a 0.16 molar solution which contained 21.9 mgs of methanarsonic acid/ml and had a specific activity of 1.85 microcuries/ml.

The first plant was treated 168 hours before harvest, subsequent treatments were made at 144, 120, 96, 72, 48, 24 and 8 hours prior to harvest. Harvesting consisted of removing the plants from the nutrient culture and rinsing the rhizomes and roots in distilled water. The plants were then freeze dried, mounted on white paper, pressed and exposed to Kodak Royal Blue Medical x-ray film for 21 days. The x-ray film was developed by a commercial photographer. Measured amounts of the nutrient solutions which each plant was growing in was removed from the nutrient culture jars and surveyed for radioactivity with a Nuclear Chicago Liquid Scintillation counter.

RESULTS AND DISCUSSION: Visual observation of the developed x-ray film indicated little difference between the movement of radioactive MAA in rhizome Johnsongrass and seedling Johnsongrass as reported in previous experiments. Plants treated 8 and 24 hours before harvest showed movement of tagged MAA only in above-crown portions of the plant. Plants treated 48 hours and longer before harvest showed evidence of movement throughout the plant. In addition, the degree of film exposure generally increased with length of time between treatment and harvest as would be expected.

The liquid scintillation counter was used to measure the amount of radioactivity in the nutrient solution jars in which the individual plants were grown. The results presented in Table 7 generally support the visual observations obtained from the audioradiographs. One exception to this was the fact that the nutrient solution from the 72 hour treatment contained more radioactivity than any others, also the 92 hour treatment contained less radioactivity than would be expected. This difference may be due to individual plant differences in rate of MAA transport or to other factors not known.

TABLE 7. Average counts per minute of radioactive MAA per ml of nutrient solution in which Johnsongrass plants were grown.

Hours from treatment to harvest	Counts per minute per ml
Check	0
8	0
24	3.2
48	2.4
72	187.4
96	2.2
120	23.6
144	93.6
168	159.6

CONCLUSIONS: Although translocation of MAA apparently occurs soon after a foliar treatment, results from this experiment indicate that a time interval of 24 hours or more may elapse before the herbicide reaches the crown of the plant. Translocation into the roots appears to occur about 48 hours after treatment.

9. Experiment L-12-66. Movement of MAA from roots to tops of Johnsongrass.

INTRODUCTION: Previous experiments have shown that MAA is translocated throughout the Johnsongrass plant when applied to the foliage. The fate of MAA from the roots of Johnsongrass is not known.

OBJECTIVE: The objective of this experiment was to determine if MAA could be taken up by the roots of Johnsongrass and transported throughout the plant.

MATERIALS AND METHODS: Johnsongrass seed was planted in sand culture and watered with half strength Hoagland's solution. When the seedlings were 7 days old they were removed from the sand culture, and transferred to 120 ml jars (one seedling per jar) containing half strength Hoagland's solution and allowed to grow for 10 days. At the end of 10 days the treatment of plants with radioactive MAA was begun. To one liter of half strength nutrient solution was added 1 ml of radioactive MAA (1.85 mc/ml). At various intervals of time 100 ml of this solution was added to each jar containing a Johnsongrass seedling. The time intervals were 168, 144, 120, 96, 72, 48, 24, 8, 4 and 2 hours before harvest. Plants were removed from the nutrient solutions and the roots were thoroughly washed in distilled water. The plants were then freeze dried, mounted on white paper, pressed, and exposed to Kodak Royal Blue Medical x-ray film for 21 days. The film was then developed by a commercial photographer.

The remaining nutrient solution in each jar was measured. Two samples were taken from each jar and surveyed for radioactivity with the liquid scintillation counter. The counts per minute obtained from each sample were used to calculate the quantitive estimate of the total radioactivity taken up by each plant. Statistical analysis of the data was performed to determine differences between treatment times.

RESULTS AND DISCUSSION: Exposed x-ray film clearly showed that MAA was taken up by the roots of the Johnsongrass seedlings and transported to other plant parts. Plants treated 1 hour before harvest showed a faint image of the roots. As the time interval between treatment and harvest increased the intensity of the root images on the film increased until the maximum intensity was evident at the 96 hour treatment interval.

Some movement of MAA from the roots into the lower portions of the stem was evident in plants treated 2 hours before harvest. The image was very faint however. The degree of movement into the upper portions of the plant increased with increasing time interval between treatment and harvest. The 72 hour plant was the first to produce an image of the entire plant. Image intensity of plants increased as time interval increased up to 120 hours.

During the experiment, there appeared to be no adverse effects from the herbicide, however, roots from plants treated for periods greater than 48 hours prior to harvest appeared darker.

An attempt was made to correlate the radioactivity in the nutrient solution remaining with the intensity of plant images on x-ray film. Counts per minute from samples taken from individual nutrient solution jars are presented in Table 8.

TABLE 8. Effect of plant growth time on the amount of radioactive herbicide remaining in each jar and the calculated quantity taken up by each plant. Data are average of 2 samples.

Treatment time	Radioactivity remaining counts/minute	Calculated radioactivity taken up by plant counts/minute
nutrient solution*	392,405 a**	-------
1 hour	342,591 b	49,814
2 hours	285,510 cd	106,895
4 hours	274.474 de	117,931
8 hours	273,104 de	119,301
24 hours	283,038 cd	109,367
48 hours	275,494 cde	116,911
72 hours	242,068 ef	150,337
96 hours	174,632 g	217,773
120 hours	215,462 f	176,943
144 hours	261,544 de	130,861
168 hours	309,274 bc	83,131

* Nutrient solution was counted before it was added to jars. One hundred mils contained 392,405 counts per minute of radioactivity.
** Any two means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

These results indicate that plants exposed to radioactive MAA in nutrient solutions took up a significant amount through the roots in as short as 1 hour. Plants grown for 96 hours had taken up the maximum amount of radioactive MAA after which uptake decreased. This perhaps could be due to herbicidal effects after 96 hours.

CONCLUSIONS: Evidence from audioradiographs and liquid scintillation counts indicate that MAA is taken up by Johnsongrass roots very soon after exposure and transported throughout the plant. Maximum movement of MAA was shown to occur approximately 96 hours after exposure to the material.

10. Experiment No. L-11-67. Adsorption and translocation of MAA in Johnsongrass.

INTRODUCTION: Audioradiography experiments previously reported have shown that

MAA is absorbed quite quickly by Johnsongrass and translocated throughout the plant. The concentration of MAA used in previous experiments was quite low. It was thought that at higher concentrations of MAA, translocation might be different due to herbicidal activity.

OBJECTIVE: The objective of this experiment was to determine the effects of an increase in concentration on translocation of MAA in Johnsongrass which was observed in experiments reported earlier.

MATERIALS AND METHODS: Johnsongrass seedlings were germinated in sand culture and transferred to 120 ml nutrient solution jars containing half strength Hoagland's solution after 7 days growth. After 10 days growth plants were placed in half-strength Hoagland's solution containing a 3.3×10^{-4} concentration of radioactive MAA (1.85 mc/ml). The concentration of MAA in the nutrient solution was approximately double that reported in the previous experiment. Plants were harvested 1, 2, 4, 8, 24, 48, 72, 96, 120, 144 and 168 hours after treatment, freeze dried, pressed and exposed to x-ray film for 21 days. Plants in nutrient solutions containing radioactive MAA for longer than 24 hours became wilted and were removed and placed in untreated nutrient solution. Therefore 24 hours was the longest exposure to MAA.

RESULTS AND DISCUSSION: Since extreme wilting was observed at the end of exposure of plants to MAA at a concentration of 3.3×10^{-4} the plants were placed in untreated nutrient solution. Development of the x-ray film showed that MAA concentration increased up to the time that the plants were taken out of the treated solutions. MAA uptake occurred sooner and at a greater rate when compared to previous experiments where lower concentrations were used. In this experiment MAA movement into the lower portions of the stem was observed in the plant harvested two hours after treatment. Movement throughout the entire plant was evident in the plant harvested 24 hours after treatment. In the previous experiment in which a lower concentration of MAA was used, MAA was not observed to move throughout the plant until after 72 hours. Wilting symptoms appeared to be related to movement of MAA through the entire plant.

CONCLUSIONS: Adsorption and translocation of MAA appeared to be increased at the higher concentration of MAA in the nutrient solution. Plants were wilted 24 hours after exposure to MAA at this concentration. Audioradiographs showed that MAA had been translocated throughout the plant by exposure to nutrient solutions containing radioactive MAA at this concentration for 24 hours.

11. Experiment L-12-67. Adsorption and translocation of MAA.

INTRODUCTION: Results of the previous experiment indicated that an increase in concentration of MAA in nutrient solution resulted in increased rate of uptake and translocation of MAA through the root system to other plant parts. This experiment was conducted to determine if increased rates of translocation result when MAA is applied to the foliage at a higher concentration.

OBJECTIVE: The objective of this experiment was to determine the effect of an increase in concentration of MAA on adsorption and translocation when applied to the foliage of Johnsongrass.

MATERIALS AND METHODS: Johnsongrass rhizome segments, each consisting of 4 nodes, were planted in sand culture, allowed to initiate growth and then transferred to nutrient solutions. When the plants had reached a height of 6-8 inches, radioactive MAA (specific activity 1.95 mc/ml; 0.16 molar MAA) was applied as a spot to the two newest formed, fully developed, leaves of each plant at the rate of 20 microliters per leaf. This was twice the volume applied to the foliage in previously reported experiments. All plants were treated on the same day and harvested 8, 24, 48, 72, 96, 120, 144 and 168 hours after treatment. Plants were freeze dried, mounted, pressed and exposed to x-ray film as previously reported. Samples from the nutrient solutions from each plant were counted in the liquid scintillation counter.

RESULTS AND DISCUSSION: Visual observations of the audioradiographs indicate that basipetal as well as acropetal movement of MAA was much more rapid in this experiment as in previous experiments where one-half as much MAA was applied. MAA was observed to have moved into the roots within 8 hours after treatment of the leaves. Since 8 hours was the shortest treatment time in this experiment it is not known at what time MAA actually moved into the roots. An image of the entire plant on x-ray film was observed in plants treated for 24 hours before harvest. Plant image intensity, in general, increased with increasing time interval between treatment and harvest. It was clear from the images of earlier treated plants that movement acropetally occurs, first, followed quickly by basipetal movement.

CONCLUSIONS: The results of this experiment indicate that increased concentration of MAA results in more rapid uptake and translocation of MAA applied to the foliage of Johnsongrass.

12. Separation and identification of plant metabolites of MAA from treated plants.

INTRODUCTION: Since its introduction in 1941, paper chromatography has been used extensively to detect a great many different kinds of organic compounds such as sugars, amino acids, and organic acids. The technique has been developed since its inception to include various other types of chromatography such as column, ion exchange, and thin layer chromatography. Thin layer chromatography was selected as a technique for studying the mode of action of organic arsenicals on Johnsongrass in the studies reported below. Work reported below is not just one experiment but consists of a compilation of the techniques used and the results of separating and identifying MAA metabolites in treated Johnsongrass.

OBJECTIVE: The objectives of the work reported here were to separate and attempt to identify metabolites of radioactive MAA after application to plants.

MATERIALS AND METHODS: Johnsongrass plants were grown from one-node rhizome segments in 4-inch plastic pots in the greenhouse. Two leaves of each plant were spot treated with varying amounts of radioactive MAA (0.08 molar MAA, having a specific activity of 0.98 microcuries per ml). Plants were harvested at intervals of time from one to seven days after treatment. Cotton plants were also treated with radioactive MAA both on the leaves and on the stems. These plants were harvested three days after treatment. Harvesting of Johnsongrass consisted of obtaining samples from the point of application, acropetal to the point of application, and basipetal to the point of application. Samples from the cotton plants were obtained from the point of application and acropetal to the point of application. Additional Johnsongrass plants were dipped in a solution of non-radioactive MAA equivalent to 0.5 pounds per acre. These plants were harvested three days after treatment and bulked as a single sample. All plant samples were dried, ground in a Wiley mill to pass a 40 mesh screen, and then extracted by boiling in methanol for 5 minutes. The methanol was poured off and the extraction was repeated twice more with fresh methanol. Each sample was filtered through #1 Whatman filter paper. An aliquot of each sample was counted in the Liquid Scintillation Counter to determine if radioactivity had been recovered and at what concentration. If no radioactivity or only a small amount was present in a sample, the sample was not used in further experimentation.

Thin-layer chromatogram plates were used in these experiments. The thin-layer plates were prepared using either Avicel micro-crystalline cellulose or Celite mixed with anhydrous calcium sulfate which was then spread at a thickness of 250 microns and allowed to dry. Varying amounts of plant extract were then either spotted or streaked on the thin-layer plates. After spotting, the cellulose plates were developed in a solvent system consisting of ethanol: pyridine:water in a 1:1:1 ratio while the Celite-anhydrous calcium sulfate plates were developed in a solvent system consisting of ethyl acetate:ios-propanol:water in varying ratios. Ascending chromatography was used in all cases and development was allowed to proceed until the solvent front had moved approximately 7 inches on the 8 inch plate. After development the plates were either treated to determine presence of arsenic by spraying with potassium iodide which reacts to form a brown spot on cellulose material or treated with anisaldehyde which reacts with sugars to form blue spots on Celite-anhydrous calcium sulfate plates.

A different technique was employed to separate sugar compounds from amino acid and/or protein compounds in the plant extract. The plant extract was added to a glass column packed with Dowex 50 x 4 resin which was in the hydrogen active form. Initially the column was eluted with 15 mls of distilled water which would carry sugar and organic acid compounds through the column while the resin would adsorb and hold amino acid and protein molecules due to their chemical charge. The column was then eluted with 40 mls of 2N ammonium hydroxide which would carry the amino acid and protein fraction through the column as the second fraction. Each fraction was dried with the aid of vacuum evaporation. The residue was taken up in ethanol and concentrated to a specific volume. An aliquot of each sample was counted in the Liquid Scintillation Counter to determine which fraction contained radioactivity and at what concentration. Extracts from the Johnsongrass plants that were dipped in non-radioactive MAA were fractioned the same way as the radioactive extracts.

It was determined that the second fraction (ammonium hydroxide fraction) was radioactive to some extent. As a result of this the second fraction from the non-radioactive Johnsongrass sample was used for spotting thin-layer plates for the purpose of determining where the arsenic was located with respect to the amino acid fraction. Amino acids were located on the plates when sprayed with ninhydrin which reacts to form blue spots. Before spraying, the plates were developed in two different solvent systems, which is termed "two-dimensional chromatography". Pictures were taken of the amino acid plates. The radioactive fractions were not used for amino acid determinations due to the fact that the level of radioactivity was so low that the spots could not be found on the plates and also the arsenic level was not high enough to be found on the plates.

<u>RESULTS AND DISCUSSION:</u> Initial experiments were aimed at determining if an MAA plant metabolite complex did form after treatment, and if it did, what group of plant compounds did the metabolite resemble. Cellulose plates were streaked with extracts from the three Johnsongrass samples. A standard radioactive MAA sample was included on each plate. Figure 1 shows a typical autoradiograph of a cellulose thin-layer chromatogram. Note that the MAA standard has moved further up the plate than any of the three Johnsongrass

extracts. This clearly indicates that MAA, after entering the plant, is complexed with some component within the plant. One would suspect that this component could very well be a sugar type compound. Exhaustive testing using both cellulose and celite thin-layer plates has failed to confirm this hypothesis, however.

A cellulose plate similar to the one in Figure 1 but spotted with extract from cotton was then developed and sprayed with ninhydrin. The sprayed plate and its autoradiograph is presented in Figure 2. As can be seen, the exposed area on the film corresponds exactly with the ninhydrin reactive area on the plate which suggests that the MAA-plant metabolite complex may be an amine containing compound.

On the basis of this information numerous cellulose plates were spotted with the ammonium hydroxide fraction from the non-radioactive MAA treated Johnsongrass. The fraction, therefore, represented the amino acid or protein portion of the sample. The plates were subjected to two-dimensional chromatography in two different solvent systems. In Figure 3, non-radioactive MAA standard is compared with a plate which was treated with the protein fraction. Both plates were sprayed with KI, an arsenic location reagent. The small black "O" in the lower left hand corner of each plate represents the origin of the sample. Plate #1 on the left shows that the MAA standard (see arrow) moved to an Rf value of 0.79 in the first solvent run with no movement occurring towards the right in the second solvent run. Plate #2 on the right (spotted with plant extract) shows that the arsenic (see arrow) in the plant sample moved to an Rf value of 0.25 in the first solvent run, and to an Rf value of 0.13 towards the right in the second solvent run. This points to the fact that the MAA in the amino acid fraction may be tied up or complexed with a plant component in the amino acid fraction.

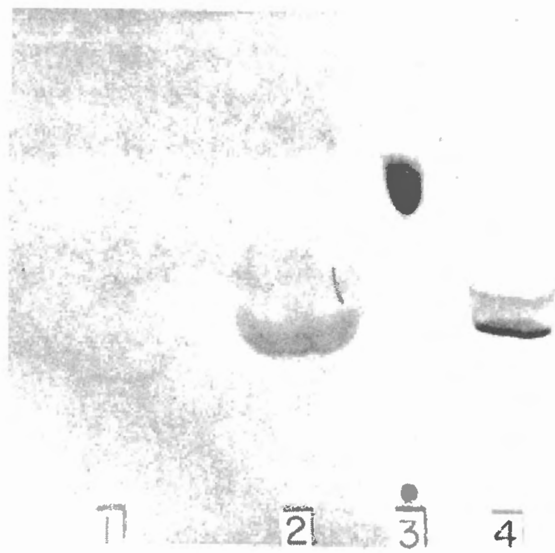


Figure 1. Autoradiograph of extracts from Johnsongrass treated with radioactive MAA and spotted on a cellulose thin-layer chromatogram plate. (1) Basipetal to point of application (2) Acropetal to point of application (3) Standard radioactive MAA (4) Point of application. MAA standard moved further up the plate than the extracts, indicating that MAA becomes complexed with some plant component after absorption by Johnsongrass.

Figure 2. Autoradiograph (on left) of extracts from cotton treated with radioactive MAA, and spotted on a cellulose thin-layer chromatograph plate (on right). The ninhydrin positive streaks (see arrows) correspond with the exposed area on the film indicating a possible amine containing MAA-plant metabolity complex.

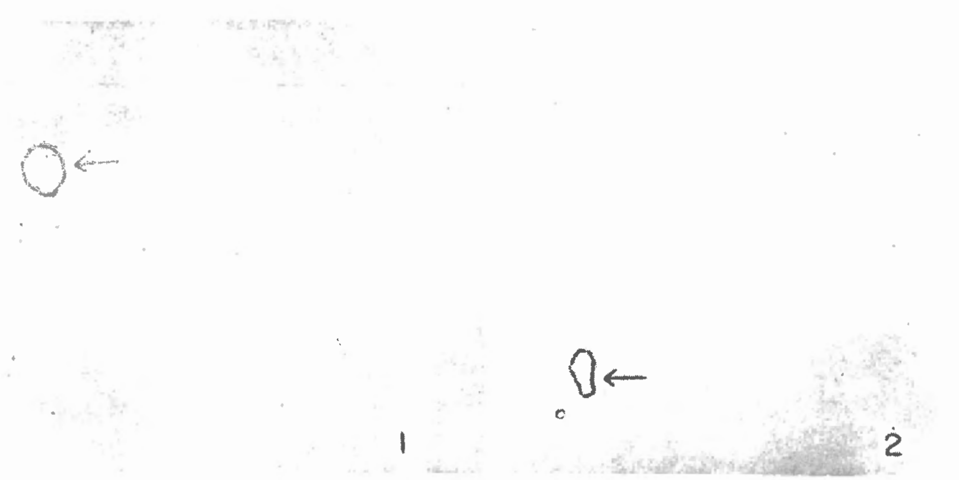


Figure 3. Two thin-layer chromatogram plates which compare the relative position of arsenic located by spraying with KI (see arrows). Plate on left was spotted with standard MAA. Plate on right was spotted with the amino acid fraction of plant extract from Johnsongrass plants treated with MAA.

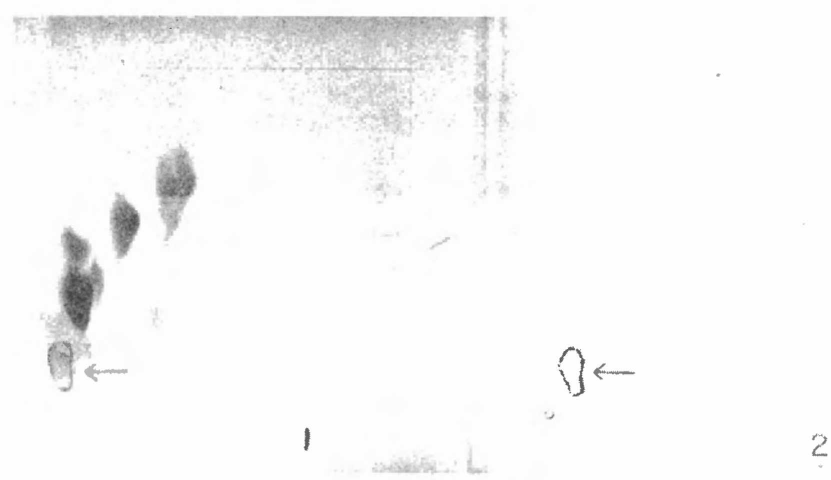


Figure 4. Two thin-layer chromatogram plates that were spotted with equal amounts of the same plant extract. Plate on right was sprayed with KI. The arrow at the left points to comparable ninhydrin positive spot.

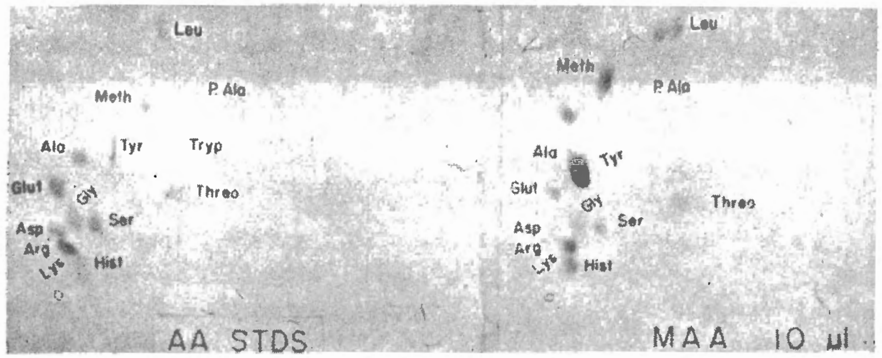


Figure 5. Two thin-layer chromatogram plates comparing standard amino acids on the left to amino acids from plant extract of Johnsongrass treated with MAA on the right. The 3 basic amino acids: arginine, lysine, and histidine appear to occupy the area that is also occupied by arsenic (see Figure 6).

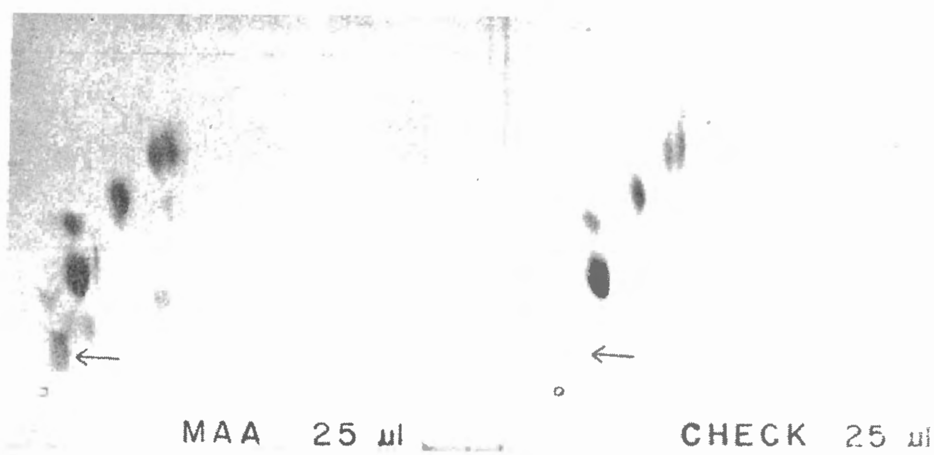


Figure 6. Two thin-layer chromatograms comparing extract from MAA treated Johnsongrass plants (left), and that of untreated Johnsongrass. Note high concentration of basic amino acids from the treated plant extract.

Figure 4 shows duplicate plates that were spotted with equal amounts of plant extract. Plate #1 on the left was sprayed with ninhydrin, an amino acid location reagent, while plate #2 was sprayed with KI. When one compares the two plates it is obvious that the arsenic spot is located in the same area as one or more ninhydrin-positive plant components.

Subsequent to this a plate was spotted with 16 amino acid standards. In Figure 5 the standard amino acid plate on the left is compared with the plate which was spotted with plant extract. It is seen that the three amino acids on the standard plate that move to the approximate area that the MAA-metabolite moves to are arginine, lysine, and histidine, all three being basic amino acids. On the basis of this work, therefore, it is postulated that MAA, after being absorbed into Johnsongrass, is actively metabolized and complexed with one or more of the basic amino acids arginine, lysine, and histidine.

Figure 6 compares the plate spotted with extract from MAA treated Johnsongrass (left) to a plate spotted with extract from Johnsongrass that was not treated. Although the concentration of the two samples was practically equal, it is obvious that the treated plant extract had a very high concentration of amino acids in the area being discussed (see arrow) compared to the check plant extract. This would indicate that a metabolic block occurs in Johnsongrass that is treated with MAA. Although it is not proposed that this is the only plant metabolic reaction that may occur in MAA treated plants, it may well be a very important metabolic reaction.

13. Experiment No. GH-11-67. Control of Johnsongrass with DSMA at different temperatures and relative humidities.

<u>INTRODUCTION:</u> Temperature has been shown by several to influence the effect of organic arsenical herbicides on Johnsongrass. Generally, the organic

arsenical herbicides become increasingly effective as temperature increases above 75° F. Little information has been published on the effects of humidity on Johnsongrass control with organic arsenicals. Information on temperature and humidity effects are needed if best use of selective herbicides is made.

OBJECTIVE: The objective of this experiment was to measure the effect of temperature on the degree of Johnsongrass control with MSMA.

MATERIALS AND METHODS: Dormant Johnsongrass rhizomes were sectioned into one node segments and planted in 4 inch plastic pots in a controlled environment chamber. Twenty four hour per day illumination was maintained throughout the experiment. Plants were allowed to grow for 18 days prior to imposing the different temperature and relative humidity treatments. Since space in the growth chamber was limited, four separate tests were run with different temperatures and relative humidities in each test. Tests were: (1) temperature 72° F and relative humidity 55%, (2) temperature 72° F and relative humidity 88%, (3) temperature 90° F and relative humidity 55%, and (4) temperature 90° F and relative humidity 88%. In each test the Johnsongrass was sprayed at rates equivalent to 0, 0.5, 1.0, 1.5, 2.0, and 2.5 pounds per acre active ingredient of MSMA. Each treatment was replicated three times within each test. Fourteen days after spraying, the plants were harvested. The above ground material was separated from the roots and dry weights of both tops and roots were recorded. Each test was designed as a randomized complete block, and a "combined experiments" analysis was utilized for the statistical analysis.

RESULTS AND DISCUSSION: At the time of harvest all above ground plant material was obainted, however, it was obvious that large differences existed between treatments in the amount of green leaves remaining. The leaves that were green and viable were separated from the obviously dead material, and dry weight of the green leaf remaining was thought to be a better index of relative effectiveness of the herbicide rates.

Average dry weight of the remaining green leaves are presented in Table 9.

TABLE 9. Effect of MSMA on above ground plant growth when temperature and humidity are varied.

Treatment lbs/A MSMA	gms dry wt/plant of remaining green plant material: Temperature 72°	90°	Humidity 55%	88%	Avg. wt. per rate of MSMA
Check	5.33	6.78	6.63	5.48	6.06a*
0.5	3.37	3.53	5.10	1.80	3.45 b
1.0	2.06	2.06	3.22	0.90	2.06 c
1.5	1.19	1.54	2.26	0.60	1.37 d
2.0	1.14	1.20	1.74	0.48	1.17 de
2.5	0.49	0.79	0.92	0.36	0.64 e

* Any two means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

The data indicate that differences were obtained in this experiment from all three variables: rates of MSMA, temperature and humidity. The average weights of remaining gram leaves in Table 9 show that as rates of MSMA increased the weight of remaining green leaf decreased. With respect to temperature it is logical to expect less growth would occur at the lower temperature. The check treatment bears this out. Humidity appears to be critical in its effect on rate of control of Johnsongrass with MSMA. Even at 0.5 lbs/acre MSMA remaining green leaf material was relatively small

(1.8 gms/plant) at 88% relative humidity compared to that of the 55% humidity treatment (5.1 gms/plant). Humidity had the most pronounced influence of any of the variables in this experiment.

The interaction between temperature and humidity was evidenced by the fact that no differences between temperature levels were found at 88% relative humidity while at 55% relative humidity differences existed between temperature levels (Table 10). The data in Table 10 would seem to indicate that at the 55% relative humidity more Johnsongrass kill occurred at 72° F than at 90° F. This difference was very likely due to less vegetative growth occurring at the low temperature.

TABLE 10. Effect of temperature and humidity on remaining green plant material when treated with MSMA. Plant material was measured in gms dry wt/plant.

	Humidity	
Temperature	55%	88%
72°	2.92	1.61
90°	3.70	1.60

Dry weight of roots were affected very similarly to that of dry weight of remaining green leaves in this experiment. Significant differences in root weight were found between different rates of MSMA, temperature; and relative humidity. Humidity resulted in large differences in root weights at the different levels of DSMA application (Table 11).

TABLE 11. Effect of MSMA on roots when temperature and humidity are varied.

	gms dry wt. of roots/plant				
Treatment	Temperature		Humidity		Avg. wt. per rate
lbs/A MSMA	72°	90°	55%	88%	of MSMA
Check	3.83	8.62	6.19	6.26	6.22a*
0.5	2.78	4.69	5.27	2.20	3.74 b
1.0	2.20	3.45	3.68	1.96	2.82 c
1.5	1.52	3.14	3.44	1.22	2.33 cd
2.0	1.61	2.48	2.89	1.20	2.05 de
2.5	1.27	1.82	2.09	1.00	1.55 e

* Any two means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

Interactions between temperature x humidity, rates x temperatures, and rates x humidity were also significant. In Table 12 it again appears that less root kill occurred at the low humidity and high temperature than at the low humidity and higher temperature. Most of this difference is thought to be due to less growth at the low temperatures rather than herbicide effects.

TABLE 12. Effect of temperature and humidity on dry weight of roots when treated with MSMA. Plant material was measured in gms dry/wt plant.

	Humidity	
Temperature	55%	88%
72°	2.47	1.93
90°	5.38	2.68

CONCLUSIONS: Significant differences in dry weight of remaining green leaves and roots occurred as a result of the three variables; rates of MSMA, temperature, and humidity. There were also interactions between temperature x humidity, rates x temperatures, and rate x humidity. Results indicate that humidity has a profound effect on kill of Johnsongrass with MSMA. Much greater kill, as measured by both root weights and remaining green leaf, was apparent at the 88% relative humidity compared to the 55% relative humidity.

SECTION IV

FIELD EXPERIMENTS CONCERNING

GROWTH RETARDANTS AND CHEMICAL HERBICIDES

1. Growth regulation of grasses on highway rights-of-way.

INTRODUCTION: Greenhouse experiments previously reported, as well as work of other researchers, have shown that MH-30 (Maleic Hydrazide) is an effective growth retarding compound for use on various grass species. The value of a growth regulator for highway rights-of-way vegetation is quite obvious when one considers the cost of mowing these areas repeatedly throughout the growing season. Hard-to-mow areas are especially likely places where growth regulators might be of use since hand labor costs would greatly increase the expense of maintaining attractive vegetation. A series of experiments were conducted in the field in 1964-1965 to determine effects of MH-30 on Kentucky 31 tall fescue and bermudagrass. These experiments are presented separately here.

A. Experiment No. 3-11-64. Growth regulation of Kentucky 31 tall fescue with MH-30.

OBJECTIVE: The objective of this experiment was to determine the effects of MH-30 at different rates on growth and appearance of Ky. 31 tall fescue under field conditions.

MATERIALS AND METHODS: A section of right-of-way on state Highway 53 in Nevada County in District 3 was selected for this experiment. A fair stand of tall fescue was present on this site when the experiment was initiated. Application of MH-30 was made on April 16, 1964. The fescue was approximately 4 inches tall at this time. Five rates of MH-30 (0, 2, 4, 6, and 8 pounds/acre active material) were sprayed on plots 20 by 40 feet in size. Solution was sprayed at the rate of 50 gal/acre. A surfactant (X-77) was added to the solutions at a rate of 0.5% volume. Also added was 2,4-D amine at 2 pounds active ingredient per acre for controlling broadleaf weeds. Each treatment was replicated three times. Growth retardation of tall fescue was evaluated on June 10 using a visual rating of 0-10 with 0 being no retardation and 10 meaning complete retardation.

RESULTS AND DISCUSSION: Soil moisture was very low at the time retardation ratings were made and normal growth of the fescue was likely affected. Generally, however, growth retardation by MH-30 increased as rate of application increased. (Table 1) Statistically, there were no significant differences in growth retardation between any of the 4 through 8 lbs/acre rates of MH-30. Fescue in the plots treated with 8 lbs/acre showed considerable damage from the chemical and looked very light in color. Fescue in plots treated with 4 or 6 lbs/acre was very green in color and had only moderate growth with very few seedheads. Plots which received only 2 lbs/acre looked essentially like the checks with many seedheads present.

TABLE 1. Effect of four rates of MH-30 on growth of fescue in the field.

Treatment lbs/A	Average rating* of 3 reps.
0	0 a**
2	1.7 ab
4	5.0 bc
6	7.0 c
8	8.0 c

* 0 means no growth retardation; 10 means complete retardation
** Any two means followed by the same letter are not significantly different at the 5% probability level.

CONCLUSIONS: Results of this experiment confirms those obtained in greenhouse experiments reported earlier. Rates of MH-30 above 6 lbs/acre result in excessive damage to tall fescue. Four and six lbs/acre resulted in effective growth retardation with very few seedheads.

B. Experiment No. 5-11-64. Growth retardation of Kentucky 31 tall fescue with MH-30.

OBJECTIVE: The objective of this experiment was to determine the effect of various rates of MH-30 on Ky. 31 tall fescue when applied at a later stage of growth.

MATERIALS AND METHODS: A section of rights-of-way on Highways 16 and 92 in Cleburne County in District 5 was chosen for this experiment. An excellent stand of tall fescue was present on this site. The experiment was initiated on April 23, 1964. Fescue was in the boot stage approximately 12-15 inches tall when the plots were sprayed. Five rates of MH-30 (0, 2, 4, 6, and 8 lbs/acre active ingredient) were sprayed in water at the rate of 50 gals/acre solution. A surfactant was included in the solution at 0.5% by volume. Each treatment was replicated three times. Visual ratings of growth retardation were made on June 11, 1964.

RESULTS AND DISCUSSION: Due to the advanced stage of growth, satisfactory growth retardation was not obtained in this experiment. Regardless of rate of MH-30 applied, numerous seedheads were present in all plots. Plots which received 2 lbs/acre MH-30 were visually indistinguishable from the check plots. Those which received 4 lbs/acre were very un-uniform in growth. Plots which received 6 lbs/acre showed effective growth retardation as the fescue was approximately 18 inches shorter than in the check plots. As was mentioned previously, however, numerous seedheads were present. Plots treated with 8 lbs/acre MH-30 showed similar growth retardation to the 6 lbs/acre plots, but damage was excessive and grass did not appear healthy.

CONCLUSIONS: Growth retardation occurred in this experiment when 6-8 lbs/acre MH-30 was applied, however, excessive damage occurred at 8 lbs/acre and no rate of MH-30 applied was effective in reducing unattractive seedheads. This experiment confirms the need for applying MH-30 at early stages of vegetative growth. It is recommended that fescue be treated with MH-30 when between 2 and 4 inches in height. If grass exceeds this height it should be clipped before spraying.

C. Experiment No. 4-11-65. Growth retardation of Kentucky 31 tall fescue with MH-30.

OBJECTIVE: This is one of a series of experiments to determine effects of MH-30 on tall fescue under field conditions.

MATERIALS AND METHODS: A section of right-of-way on Highway 270 in Scott County in District 4 was selected for this experiment. An excellent stand of Ky. 31 tall fescue was present. The experiment was initiated on April 30, 1965. Growth of tall fescue was excessive when the plots were established, therefore they were mowed at approximately 4 inches immediately prior to application of the MH-30. Four rates of MH-30 (0, 4, 5, and 6 lbs/acre active material) were applied in water solution at the rate of 50 gals/acre. A surfactant (X-77) was included at 0.5% by volume of the solution. There were three replications. Plot size was 20 by 50 feet. Observations of the plots were made on May 27 and June 25, 1965.

RESULTS AND DISCUSSION: Results from this experiment were similar to that of the others. When the plots were checked on May 27 very little growth had occurred on the plots treated with either of the three rates of MH-30. Fescue on the check plots at this time was 30 inches high and beginning to head out. Color differences were observed in the fescue in the different MH-30 levels. Plots which received 4 lbs/acre were bright green in color, plots which received 6 lbs/acre appeared brown in color and did not look as attractive.

At the June 25 observation there were greater differences between rates of MH-30 with respect to plant growth. Numerous seedheads were present in plots which received 4 lbs/acre while very few were present in plots treated with 6 lbs/acre. At both observation dates the 5 lbs/acre appeared intermediate between the 4 and 6 lbs/acre treatments. Environmental conditions with respect to moisture and temperature were ideal throughout the duration of this experiment.

CONCLUSIONS: On the basis of this and other experiments it has been shown that MH-30 can be used successfully to control growth of fescue under field conditions. It appears that 5-6 lbs/acre are necessary to effectively retard growth and seedhead production.

D. Experiment No. 5-12-64. Growth retardation of bermudagrass with MH-30.

OBJECTIVE: This is one of a series of experiments concerning the effects of MH-30 as a growth retardant for grasses on highway rights-of-way.

MATERIALS AND METHODS: A section of right-of-way on Highway 67 in White County in District 5 was selected for this experiment. A good stand of common bermudagrass was present. The experiment was initiated on May 7, 1964. The bermudagrass was clipped to approximately 3 inches just prior to application of the herbicides. Five rates of MH-30 (0, 2, 4, 6, and 8 lbs/acre active ingredient) were applied in water solution at the rate of 50 gals/acre. A surfactant (X-77) was included at 0.5% by volume of the solution. Each treatment was replicated three times. Observations of the plots were made on June 11, 1964.

RESULTS AND DISCUSSION: The major portion of these plots were mowed by mistake a few days before observations were made, therefore no ratings were made. The lower portion of the plots, however, was not mowed and observations of this portion of the plots were made. It was thought that the results on the lower portion of the plots, although limited, would be representative of the entire plots.

Four lbs/acre of MH-30 retarded the bermudagrass quite effectively but seedheads were numerous. Few seedheads were present on plots treated with 6 lbs/acre and growth retardation was also quite effective. Eight or 10 lbs/acre reduced growth but produced extreme chlorosis.

CONCLUSIONS: Although observations were limited due to mowing part of these plots by mistake, it was apparent that 8-10 lbs/acre MH-30 was damaging to bermudagrass. Four lbs/acre effectively retarded growth but numerous seedheads were produced at this treatment rate. Six lbs/acre effectively reduced growth and seedhead production in this experiment.

2. Control of vegetation in difficult to mow areas by use of soil sterilants.

INTRODUCTION: Tractor powered mowers are very effective in mowing highway rights-of-way. The presence of delineator posts, guard rails, fences, and other obstructions require hand labor to control unwanted vegetative growth. Increased maintenance costs are obvious as increased hand labor becomes involved. At present there are a large number of chemical compounds available which effectively inhibit growth of all vegetation where applied. These compounds are generally termed "soil sterilants". There are many differences in these compounds in terms of effectiveness against different types of vegetation, ability to control vegetation for long periods, cost of treatment, etc. Experiments were conducted during the term of this project whereby a number of soil sterilants were evaluated in several districts of the state. A wide range of soil types and vegetation composition was encountered in these experiments as one would suspect when the different districts involved are considered. Experiments will be discussed separately in this report.

A. Experiment No. 3-12-64.

MATERIALS AND METHODS: Delineator posts on Highway 53 in Nevada County, District 3 were selected for this experiment. Five soil sterilants, each representing a treatment, were applied around delineator posts on April 16, 1964. Each treatment was replicated three times while each plot consisted of two posts each receiving an equal amount of soil sterilant. A constant rate of approximately 15 square feet was covered by the sterilant around each post. The shape of the area was two equal isosceles triangles having the post as the center of the common base which was about 3 feet long. The triangle sides were about 5 feet 10 inches in length with the points parallel to the pavement of the highway. A wooden frame having the described dimensions was placed around the post and the sterilant was applied inside the enclosed area to assure uniformity of treated area. The soil sterilants used, the method and rate of application are given in Table 2.

TABLE 2. Soil sterilants and the method and rate of their application for field experiment in District 3.

Soil Sterilant*	Method of application	Rate of application actual lbs/acre
Concentrated Borascu	Dry form	3500
Ureabor	" "	870
Telvar	Spray form	40
Simazine	" "	30
Hyvar X	" "	25

* Trade, common, and chemical names of soil sterilants used:

Trade Name	Common Name	Chemical Name
Concentrated Borascu	Borascu	Sodium-metaborate
Ureabor	BMM	Borate-Monuron Mixtures
Telvar	Monuron	3-(P-chlorophenyl)-1, 1-dimethylurea
Simazine 80W	Simazine	2-Chloro-4, 6-bis (ethylamino)-S-Triazine
Hyvar X	Bromocil	5-bromo-3-sec-butyl-6-methyluracil

Sterilants which were applied in the spray form were mixed with water and sprayed at the rate of 400 gals/acre of solution. Sterilants applied in the dry form were sprinkled evenly over the area by hand. Plots were rated on June 10 and August 27, 1964.

In 1965 one-half of the original rate of soil sterilant was applied to one post in each treatment plot. This resulted in one post receiving no additional soil sterilant in 1965 while the first post received one-half the original application rate.

In 1966 each post in the individual treatments which received a one-half rate of sterilant in 1965 was again treated with a one-half rate while the post which was untreated in 1965 received the full rate of original treatment. As a result, each post in each treatment received equal amounts of soil sterilants over a three year period, but one post received two applications while the third received three.

All ratings were made on a scale of 0-10 with 0 meaning no control and 10 meaning complete control of vegetation. Plots were rated independently by two people and ratings were averaged for statistical analysis.

RESULTS AND DISCUSSION: Plots were first evaluated 8 weeks and 19 weeks after soil sterilants were applied. An average of the ratings is given in Table 3.

TABLE 3. Effect of soil sterilants on vegetation, and cost approximations of sterilants for field experiment in District 3.

	Ave. rating of 3 reps*		
Soil sterilant	June 10	Aug. 27	Approx. Cost** per post
Concentrated Borascu	1.0 a***	4.9 a	7.8¢
Simazine	6.7 b	8.3 b	2.2¢
Telvar	9.0 c	8.8 b	3.3¢
Ureabor	9.1 c	8.0 b	9.3¢
Hyvar X	9.5 c	9.4 b	5.0¢

* 0 meaning no effect; 10 meaning complete plant kill.
** Cost figured on basis of 15 square feet.
*** Any two means followed by the same letter are not significantly different at the 5% probability level.

Concentrated Borascu was significantly less effective in controlling vegetative growth than any of the other materials at these two rating dates. After 19 weeks there were no significant differences in vegetation control between any of the other 4 compounds.

In this experiment the posts were located on the slope near the pavement edge. Damage of vegetation down the slope from point of application was observed for all sterilants. There were varying degrees of damage. Slope damage was most severe from Hyvar X while Simazine moved very little down the slope.

Cost of the material would be an important factor to consider when applying soil sterilants. The approximate cost of the different materials per post is presented in Table 3 also. It should be pointed out that these are figures for 1964 and are subject to change from year-to-year, however, some idea of the relative cost of the various materials used can be obtained from these figures.

Data from ratings made on June 25, 1965, after applying one-half rate of sterilant to one post in the treatments are presented in Table 4.

TABLE 4. Soil sterilants, their application rate, and the average rating of 3 reps for field experiment no. 3-12-64.

	Rate of application actual lbs/acre		Mean rating of 3 reps*
Soil Sterilant**	1964	1965	Rated June 25, 1965
Hyvar X Post 1	25	none	4.7 c
" " " 2	25	12.5	10.0 a
Simazine Post 1	30	none	5.8 bc
" " 2	30	15	9.8 a
Telvar Post 1	40	none	5.3 bc
" " 2	40	20	9.7 a
Ureabor Post 1	870	none	4.7 c
" " 2	870	435	8.7 ab
Concentrated Borascu Post 1	3500	none	5.2 bc
" " " 2	3500	1750	6.7 bc

* 0 meaning no effect; 10 meaning complete plant kill. Any two means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

It can be seen that some residual effect of the previous year's application is still apparent, since posts which were untreated rated from 4.7 to 5.8 in vegetation control. This level of vegetation control is not satisfactory. The posts which received one-half the original rate of herbicide in 1965 showed excellent vegetation control with the exception of concentrated Borascu.

Of the soil sterilants used in this experiment, concentrated Borascu was inferior in vegetation control.

B. Experiment No. 5-13-64.

MATERIALS AND METHODS: The materials and methods for this experiment are identical to those of the previously mentioned experiment except for the location of the experiment and the materials used. This experiment was established on Highway 67 near Beebe in District 5. Soil sterilants used, their rate, and method of application are given in Table 6.

TABLE 6. Soil sterilants and the method and rate of their application for field experiment in District 5.

Soil Sterilant*	Method of application	Rate of application actual lbs/acre
Concentrated Borascu	Dry form	3500
Polybor-Chlorate	" "	1310
Chlorea	" "	870
Urox	" "	220
HRS-1651 (Experimental)	" "	200
Prometone	Spray form	17.5 gals/acre

* Trade, common, and chemical names of soil sterilants used:

Trade Name	Common Name	Chemical Name
Concentrated Borascu	Borascu	Sodium-metaborate
Polybor-Chlorate	--	Sodium metaborate tetrahydrate and sodium chlorate
Chlorea	CBMM	Chlorate-Borate-Monuron Mixtures
Urox 22	Monuron TCA	3-(p-chlorophenyl)-1, 1-dimethylurea trichloroacetate
Prometone	Methoxypropazine	2-methoxy-4, 6-bis (isopropylamino)
HRS-1651	Experimental herbicide	

RESULTS AND DISCUSSION: An average of the first ratings are given in Table 7. In this experiment there were no significant differences in vegetation control with any of the sterilants at the August 28 rating. Promotone was significantly less effective than Chlorea at the June 1 rating with no differences between any of the other compounds. A great deal of variation was present in ratings obtained in this experiment which accounts for non-significance in differences.

TABLE 7. Effect of soil sterilants on vegetation, and cost approximations of sterilants for field experiment in District 5.

Soil Sterilant	Ave. rating of 3 reps*		Approx. Cost** per post
	June 1	Aug. 28	
Chlorea	9.3 a***	8.9 a	6.7¢
Polybor-Chlorate	8.2 ab	5.8 a	4.9¢
Concentrated Borascu	8.1 ab	7.9 a	4.7¢
Urox 22	7.9 ab	8.1 a	3.6¢
HRS-1651 (Exp)	6.6 ab	5.0 a	----
Prometone	5.3 b	6.7 a	2.6¢

* 0 meaning no effect; 10 meaning complete plant kill.
** Cost figured on basis of 9 square feet.
*** Any two means followed by the same letter are not significantly different at the 5% probability level.

The slope was fairly flat in this site and no movement of chemicals was noted.

Results of the 1965 ratings are given in Table 8. Generally, the results of this experiment are similar to those for Experiment 4-12-64 in that one-half the original rate applied the second year resulted in excellent vegetation control while the residual effect from the original application was not sufficient to provide acceptable control on untreated posts the second year. The experimental herbicide HRS-1651 did not provide acceptable control of vegetation around either post.

TABLE 8. Soil sterilants, their application rate, and the average rating of 3 replications for field experiment 5-13-64.

Soil Sterilant**	Rate of application actual lbs/acre 1964	1965	Mean rating of 3 reps* Rated July 9, 1965
Concentrated Borascu Post 1	3500	none	3.2 de
" " " 2	3500	1750	9.0 a
Urox 22 Post 1	220	none	5.0 bcd
" " " 2	220	110	9.0 a
Chlorea Post 1	870	none	4.3 cd
" " 2	870	435	8.6 a
Polybor Chlorate Post 1	1310	none	1.5 e
" " " 2	1310	655	8.4 ab
Prometone Post 1	35	none	2.6 de
" " 2	35	17.5	7.5 abc
HRS-1651 (Experimental) Post 1	200	none	1.2 d
" " " " 2	200	100	5.5 bcd

* 0 meaning no effect; 10 meaning complete plant kill. Any two means followed by the same letter are not signficnatly different at th 5% probability level as determined by Duncan's Multiple Range Test.

The data for the 1966 ratings are shown in Table 9. As in the previous experiment, posts which received no soil sterilant in 1965 were treated with the full rate of the original application in 1966. Those posts which received one-half of the original treatment rate in 1965 received one-half the original rate in 1966 so that all posts received equal rates, but one post was treated every other year while one was treated every year at a reduced rate. Ratings indicated that there were no significant differences in the degree of vegetation control with any given sterilant due to application rate. There were differences between the soil sterilants in degree of vegetation control. HRS-1651 and concentrated Borascu were greatly inferior to other compounds. Ratings for all sterilants in this experiment were inferior to those in the previous experiment. The soil in this area was much higher in clay content and was thought to be responsible for the low vegetative control rating.

TABLE 9. Soil sterilants, their application rate, and the average rating of 3 replications for field experiment 5-13-64.

	Rate of application actual lbs/acre			Mean rating of 3 reps*
Soil Sterilant	1964	1965	1966	Rated Sept. 8, 1966
Conc. Borascu Post 1	3500	none	3500	3.4 cd
" " " 2	3500	1750	1750	4.7 bcd
Urox 22 Post 1	220	none	220	8.1 ab
" " " 2	220	110	110	6.7 abc
Chlorea Post 1	870	none	870	8.8 a
" " 2	870	435	435	8.3 ab
Polybor Chlorate Post 1	1310	none	1310	7.2 ab
" " " 2	1310	655	655	7.8 ab
Prometone Post 1	35	none	35	7.3 ab
" " 2	35	17.5	17.5	7.6 ab
HRS-1651 (Exp.) Post 1	200	none	200	2.5 d
" " " 2	200	100	100	3.4 cd

* 0 meaning no effect; 10 meaning complete plant kill. Any two means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

C. Experiment No. 9-11-64.

MATERIALS AND METHODS: The materials and methods for this experiment are identical to those of the two previous soil sterilant experiments except for the location and one soil sterilant used in this test which was not used in one of the other experiments.

This experiment was located on Highway 16 in Washington County, District 9. Soil sterilants used and their method and rate of application are given in Table 10. The new material, Urox J, contains chlorate/chloride solution plus Urox in oil and water.

TABLE 10. Soil sterilants and the method and rate of their application for field experiment in District 9.

Soil Sterilant	Method of application	Rate of application actual lbs/acre
Concentrated Borascu	Dry form	3500
Chlorea	" "	870
Ureabor	" "	870
Urox	" "	220
Hyvar X	Spray form	25
Urox "J"	" "	200 gals/acre

RESULTS AND DISCUSSION: Extremely dry conditions prevailed from the time the sterilants were applied until mid-August. No vegetative control resulted until the time that soil moisture was more available. There were no significant differences between any of the soil sterilants when the plots were rated on September 11, 1964. Plots averaged generally high in vegetative control ratings for all sterilants. Except for the fact that concentrated Borascu was lowest again, no definite trends could be established. It was thought that the lack of soil moisture soon after applying the chemicals may have been responsible for the lack of differences between sterilants.

The ratings for 1965 are shown in Table 11. In general, as in other experiments, vegetation control around posts treated with one-half the original rate of sterilant was good when compared to posts receiving no additional sterilant in 1965. This experiment was also located on a slope, and movement of all sterilants down the slope resulted in injury to vegetation on the slope. Hyvar X again caused the most slope damage and Simazine the least. The experimental sterilant, HRS-1651, was the only material which did not result in effective control of vegetation in this experiment. Urox J was taken off the market by the manufacturer and, therefore, was not included in 1965.

TABLE 11. Soil sterilants, their application rate, and the average rating of 4 replications for field experiment 9-11-64.

Soil Sterilant	Rate of application actual lbs/acre 1964	1965	Mean rating of 4 reps* Rated August 27, 1965
Hyvar X Post 1	25	none	3.5 d
" " " 2	25	12.5	9.6 a
Urox Post 1	220	none	5.8 bc
" " 2	220	110	9.7 a
Ureabor Post 1	870	none	6.0 bc
" " 2	870	435	9.5 a
Chlorea Post 1	870	none	7.1 bc
" " 2	870	435	9.2 a
Concentrated Borascu Post 1	3500	none	5.2 cd
" " " 2	3500	1750	7.6 b

* 0 meaning no effect; 10 meaning complete plant kill. Any two means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

The ratings for 1966 are shown in Table 12. Again there were no differences in vegetation control between rates of application with the exception of concentrated Borascu which gave inferior control with one-half the original rate of application. No differences were observed between any of the other soil sterilants in this experiment. Concentrated Borascu has proven inferior to most of the materials used in all three of these experiments.

TABLE 12. Soil sterilants, their application rate, and the average rating of 4 replications for field experiment 9-11-64.

	Rate of application actual lbs/acre			Mean rating of 3 reps*
Soil Sterilant	1964	1965	1966	Rated October 11, 1966
Hyvar X Post 1	25	none	25	9.7 a
" " " 2	25	12.5	12.5	9.3 a
Urox 22 Post 1	220	none	220	9.6 a
" " " 2	220	110	110	8.6 a
Ureabor Post 1	870	none	870	9.5 a
" " 2	870	435	435	9.2 a
Chlorea Post 1	870	none	870	9.7 a
" " 2	870	435	435	9.5 a
Conc. Borascu Post 1	3500	none	3500	8.6 a
" " " 2	3500	1750	1750	6.3 b

* 0 meaning no effect; 10 meaning complete plant kill. Any two means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

CONCLUSIONS: Concentrated Borascu and HRS-1651 (an experimental soil sterilant) were the only two materials in these three similar experiments which did not adequately control vegetation. There were no significant differences between the other materials in any one test. One-half of the original rate of soil sterilant in years following the initial application resulted in satisfactory vegetation control. Residual effect from the original application was not sufficient for adequate control in treatments applied in alternate years.

D. Experiment No. 4-12-65.

MATERIALS AND METHODS: Delineator posts on Highway 71 in Scott County, District 4, were selected for this experiment, which was initiated on April 30, 1965. Seven new soil sterilants, each representing a treatment, were applied around delineator posts. Each plot consisted of two posts and each treatment was replicated 3 times. In 1966 one-half the original rate of each material was applied to one of the posts while the second was untreated. In 1967 the post which was untreated in 1966 was again treated with the original rate of soil sterilant while the post which received one-half the original rate in 1966 received the same in 1967. Soil sterilants were applied inside a square wooden frame 3 x 3 feet in size, which was placed around each post to insure uniform area of coverage. Sterilants applied in dry form were sprinkled inside the wooden frame by hand. These materials were Chlorvar, Borocil, Borolin and Tritac. Materials applied as spray were mixed with water and applied at the rate of 400 gals/acre of solution. Sprayed materials were Maintain, Fenac, and Cotoran. Visual ratings were made for degree of vegetation control each year and analysis of variance performed on all data.

RESULTS AND DISCUSSION: Table 13 contains a listing of all sterilants used in this experiment along with the rating for vegetation control on July 1, 1965. Chlorvar and Borocil controlled vegetative growth better than any of the other materials used in this experiment at the July 1, 1965, rating. Both these materials contain Hyvar X as an active ingredient. Johnsongrass was the principal species not controlled by the other materials.

TABLE 13. Soil sterilants, their application rate, and the average rating of 3 replications for field experiment no. 4-12-65.

Soil Sterilant**	Rate of application lbs/acre	Mean rating of 3 reps*
Chlorvar	650	9.4a
Borocil	435	9.0a
Tritac	120	5.8 b
Borolin	150	5.4 b
Cotoran	10 lbs/A active	4.9 b
Maintain	16 lbs/A active	4.6 b
Fenac	10 lbs/A active	4.4 b

* 0 meaning no effect; 10 meaning complete plant kill. Any two means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

** Trade, common and chemical names of soil sterilants used:

Trade Name	Common Name	Chemical Name
Chlorvar Granular	Chlorvar	Sodium chlorate, sodium metaborate, and bromacil (5-bromo-3-sec-butyl-6-methyluracil)
Borocil	Borocil	Disodium tetraborate penta and decahydrates, and bromacil
Tritac 10G	Tritac	2,3, 6-Trichlorobenzyloxy-propanol
Borolin	Borolin	Disodium tetraborate penta and decahydrates, and pic-cloram (4-amino-3, 5, 6-trichloropicolinic acid).
Cotoran	Cotoran	3-(m-trifluoromethylphenyl)-1-dimethylurea
Maintain	Maintain	2-ethylhexyl ester of 2,4-D bromacil, and tritac
Fenac Industrial	Fenac	2,3, 6-Trichlorophenyl-acetic acid

Ratings taken on September 1, 1966, are given in Table 14. Borocil was significantly better than any of the other materials in degree of vegetation control at this time. Residual control, as indicated by the ratings for posts not treated in 1966, was generally inferior to that of posts treated with one-half the original rate of soil sterilant. Borocil, Chlorvar and Tritac were the only materials which gave satisfactory control of vegetation when treated with one-half the original rate.

TABLE 14. Soil sterilants, their application rate, and the average rating of 3 reps for field experiment no. 4-12-65.

	Rate of application lbs/A		Mean rating of 3 reps*
Soil Sterilant	1965	1966	Rated Sept. 1,1966
Borocil Post 1	435	none	6.2 ab
" " 2	435	220	9.8 a
Chlorvar Post 1	650	none	2.3 cd
" " 2	650	325	6.0 bc
Tritac Post 1	120	none	0.2 d
" " 2	120	60	6.0 bc
Borolin Post 1	150	none	0.5 d
" " 2	150	75	3.9 bcd
Cotoran Post 1	10 lbs/A active	none	1.0 d
" " 2	10 " " "	5 lbs/A active	0.8 d
Maintain Post 1	16 " " "	none	0.3 d
" " 2	16 " " "	8 lbs/A active	1.2 d
Fenac Ind. Post 1	10 " " "	none	3.3 bcd
" " " 2	10 " " "	5 lbs/A active	2.6 bcd

* 0 meaning no effect; 10 meaning complete plant kill. Any two means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

The 1967 ratings are given in Table 15. These ratings show that again only Chlorvar and Borocil gave satisfactory vegetation control at all rates. Maintain applied at the full rate also gave satisfactory control, but not at one-half the original rate. Johnsongrass was present in heavy infestations in this area and was the primary species not controlled by the other materials.

TABLE 15. Soil sterilants, their application rate, and the average rating of 3 reps for experiment no. 4-12-65.

	Rate of application actual lbs/acre			Mean rating of 3 reps*
Soil Sterilant	1965	1966	1967	Rated Sept. 6, 1967
Borocil Post 1	435	none	435	7.4 abc
" " 2	435	220	220	9.1 a
Chlorvar Post 1	650	none	650	8.3 ab
" " 2	650	325	325	7.7 abc
Borolin Post 1	150	none	150	3.9 bcde
" " 2	150	75	75	2.0 e
Tritac Post 1	120	none	120	3.2 bcde
" " 2	120	60	60	2.1 de
	lbs/acre active - applied as spray			
Maintain Post 1	16	none	16	7.2 abcd
" " 2	16	8	8	1.6 e
Fenac Post 1	10	none	10	2.9 cde
" 2	10	5	5	0.6 e
Cotoran Post 1	10	none	10	2.0 e
" " 2	10	5	5	1.1 e

* 0 meaning no effect; 10 meaning complete plant kill. Any two means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

CONCLUSIONS: Only Chlorvar and Borocil, which have a common active ingredient, were effective in providing adequate vegetation control in this experiment. One-half the original rate of these materials each year following the original application resulted in satisfactory control.

3. Johnsongrass control.

INTRODUCTION: Large areas of the state of Arkansas are infested with Johnsongrass. This weed has been quite difficult to control, and if left unchecked will soon crowd out more desirable vegetation. At present, mowing is the primary method used by the Arkansas State Highway Department to control this weed.

The primary objection to this method of control is the need for frequent roadside mowings due to rapid regrowth of Johnsongrass. A herbicide to effectively control this pest would be of great benefit to the Highway Department. Selective herbicides were tested for their effect on controlling Johnsongrass as well as on desirable species.

A. Experiment No. 10-11-64.

OBJECTIVE: The objective of this experiment was to compare different herbicides for selective control of Johnsongrass.

MATERIALS AND METHODS: This experiment was located on Interstate Highway 55 in Mississippi County in District 10. This area was heavily infested with Johnsongrass. Four herbicides plus a check were applied on May 6, 1964, 10 days after Johnsongrass was mowed to a height of approximately 4 inches. Each treatment was replicated 4 times. The herbicides used and their rate of application are given in Table 16.

TABLE 16. Herbicides used and their rate of application for Johnsongrass control experiment in District 10.

Herbicide*	Rate lbs/acre (action)
DSMA	3.0
MSMA	3.0
Cacodylic acid	3.0
Dalapon	8.5

* Trade, common, and chemical names of herbicides used:

Trade Name	Common Name	Chemical Name
DSMA	DSMA	disodium methylarsonate
MSMA	MSMA	monosodium methylarsonate
Cacodylic acid	Cacodylic acid	dimethyl arsenic acid
Dowpon	Dalapon	2,2-dichloropropionic acid

All herbicides were applied in water solution at 50 gals/acre. A surfactant (X-77) was included in all solutions at 0.5% by volume. Plots were 20 x 50 feet in size.

All plots were sprayed and clipped on an alternating basis. Dalapon was applied 3 times while other herbicides were applied 4 times throughout the season. Plots were rated on August 28, 1964.

RESULTS AND DISCUSSION: Plots that were sprayed with Dalapon showed 95% Johnsongrass control on August 28. Johnsongrass plants present were very small and were assumed to be seedlings which had emerged after the last spray application. Dalapon also eliminated all bermudagrass which had originally been present in the plots.

Cacodylic acid was no better than the check in Johnsongrass control, however, no damage to bermudagrass was observed in these plots.

DSMA and MSMA were equal to Dalapon in Johnsongrass control. Plots treated with these materials averaged 95% Johnsongrass control. Unlike the Dalapon plots, however, a very vigorous stand of bermudagrass was present in plots treated with DSMA and MSMA.

CONCLUSIONS: DSMA, MSMA and Dalapon effectively controlled Johnsongrass in this experiment. Dalapon also eliminated the original stand of bermudagrass while DSMA and MSMA did not. On a basis of selectivity DSMA and MSMA are far superior to Dalapon. They are considerably cheaper, also, and this would be another advantage of these materials. Cacodylic acid was ineffective in controlling Johnsongrass.

B. Experiment No. 1-11-64.

MATERIALS AND METHODS: This experiment was located on Interstate Highway 55 near West Memphis. The area was established to an excellent stand of common bermudagrass with a slight infestation of Johnsongrass. DSMA and Dalapon were the two herbicides used in this experiment. It was originally planned to apply 3 applications of both herbicides approximately 10 days apart, however, after the first application of Dalapon it was observed that the bermudagrass was severely injured. Due to the desirability of maintaining vegetative cover in this area, Dalapon sprayings were discontinued. DSMA was resprayed for a total of 3 applications at the rate of 3 lbs/acre at each application. Plots were rated on August 28, 1964.

RESULTS AND DISCUSSION: DSMA plots received a rating of 95% Johnsongrass control. No bermudagrass injury was observed in any of the plots sprayed with this material.

The one application of Dalapon resulted in severe damage to the bermudagrass in all plots. Some of the bermudagrass had regrown by August 28, however, the Johnsongrass had also regrown by this date and control was ineffective.

CONCLUSIONS: One application of Dalapon caused severe injury to the bermudagrass. Three applications of DSMA did not injure bermudagrass and resulted in excellent Johnsongrass control.

C. Experiment No. 8-11-66.

OBJECTIVE: The objective of this experiment was to compare the effectiveness of various rates and formulations of MSMA for controlling Johnsongrass.

MATERIALS AND METHODS: A section of right-of-way along Highway 64 in Conway County, District 8, was selected for this experiment. An excellent cover of common bermudagrass was present on the entire area, but it was heavily infested with Johnsongrass.

The experiment was designed as a 3 x 6 factorial consisting of 5 rates of MSMA (0, 1, 2, 3, and 4 lbs/acre) mixed with water and a sixth treatment of 2 lbs/acre MSMA in water with a non-phytotoxic emulsifiable oil mixed in at the rate of 380 ml/gal of water. Three spraying dates made the other variable. The first of two applications was made to all plots on June 22 when Johnsongrass was near the "boot stage" of maturity. Second applications were on July 28, August 4 or August 11. All spray solutions were applied at the rate of 50 gals/acre to plots that were 20 x 40 feet. Plots were rated on September 2, 1966. No additional herbicide was applied in 1967, but plots were rated on September 8, 1967, to determine residual effects. All data were subjected to analysis of variance.

RESULTS AND DISCUSSION: The data presented in Table 17 indicate that the stage of growth of Johnsongrass is quite important with respect to timing of herbicide applications.

TABLE 17. Effect of various rates and time of second application of MSMA on Johnsongrass. Plots were rated on September 2, 1966.

	Date of second application of MSMA		
MSMA lbs/acre	July 28	August 4	August 11
0	0.0 a*	0.0 a	0.0 a
1 in water	2.6 b	5.5 b	5.3 b
2 " "	8.9 c	5.9 b	8.7 c
3 " "	9.3 c	7.7 b	9.0 c
4 " "	8.9 c	6.8 b	9.1 c
2 in water and oil	7.7 c	7.3 b	8.8 c

* Any two means in individual columns followed by the same letter are no significantly different at the 5% probability level as determined by Duncna's Multiple Range Test. All entries are visual ratings. 0 meaning no effect; 10 meaning complete Johnsongrass kill.

The regrowth of Johnsongrass was approximately 12-18 inches tall on July 28 when the first group of plots received the second application of DSMA. On August 11, when the third group was resprayed, Johnsongrass was in the early "boot stage". This would explain the higher ratings for Johnsongrass kill for the August 11 respraying date than for the other two dates.

There were no significant differences in Johnsongrass control between the 2, 3, or 4 lbs/acre rates or the 2 lbs/acre rate in water plus oil. One pound per acre was inferior to the other rates when resprayed on July 28 and August 11, but not when resprayed on August 4.

Some plots showed fairly good residual control as indicated by the 1967 ratings (Table 18). Although all plots treated in 1966 showed less Johnsongrass infestation than the check plots, no significant differences were detected between any of the rates or dates of application. The wide range of differences in the averages presented in Table 18 without accompanying significant differences is an indication of the variation between replications. This indicates regrowth will occur and more than one year's treatment is required to control Johnsongrass.

TABLE 18. Effect of various rates and time of second application of MSMA on Johnsongrass treated in 1966. Plots were rated on September 8, 1967.

	Date of second application of MSMA in 1966		
MSMA lbs/acre	July 28	August 4	August 11
0	0.0 a*	0.0 a	0.0 a
1 in water	3.6 b	4.9 b	4.7 b
2 " "	5.7 b	3.9 b	5.2 b
3 " "	7.1 b	6.2 b	6.3 b
4 " "	6.4 b	3.7 b	8.2 b
2 in water and oil	6.6 b	4.8 b	4.9 b

* Any two means in individual columns followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test. All entries are visual ratings. 0 meaning no effect; 10 meaning complete Johnsongrass kill.

CONCLUSIONS: Growth stage, as well as rate of application, was found to influence the degree of Johnsongrass control in this experiment. It has generally been found that Johnsongrass is more susceptible to organic aresnical herbicides when in the "boot stage" of growth. These data seem to agree with this hypothesis.

From data obtained the second year after applying herbicides, it was concluded that reapplication of organic arsenicals is necessary for adequate Johnsongrass control. All treatments to which MSMA was applied in 1966 were less heavily infested with Johnsongrass in 1967, but the degree of infestation was thought to be too great to be acceptable.

D. Experiment No. 8-11-65.

OBJECTIVE: The objective of this experiment was to compare the effectiveness of DSMA and MSMA for controlling Johnsongrass.

MATERIALS AND METHODS: A section of right-of-way along Highway 65 in Conway County was selected for this experiment. An excellent stand of common bermudagrass, heavily infested with Johnsongrass, was present on the entire area. Three rates each (2, 3, and 4 lbs/acre) of DSMA and MSMA along with a check were applied for a total of 7 treatments with 3 replications. A surfactant (X-77) was added to each DSMA solution. MSMA used in this experiment contained a surfactant which was added by the formulator. All treatments were applied in water solution at the rate of 50 gals/acre. The experiment was initiated on June 4 when Johnsongrass was approximately 24 inches tall. All plots were sprayed three times during the growing season (June 4, June 11, and July 15). Ratings were made on July 8 and August 31, 1965. No additional herbicide was applied in 1966 or 1967. Plots were rated on September 2, 1966, and September 8, 1967, to determine residual effects. All data were subjected to analysis of variance.

RESULTS AND DISCUSSION: All rates of both herbicides gave significantly better control than the check treatment in 1965 (Table 19). DSMA at two pounds per acre was significantly poorer in Johnsongrass control than other treatments. With the exception of this treatment, final ratings indicate that approximately 90% control of Johnsongrass was obtained with both materials at other rates. No injury to the bermudagrass was observed in any of the plots.

TABLE 19. Johnsongrass control with DSMA and MSMA at various rates when applied three times during the growing season.

Herbicide	Rate lbs/acre active each application	1st rating* July 8	2nd rating* August 31
Check	none	0.0 a	0.0 a
DSMA	2	6.7 b	7.4 b
"	3	8.8 c	9.1 c
"	4	9.2 c	9.3 c
MSMA	2	8.3 c	9.0 c
"	3	8.8 c	8.3 bc
"	4	8.8 c	9.0 c

* 0 meaning no effect; 10 meaning complete plant kill. Any two means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

Data presented in Table 20 indicate that less Johnsongrass was present in 1966 than in 1965 even though plots were not sprayed in 1966. It was thought the excellent stand of bermudagrass present in these plots provided sufficient competition to make re-establishment of Johnsongrass seedlings difficult once adequate control was obtained.

TABLE 20. The degree of Johnsongrass control during the year following treatment with DSMA and MSMA at various rates. Three applications of herbicide were applied in 1965 but none in 1966.

Herbicide	lbs/acre each application	Rated* August 31, 1965	Rated Sept. 2, 1966
Check	none	0.0 a	0.0 a
DSMA	2	7.4 b	9.0 b
"	3	9.1 c	9.8 b
"	4	9.3 c	9.6 b
MSMA	2	9.0 c	9.6 b
"	3	8.3 bc	8.7 b
"	4	9.0 c	9.2 b

* 0 meaning no control; 10 meaning complete Johnsongrass kill. Any two means in individual columns followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

Data in Table 21 indicate that some regrowth of Johnsongrass had occurred by the second year after treatment, however, infestation was slight even at this date.

TABLE 21. The degree of Johnsongrass control for 3 years following treatment with DSMA and MSMA at various rates. Three applications of herbicide were applied in 1965 but none in 1966 or 1967.

Herbicide	lbs/acre each application	Rated* Aug. 31, 1965	Rated Sept. 2, 1966	Rated Sept. 8, 1967
Check	none	0.0a	0.0a	0.0a
DSMA	2	7.4 b	9.0 b	7.4 b
"	3	9.1 c	9.8 b	7.1 b
"	4	9.3 c	9.6 b	6.9 b
MSMA	2	9.0 c	9.6 b	8.4 b
"	3	8.3 bc	8.7 b	7.8 b
"	4	9.0 c	9.2 b	8.6 b

* 0 meaning no control; 10 meaning complete Johnsongrass kill. Any two means in individual columns followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

CONCLUSIONS: Ratings for three years following 3 applications of DSMA and MSMA for Johnsongrass indicate that once adequate control is obtained, reinfestation is slow when sufficient competition is provided by a vigorous species such as common bermudagrass. This, and laboratory and greenhouse experiments previously reported, indicates that Johnsongrass rhizomes are killed when organic arsenical herbicides are applied. Reinfestation appears to occur from seed present in the soil. A good cover of desirable vegetation will provide sufficient competition to make reinfestation slow.

E. Experiment No. 10-11-66.

OBJECTIVE: The objective of this experiment was to determine the influence of time of day when application of organic arsenical herbicides is made on control of Johnsongrass. Experiments in central Arkansas have always shown better Johnsongrass control than those in eastern Arkansas. Personnel of this project are located in Fayetteville. The usual procedure in applying treatments to these experiments was to drive to central Arkansas and make the applications to those experiments during the morning, then apply treatments to tests in eastern Arkansas in the afternoon.

MATERIALS AND METHODS: A section of right-of-way on I-55 in District 10 was selected for this experiment. A thick stand of Johnsongrass was present. This was primarily the only species on the area. Treatments consisted of 3 rates of MSMA (1, 2, and 3 lbs/acre) mixed with water containing emulsifiable oil at the rate of 380 mls/gal and the same 3 rates of MSMA in water alone. The 6 treatments plus a check were applied during late afternoon on June 15, 1966. A duplicate set of the same 6 treatments were applied the following morning. Second applications were made on July 12 (PM) and 13 (AM) and third applications were made on September 14 (PM) and 15 (AM), 1966. All spray applications were applied at the rate of 50 gals/acre solution. There were 3 replications of plots 10 x 40 feet. Plots were rated on September 14 and October 10, 1966, and the data subjected to analysis of variance.

RESULTS AND DISCUSSION: The data obtained from this experiment indicate that time of day when MSMA is applied has no influence on the degree of Johnsongrass control. The averages of the visual ratings are presented in Table 22. There were no significant differences between any of the rates applied when rated September 14, 1966, but all treatments were better than the check. Much better control was obtained after the third application as can be seen from the data in Table 22. The two 1 lb/acre treatments applied in the evening resulted in poorer control than any of the other treatments. A rain which occurred approximately 3 hours after these applications was thought to have reduced the effectiveness of these applications. There was no apparent advantage to adding an emulsifiable oil to the spray solution in this experiment.

TABLE 22. Effect of various rates and time of day of MSMA application on Johnsongrass control in eastern Arkansas.

MSMA lbs/acre	Time of Application	Rated* Sept. 14	Rated Oct. 10
1 in water	evening	3.2 a	5.2 a
1 " "	morning	3.4 a	8.3 ab
2 " "	evening	5.2 a	7.7 b
2 " "	morning	3.2 a	9.3 a
3 " "	evening	4.6 a	7.7 b
3 " "	morning	5.3 a	9.3 a
1 in water plus oil	evening	3.8 a	5.0 c
1 " " " "	morning	3.7 a	8.7 ab
2 " " " "	evening	5.7 a	8.6 ab
2 " " " "	morning	4.8 a	9.3 a
3 " " " "	evening	6.0 a	8.5 ab
3 " " " "	morning	4.3 a	9.5 a
Check		0.0 b	0.0 d

* 0 meaning no control; 10 meaning complete Johnsongrass kill. Any two means in individual columns followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

CONCLUSIONS: Time of day when MSMA was applied had no influence on the degree of Johnsongrass control. The poor control of Johnsongrass obtained in previous experiments in eastern Arkansas was attributed to the fact that Johnsongrass was the sole species present in most cases where poor control was obtained. Plots in eastern Arkansas had good stands of bermudagrass which offered competition to the Johnsongrass seedlings as they emerged and made reinfestation slower. Good control of Johnsongrass was originally obtained in all experiments in eastern Arkansas as they were in this experiment. Johnsongrass seed are known to survive in soil for many years, however, and would result in reinfestation if no competing species are present.

3. Brush control experiments.

INTRODUCTION: On many highway rights-of-way throughout the state there are areas which are inaccessable to mowing equipment. On many of these areas, trees and brush tend to be the dominant type of vegetation. Experiments were conducted during the course of this project to determine methods of chemical control of undesirable woody species. Many different compounds were studied at several locations throughout the state. Experiments are reported here individually.

A. Experiment No. 10-12-64.

OBJECTIVE: The objective of this experiment was to compare different herbicides for the control of willows along drainage ditches.

MATERIALS AND METHODS: The area selected for this experiment was along a drainage ditch on I-55 in Mississippi County. The ditches at 4 corners of a bridge on the drainage ditch were lined with large stones to prevent soil erosion.

A thick stand of willows were growing up through the stones. Four herbicides, all in granular form, were applied in this experiment. The four herbicides and the rate of application of each are listed in Table 23.

TABLE 23. Herbicides used and their rate of application for brush control experiment in District 10.

Herbicide*	Rate lbs/acre (active)
2,4-D Weed Rhap	4
2,4,5-TP Silvi-Rhap	2
Banvel D	3
Tordon 10K	2

* Trade, common, and chemical names of herbicides used:

Trade Name	Common Name	Chemical Name
2,4-D Weed Rhap	2,4-D	2,4-dichlorophenoxyacetic acid
2,4,5-TP Silvi-Rhap	2,4,5-TP	2,4,5-Trichlorophenoxypropionic acid
Banvel D	dicamba	2-methoxy-3, 6-dichlorobenzoic acid
Tordon 10K	Tordon	4-amino-3,5,6-Trichloropicolinic acid

All herbicides were mixed with sand to increase the total volume and facilitate more even distribution. The mixtures were then applied by hand. The experiment was initiated on June 16, 1964, when willows were actively growing. There was only one replication of each treatment.

RESULTS AND DISCUSSION: The plots were observed on August 28, 1964, and Tordon was found to be the only chemical effective in controlling willows in this experiment.

CONCLUSIONS: Tordon was the only material effective in controlling willows along a drainage ditch in this experiment.

B. Experiment No. 6-12-65.

OBJECTIVE: The objective of this experiment was to determine the possibility of controlling vegetative growth on riprap areas along ditch banks with a soil sterilant.

MATERIALS AND METHODS: The site selected for this experiment were the 4 bridges over Crooked Creek on I-30 in District 6. All creek bank areas adjacent to the bridges had stone riprap laid down to prevent erosion. Vegetation growing up through the riprap consisted of bermudagrass, willows and various species of brush and vines. MCGD (Monobor Chlorate Granular D) was applied by hand at the rates of 1, 2, and 3 pounds per 100 square feet. The experiment was initiated on June 23, 1965. Visual ratings of vegetation control were made on August 19, 1965. Data from this experiment were not analyzed statistically since the areas to which the different rates varied in size and species present.

RESULTS AND DISCUSSION: The rates of MCGD used in this experiment were not sufficient to control all vegetation (Table 24).

TABLE 24. Brush control ratings for Crooked Creek experimental area.

Treatment lbs/100 square feet		Average rating*
MCGD	1 lb	7.0
MCGD	2 lbs	8.9
MCGD	3 lbs	9.6

* 0 meaning no effect; 10 meaning complete plant kill.

The ratings indicate that 1 lb/100 sq ft did not satisfactorily control vegetation. The 2 lbs rate eliminated 90% of the vegetation and the 3 lbs rate 95%. The type of vegetation not killed, however, was vines and brush, and this is the type which needs to be killed on sites of this nature. The higher rates did result in defoliation of much of the vine and brush vegetation. It was thought perhaps if treatments had been made at an earlier stage of growth, these species may have been controlled.

CONCLUSIONS: The two higher rates of MCGD controlled 90-95% of the vegetation on this riprap area. Earlier treatment may have given better control.

C. Experiment No. 6-13-65.

MATERIALS AND METHODS: This experiment was similar to the experiment just discussed except that the site of the experiment were the 4 bridges over Otter Creek on I-30, District 6. MCGD at 2 and 3 lbs/100 sq ft and Urox-HS (a mixture of monuron TCA and Hyvar X) at 1 lb/100 sq ft were applied in this experiment. All materials were applied by hand. Ratings were made August 19, 1965, for vegetation control.

RESULTS AND DISCUSSION: The average ratings for vegetation control presented in Table 25 show that Urox-HS at the rate applied was inferior to MCGD at either rate in controlling the vegetation which was present. There was not as great a difference between the two rates of MCGD in this experiment as in the previous one, but control of vegetation as a whole was about the same.

TABLE 25. Brush control ratings for Otter Creek experimental area.

Treatment lbs/100 square feet		Average rating*
Urox-HS	1 lb	6.5
MCGD	2 lbs	8.7
MCGD	3 lbs	8.6

* 0 meaning no effect; 10 meaning complete plant kill.

CONCLUSIONS: Results from this experiment and Experiment No. 6-12-65 indicate that MCGD applied at the rate of 2 lbs/100 sq ft will give approximately 90% vegetation control on riprap areas in ditch banks. There was indication, however, that the uncontrolled vegetation was the most undesirable type.

D. Experiments No. 4-13-65, 9-12-65, and 10-12-65.

OBJECTIVE: Herbicidal oils have long been used for general weed and brush control on railroad rights-of-way. Although generally non-selective in nature, it is feasible that herbicidal oils might have use in certain instances for general brush and weed control on highway rights-of-way if selectivity were of little importance. The objective of these experiments was to determine the effectiveness of various herbicidal oils and herbicidal oils fortified with other herbicides for general weed and brush control on highway rights-of-way.

MATERIALS AND METHODS: Treatments were the same at all three locations, therefore, these experiments are grouped together.

Locations of the three experiments were: Highway 28, District 4, in Scott County; Highway 45, District 9, in Washington County; and I-55, District 10, in Mississippi County. Each treatment consisted of 16 treatments replicated 3 times. Treatments are listed in Table 26. All oils were sprayed onto

10 x 20 feet plots at the rate of 100 gals/acre. All three experiments were initiated in May, 1965. Treatments were rated for vegetation control by two individuals, the ratings averaged, and analyzed by analysis of variance.

RESULTS AND DISCUSSION: Average ratings for all three experiments are presented in Table 26. It should be noted that the type of vegetation varied greatly between locations. Vegetative cover at Experiment No. 4-13-65 on Highway 28 was primarily broadleaf weeds with some vines and other perennial woody species. Good weed control was obtained with two applications of oil at this location. Oil treatments fortified with Hyvar X at 12 lbs/acre and Prometone at 40 lbs/acre gave vegetation control comparable to the two applications of oil alone.

Vegetative cover at the other two experimental areas was similar. Highway 45 (Experiment No. 9-12-65) had a mixture of native grasses, some perennial broadleaf weeds and Johnsongrass. I-55 (Experiment No. 10-12-65) was about 95% Johnsongrass. At these two locations, two applications of oil alone gave unsatisfactory control of the vegetation present. Oil fortified with Hyvar X at 12 lbs/acre or Prometone at 40 lbs/acre gave good control.

CONCLUSIONS: On the basis of these experiments it appears that herbicidal oils applied twice to heavy stands of broadleaf weeds and brush will give quick burndown and fairly good residual control of these species. Control of Johnsongrass is not adequate from the same treatment. Hyvar X at the rate of 12 lbs/acre and Prometone at 40 lbs/acre controlled between 85 and 90% of the Johnsongrass in the two locations where it was present. It should also be pointed out that the materials used in this experiment have little or no selectivity and would not be desirable except in areas where all vegetation was unwanted.

TABLE 26. Herbicidal oil treatments and the average rating of each treatment by location.

Treatment No.	Treatment* components	Mean Rating of 3 Reps** Hwy 28	Hwy 45	I-55	Overall Average
1	Oil 8764-May only	3.5 de	2.9 f	1.5 efg	2.6
2	Oil 8764-May and July	9.1 ab	7.5 abc	5.2 b	7.3
3	Oil 0883-May only	2.8 e	4.1 ef	1.0 fg	2.6
4	Oil 0883-May and July	9.0 ab	5.3 de	3.3 cd	5.9
5	Oil 0884-May only	2.4 e	4.0 ef	1.0 fg	2.5
6	Oil 0884-May and July	8.5 ab	5.1 de	2.2 def	5.3
7	Oil 0883-plus Hyvar X-3lbs/A	3.2 de	***	3.2 cde	3.2
8	Oil 0883-plus Hyvar X-6 lbs/A	5.5 cd	6.9 cd	5.6 b	6.0
9	Oil 0883-plus Hyvar X-12 lbs/A	8.3 ab	9.3 a	8.2 a	8.6
10	Water-plus Hyvar X-12 lbs/A	9.7 a	***	9.5 a	9.6
11	Oil 0883 and water 1:3 plus Hyvar X-6 lbs/A	6.4 bc	6.2 cd	5.4 b	6.0
12	Oil 0883 and water 1:1 plus Hyvar X-6 lbs/A	6.4 bc	5.8 cde	4.7 bc	5.6
13	Oil 0883 and water 1:4 plus Prometone-40 lbs/A	8.2 abc	9.1 ab	8.6 a	8.6
14	Oil 0883-plus Prometone-40 lbs/A	8.0 abc	9.0 ab	8.9 a	8.6
15	Oil 0883-plus Prometone-10 lbs/A	3.3 de	7.1 bcd	4.2 bc	4.9
16	Check	0.0 f	0.0 g	0.0 g	0.0

* All oils were supplied by the American Oil Company.

** 0 meaning no effect; 10 meaning complete plant kill. Any two means in individual columns followed by the same letter are not significantly different at the 5% level as determined by Duncan's Multiple Range Test.

*** Experimental spraying error resulted in missing plots.

E. Experiment No. 4-11-66.

OBJECTIVE: The objective of this experiment was to compare various selective herbicides for controlling woody vegetation on highway rights-of-way.

MATERIALS AND METHODS: This experiment was established on Highway 64 in Scott County, District 4. Treatments consisted of 13 different herbicide treatments plus a check and were replicated 3 times. Each plot was approximately 500 sq ft in area. Five of the treatments used were granular materials and were applied by hand. The other materials were sprayed in water solution at the rate of 100 gals/acre of solution. The experiment was established on June 21, 1966. Plots were rated on September 1, 1966. No additional herbicides were applied in 1967 but the plots were again rated in September 1967 to evaluate regrowth. All data were subjected to analysis of variance.

RESULTS AND DISCUSSION: The woody species most prominent in this experiment were winged elm, American elm, maple, sycamore, hickory, semac and various species of vines. The average ratings presented in Table 27 indicate that, of the materials applied as sprays, only Ammate X was significantly different in degree of control of woody vegetation. Ammate X is essentially a contact herbicide. It defoliated the vegetation soon after application, but, at the time the plots were first rated, regrowth of leaves had occurred. The combination of Tordon plus 2,4-D or 2,4,5-T appeared to be quite effective in controlling woody species present. Tordon has the advantage of being essentially non-volatile which makes it somewhat safer to use than 2,4-D or 2,4,5-T around susceptible field crops such as soybeans or cotton, however, if Tordon is in contact with these crops it is usually more severe in effect than the other materials.

CONCLUSIONS: The treatments containing Tordon, 2,4-D, and 2,4,5-T appear to have given the best residual control of woody species through two years after treatment. The granular formulation of Tordon 10K at 7.5 lbs/acre resulted in much better control the second year than the first. The second year this material was equal to the other Tordon treatments in brush control. Granular materials are much more expensive than liquid formulations, however, they do not present the danger of spray drift near susceptible crops. Several factors may need to be weighed in selecting a formulation of herbicide for use on highway rights-of-way.

A P P E N D I X

AN INTERIM GUIDE FOR ESTABLISHING AND MAINTAINING GRASSES AND LEGUMES AND CONTROLLING UNDESIRED VEGETATION ON HIGHWAY RIGHTS-OF-WAY

Seedbed Preparation and Seeding Methods

A well-prepared seedbed is essential when seeding or sprigging highway rights-of-way. This could be accomplished by several methods, such as disking, raking, or harrowing. Regardless of the method used, the soil should be broken with the contour of the slope and to a depth of about two inches. The seed can either be drilled or broadcast. If the seed are not drilled into the soil, a light disking or raking is necessary to cover the seed. To conserve moisture and reduce erosion, the seedbed should be covered with a straw mulch at the rate of two tons per acre. Emulsifiable asphalt at the rate of 0.1 gallon per square yard should be sprayed over this straw as a "tie-down" material.

If a hydro-mulcher is used for seeding, the mulch, fertilizer, and seed can be incorporated into one operation. The seedbed should be prepared the same as for dry seeding. A manufactured wood cellulose mulch material should be used when seeding with this machine. When sprigging with the hydro-mulcher, unless known clean sprigs are used, the sprigs should be dipped in a vat or tub of water to allow metal objects to drop to the bottom before dumping into the sprayer tank. Mulch should be applied at the rate of 1,000 to 1,400 pounds per acre, depending upon the manufacturer's recommendation, when seeding or sprigging. However, after sprigging a second application of mulch at the rate of about 500 pounds per acre should be made to cover any exposed roots that were not covered with the first application.

If adequate rainfall is not received during the establishment phase, supplementary water must be supplied in order to obtain satisfactory stands.

TENTATIVE SEEDING GUIDE, WITH VARIETIES, RATES, DATES, AND FERTILITY REQUIREMENTS FOR NORTHERN AND SOUTHERN ARKANSAS

Northern Arkansas *

Species and Variety	Rate	Dates	Fertility #/A. **
Tall Fescue (Ky. 31)	45#/A.	Mar. 1-May 1 or Sept. 1-Oct. 15	800# 10-20-20 ***
Bermuda Seed (Common)	15#/A.	Apr. 15-June 15	800# "
Bermuda Sprigs (Common)	60-75 Bu./A.	Feb. 1-July 15	800# "
Redtop (Common)	20#/A.	Mar. 1-May 1 or Sept. 1-Oct. 15	800# "
Weeping Lovegrass	10#/A.	April 15-June 15	800# "
Ryegrass (Annual)	90#/A.	Sept. 1-Oct. 15	800# "
Lespedeza (Sericea)	90#/A.	Mar. 15-May 15	500# 12-12-12
White Clover (Common)	10#/A.	In combination with above grasses if desired.	None if seeded with grasses. 800# 0-20-20 if seeded alone.

* Northern Arkansas - All areas in Districts 5, 8, 9, and 10 and the northern five counties in District 4.

** Obtain soil samples from each major soil area and send to Soil Testing Laboratory, Fayetteville, Arkansas, for pH analysis.

pH 5.0 or below, apply 3 tons lime per acre
pH 5.0 to 5.5, apply 2 tons lime per acre
pH above 5.5 - no lime needed

If no soil test is available, apply 2 tons of lime per acre as a general application.

*** Or equivalent total amount of plant food.

Southern Arkansas *

Species and Variety	Rate	Dates	Fertility #/A. **
Tall Fescue	45#/A.	Mar. 1-May 1 or Sept. 1-Nov. 1	800# 10-20-10 ***
Bermuda Seed (Common)	15#/A.	Apr. 1-June 1	800# "
Bermuda Sprigs (Common)	60-75 Bu./A.	Feb. 1-Aug. 1	800# "
Bahia (Pensacolia)	45#/A.	Apr. 1-June 1	800# "
Weeping lovegrass	10#/A.	Apr. 15-June 15	800# "
Ryegrass (Annual)	90#/A.	Sept. 1-Nov. 1	800# "
Lespedeza (Sericea)	90#/A.	Mar. 15-May 15	500# 12-12-12
White Clover (Common)	10#/A.	In combination with above grasses if desired.	None if seeded with grasses. 800# 0-20-20 if seeded alone.
Crimson Clover (Dixie or Chief)	60#/A.	Sept. 1-Nov. 1	800# 0-20-20

* Southern Arkansas - All areas in Districts 1, 2, 3, 6, and 7 and the southern two counties in District 4.

** Obtain soil samples from each major soil area and send to Soil Testing Laboratory, Fayetteville, Arkansas, for pH analysis.

pH 5.0 or below, apply 3 tons lime per acre
pH 5.0 to 5.5 apply 2 tons lime per acre
pH above 5.5 no lime needed

*** Or equivalent total amount of plant food.

Maintenance

Clipping:

Clipping should be limited, mainly, to control of weeds, until the desirable species are well established. After establishment, grasses should not be clipped lower than four inches. Sericea lespedeza should be clipped only after it has reached 24 inches high, and it should not be clipped lower than four inches. Crimson clover should be allowed to seed before clipping to insure reseeding for an adequate stand in the fall. Weeping lovegrass should not be clipped more than one time per growing season.

Fertility:

A good initially established sod is often gradually lost due to a lack of fertility maintenance. An application of 500 pounds per acre of 10-20-10 fertilizer, or equivalent total amount on an alternate-year program, should be sufficient to maintain a good stand. If better growth is desired, additional nitrogen may be applied. In the delta counties of East Arkansas, the addition of 10-20-10 fertilizer is not usually necessary since the soils in this area are high in phosphorus and potassium.

Chemical Weed Control

Good maintenance practices will help to prevent weed problems. However, if weeds are a problem many herbicides may be used to good advantage on highway rights-of-way for weed control, but certain precautions must be observed during applications.

1. Never spray when wind velocity exceeds 10 miles per hour but for the hormone type herbicides, such as 2,4-D, when above 5 miles per hour.
2. Spray pressure should not exceed 30 psi under ordinary spraying conditions.
3. When spraying highly volatile herbicides such as 2,4-D or 2,4,5-T, care should be taken not to spray near growing crops or trees.
4. Rate of herbicide application should not exceed recommended rates.
5. Soil applications of any herbicide should not be made near desirable trees or other woody vegetation.
6. Manufacturers label precautions should be followed when using any herbicide.

Broadleaf Weed Control

Broadleaf weed control is the control of annual and perennial weeds which have contaminated a stand of desirable grass. Ordinarily, control may be obtained by applying 0.75-1.25 pounds of active 2,4-D amine salt per acre in water. The amount of water is not critical. Apply spray when weeds are in an active growing condition. The 2,4-D should not be applied to a grass-clover mixture.

Soil Sterilization

Soil sterilants can be used very effectively where vegetative growth of any kind is not desired. Sterilants can be applied around sign and delineator posts, around bridges, under guardrails, and along fence lines where terrain is relatively level. Care should be taken not to apply soil sterilants to steep slopes, because rainfall will cause the chemical to move down the slope. However, moisture is required to carry the chemical into the root zone of the soil. Particular care should be used to follow the manufacturers recommended application rate of soil sterilant, since excessive rates will result in increased vegetative damage from movement of the chemical in runoff.

All soil sterilants listed below have been tested for their effectiveness in controlling vegetative growth. A given sterilant may control certain weed species better than some others, but generally speaking the soil sterilants listed are effective on most weed species found in Arkansas. The soil sterilant to use depends primarily on its relative cost and whether one wishes to apply it as a spray or in a granular form. The cost of a given sterilant per unit area is dependent on the rate of active material applied per unit area. Generally a soil sterilant applied as a spray is somewhat less expensive than a comparable granular formulation, but the granular material is easier to apply and requires less technical supervision. Most of the soil sterilants should be applied prior to initiation of vegetative growth or shortly thereafter.

Soil sterilants which have been tested and found to be effective for controlling vegetative growth.

Soil Sterilant**	Formulation	Suggested* Rate per acre	Rate per 100 sq. ft.
Baron	Emulsion	30-40 gals.	-
Borocil	Granular	200-400 lbs.	0.5-1.0 lb.
Chlorea	Granular	400-800 "	1.0-2.0 "
Chlorvar Granular	Granular	400-800 "	1.0-2.0 "
Hyvar X	Wettable powder (Spray)	10-30 "	-
Monobor Chlorate Granular D	Granular	400-1300 "	1.0-3.0 "
Pramitol 5E	Granular	400-800 "	1.0-2.0 "
Simazine 80W	Wettable powder (Spray)	20-30 "	-
Telvar	Wettable powder (Spray)	20-60 "	-
Ureabor	Granular	400-800 "	1.0-2.0 "
Urox	Granular	100-200 "	0.25-0.50 lb.

* The lighter rate is usually sufficient for easy to kill annual weeds. The heavier rate is usually recommended for hard to kill perennial weeds and when residual control is desired.

** Trade, common, and chemical names of soil sterilants listed:

Trade name	Common name	Chemical name
Baron	erbon	/2-(2,4,5-trichlorophenoxy) ethyl-2,2-dichloropropionate/
Borocil	–	disodium tetraborate penta and decahydrates, and bromacil
Chlorea	CBMM	chlorate-borate-monuron mixtures
Chlorvar Granular	chlorvar	sodium chlorate, sodium metaborate, and bromacil (5-bromo-3-sec-butyl-6-methyluracil)
Hyvar X	bromacil	5-bromo-3-sec-butyl-6-methyluracil
Monobor Chlorate Granular D	MCGD	sodium metaborate tetrahydrate, sodium chlorate and /3-(3,4-dichlorophenyl)-1,1-dimethylurea/
Pramitol 5E	pramitol	sodium chlorate, sodium metaborate and prometone /2-methoxy-4,6-bis(isopropyl-amino)-s-triazine/
Simazine 80W	simazine	2-chloro-4,6-bis(ethyl-amino)-s-triazine
Telvar	monuron	3-(p-chlorophenyl)-1,1-dimethylurea
Ureabor	BMM	borate-monuron mixtures
Urox	monuron TCA	3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate

Research personnel on this project have tested all sterilants in the above list and found them to be satisfactory. However, there are many soil sterilants on the market that are not included in the above list. In addition, new sterilants and new formulations and new mixtures of old reliable sterilants are introduced as new products annually. We do not imply that the sterilants listed are the only ones that should be used. Instead, this list serves only as a guide and we suggest that any old or new products which have been shown to adequately control vegetation be considered as possible candidates for your soil sterilization program.

Growth Retardants

In certain areas, such as along fences, delineator posts, median strips and sign posts, it may be desirable to reduce the amount of hand mowing without killing the vegetation. In these instances, the use of a growth retarding chemical will greatly reduce the amount of hand mowing.

Maleic hydrazide (MH-30) has been proven quite effective in reducing the amount of growth of bermudagrass and fescue. However, it may be necessary to apply chemicals to control weedy species which appear after the growth of bermudagrass and fescue is reduced. Mixtures of MH-30 and 2,4-D may also be applied to eliminate existing broad-leafed weeds.

MH-30 should be applied at the rate of 4 to 6 pounds active material per acre. It should be applied early in the season when vegetative growth does not exceed 4 inches in height. Growth retardation is effective for 6 to 8 weeks, therefore it may be necessary to make two applications during the growing season.

Johnsongrass Control

In experimental tests that we have put out we have not been able to show complete Johnsongrass control in pure stands. However, in Bermudagrass turf that was heavily infested with Johnsongrass, essentially complete control of Johnsongrass has been consistently obtained when treated with either of the two organic arsenicals MSMA (monosodium methanearsonate) or DSMA (disodium methanearsonate). The choice of which of the two herbicides to use depends entirely on cost and convenience. DSMA is a powder that is completely water soluble and somewhat less expensive than MSMA. However, MSMA is a liquid and somewhat easier to handle and mix. Both herbicides are equally effective on Johnsongrass but neither one injures the Bermudagrass turf (the organic arsenicals are also non-injurious to fescue).

The first herbicide treatment should be applied to the Johnsongrass in the spring after it has attained a height of 12-18 inches and anytime thereafter up until the seed head forms. Spray DSMA or MSMA at the rate of 2.5-3.0 pounds of active ingredient per acre in a water solution at the rate of 40-50 gallons per acre (amount of water is not critical but good coverage of the Johnsongrass is essential). A surfactant must be added to the spray solution in the amount of 0.25-0.5 percent by volume. Johnsongrass will usually turn brown from four days to two weeks after treatment. When

Johnsongrass regrowth occurs the area should be mowed. The herbicide should be reapplied when the Johnsongrass again attains a height of 12-18 inches. Two applications of DSMA or MSMA the first year is usually adequate. Spot treatment of Johnsongrass clumps may be required the following season. Spot treatment of Johnsongrass clumps can easily be made by using a back-pack sprayer equipped with a one-nozzle hand controlled boom. Note: Neither DSMA or MSMA are injurious to broad-leaved crops such as soybeans or cotton.

The organic arsenicals can also be used on pure Johnsongrass stands, but regrowth from rhizomes and seed usually occurs very quickly. Better control of pure Johnsongrass stands can usually be obtained with the herbicide known as Dowpon (2,2-dichloropropionic acid). Good Johnsongrass control can be expected when Dowpon is applied in the following manner: Mow Johnsongrass when it has attained a height of 6-12 inches in the spring. After new growth reaches 6-12 inches, spray Dowpon at the rate of 10 pounds actual material (8.5 pounds active) per acre in 40-50 gallons of water per acre. Johnsongrass foliage will turn brown. After 4-6 weeks regrowth will again have reached a height of 6-12 inches. Mow and respray as described above. This procedure should be followed for at least three complete cycles per season. The following spring a stand of desirable grass such as Bermudagrass should be established. Spot treatment of Johnsongrass with DSMA or MSMA may be required during the summer. (CAUTION: Dowpon will kill all grass vegetation including Bermudagrass).

Brush Control

Certain areas on highway rights-of-way require hand-cutting to control brush and young trees. These areas can be sprayed with a herbicide which will eliminate much of the hand-cutting. Several herbicides are available that will do a good job of controlling most of the woody vegetation on any one area. The herbicide to use will depend on the species to be controlled, availability of the herbicide, and the cost. In many cases a mixture of two herbicides will be more effective than a single herbicide, especially if several species of brush or trees are present.

Some herbicides that have been tested and have given good results are: 2,4,5-T, 2,4-D plus 2,4,5-T, Tordon (4-amino-3,5,6-trichloropicolinic acid), Tordon plus 2,4-D and/or 2,4,5-T, Banvel D (3,6-dichloro-0-anisic acid). These herbicides should be applied as a spray, usually in the springtime as soon as leaves are full-grown. The spray material and fumes from the herbicides will cause damage to all broad-leaved crops. Therefore, susceptible crops should not be closer than 100 yards and wind velocity should not exceed five miles per hour when herbicide is being applied.

Tordon, 2,4-D, 2,4,5-T, and Dybar (3-phenyl-1-1-dimethylurea) are available in granular formulations. These formulations have been tested on woody vegetation and generally have given satisfactory results. In some cases the granular herbicides may be preferred over the liquid formulations. Regardless of the type of herbicide formulation selected, the manufacturers rate recommendations, precautions and methods of application which appear on the label should be explicitly followed in all cases.

EROSION CONTROL

ON

HIGHWAY RIGHTS-OF-WAY IN ARKANSAS

HRC-15

Bibliography

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The following bibliography lists publications from which information was obtained before the project was begun in July 1963 and during the time the study was being done.

HRC-15

EROSION CONTROL ON HIGHWAYS RIGHTS-OF-WAY

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