# THE EVALUATION OF VARIOUS HERBICIDES FOR THE SELECTIVE CONTROL OF JOHNSONGRASS (SORGHUM HALEPENSE L.) ON OKLAHOMA HIGHWAYS

By

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# CHAPTER I

## INTRODUCTION

Infestations of johnsongrass (Sorghum halepense L.) are frequent along Oklahoma highways. If allowed to grow, the plants often exceed heights of six feet. This tall, dense growth frequently interferes with the safe operation of motor vehicles by creating "blind" curves, intersections, and railway crossings and obscuring signs and bridge abutments.

A substantial portion of the cost of maintenance of Oklahoma highways is allocated for the mechanical mowing of johnsongrass. The objective of this mowing commonly is to remove the driving hazard created by the plant, with the idea that the mowing might reduce the stand of johnsongrass. It would, however, take frequent mowing at low heights to obtain any degree of control and the expense involved would be prohibitive.

Johnsongrass spreads by rhizomes and seeds, with the plant food reserves being generated quickly following seedling emergence. The very nature of the plant suggests that a chemical herbicide be used for its control and eradication. In order to obtain the desired control of johnsongrass it is necessary that the herbicide be translocated throughout the entire plant, including the rhizome.

It is hoped that through the use of selective herbicides johnsongrass infestations can be reduced while a desirable vegetative ground cover will be allowed to grow and develop.

This research was initiated to evaluate the effectiveness of chemical herbicides for the suppression and eradication of johnson-grass along Oklahoma highways.

## CHAPTER II

## LITERATURE REVIEW

It would seem that the organic arsenicals are the leading herbicides used for the selective control of johnsongrass. Spooner (17) reports that the methanearsonates, such as disodium methanearsonate (DSMA) and monosodium methanearsonate (MSMA), when applied at the rate of 3.0 pounds per acre, eliminated 90 percent of the johnsongrass treated in 1964, with no reduction of the stand of bermudagrass present in the test plots. Regrowth of johnsongrass during the second year appeared to be primarily from seed. Reapplication of the two herbicides gave approximately 90 percent control of the regrowth in 1965. When applied at the same rate, there was no significant difference between the two herbicides in controlling johnsongrass.

Rumburg, Engel, and Meggitt (11) found that temperatures below 65°F tend to retard the action of the arsonates, while temperatures above 65°F tend to increase their effectiveness. Widiger (18) has reported that best results are obtained when the arsenicals are applied during conditions of high temperatures and clear, sunny skies.

Sckerl and Frans (12) showed that johnsongrass plants treated with a foliage application of $C^{14}$-methanearsonic acid (MAA-$C^{14}$) would translocate the material throughout the entire plant 24 hours after treatment. It has been assumed that the MAA will move and react in much the same manner as DSMA and MSMA after entering the plant.

Millhollen (9) states that multiple applications of MSMA at 3.6 pounds per acre effectively reduced the stand of rhizomatous johnsongrass.

For many years dalapon (sodium 2, 2 dichloroproprionate) has been used widely for partial control of johnsongrass. Anderson (1) reported that three or more applications of dalapon during the same growing season are essential for effective control of johnsongrass and that with repeated applications dosages as low as six pounds per acre are as effective as higher ones, when applied to johnsongrass six to ten inches tall.

Dalapon applied three times at the rate of 8.5 pounds per acre eliminated virtually all the johnsongrass in the test plots in 1964, according to Sckerl, Frans, and Spooner (13). It also removed bermudagrass from the test areas. Hicks and Fletchall (5) state that dalapon is a short-term johnsongrass control chemical, however, dalapon does not prevent seedling emergence. McWhorter (7) reports that dalapon will give more residual control than the arsenicals but points out that dalapon is ineffective in dry weather and on mature johnsongrass.

The use of mechanical mowing has proven to be effective as a means of enhancing the chemical control of johnsongrass, according to Hicks and Fletchall (6). Hicks (4) reported that johnsongrass was controlled along the roadside with 7.4 pounds per acre of dalapon applied to regrowth, after mowing, in August of 1962. In a study conducted by Sinkler, Huffine, and Santelmann (16) DSMA and dalapon treatments were more effective on mowed johnsongrass plots (12 to 18 inches tall) than on unmowed, seedhead stage plots.

Scott (14) used bromacil (5-bromo-3-sec-butyl-6-methyluracil) at the rate of 4 to 8 pounds per acre repeated one to two times on johnsongrass 12 to 24 inches tall and received 90 to 100 percent control the second season. Commer (2) reported that bromacil applied at a 10 to 15 pound per acre rate along with DSMA gave effective control of johnsongrass, however, it was observed that virtually all vegetation was removed by this treatment.

Monobor-chlorate (MBC) reduced the stand of johnsongrass 90 to 100 percent in one season, according to Sinkler (15). Woestemeyer and Cooper (19) found that MBC-bromacil combinations used at the rate of 960 pounds per acre of MBC and 12 pounds per acre of bromacil gave longer lasting control than MBC used by itself.

Miles (8) reports that prometone 25E (2-methoxy-4, 6-bis (isopropylamine) s-triazine) at the rate of 20 pounds per acre has controlled johnsongrass when applied before the johnsongrass heads out. Hernandez (3) and Rea (10) have reported the use of arsenical-bromacil and arsenical-CIPC combinations for the control of johnsongrass.

## CHAPTER III

## METHODS AND MATERIALS

In June 1965 a program to evaluate the use of herbicides for control of johnsongrass along Oklahoma highways was initiated. The first of three studies was located in central Oklahoma on US 177 near Meeker, the second was near Fort Gibson on SH 80 in eastern Oklahoma, and the third was on US 64 near Alva in northwest Oklahoma. Two similar studies were begun in August 1965: one in southeast Oklahoma near Ada on SH 3, and one in south-central Oklahoma on US 70 near Texoma.

In June 1966 a rate of application study of bromacil-MBC combination was started on SH 51 west of Stillwater in north-central Oklahoma. The object was to find a rate of this herbicide combination that would give long-lasting control of johnsongrass while allowing a desirable ground cover to survive. This experiment was set up in a randomized block design having three replications. Two chemicals, bromacil and MBC, were used in a factorial arrangement in which bromacil, at five different levels, was applied in combination with MBC at two different levels. The rates of each chemical are given in Table I. A check plot was also run. The plots, which were mowed and allowed to regrow to a height of 12 inches before treatment, were 10 by 50 feet in size.

In addition to these experiments, the herbicide evaluations for the control of johnsongrass initiated in 1963 were continued. One of these experiments was located on I 35 near Mulhall and the other on

TABLE I

HERBICIDES AND RATES USED AT TEN LOCATIONS SINCE 1965

| Herbicide | Rates lbs. a.i. | Location | Years Applied 1967 | 1966 | 1965 |
|---|---|---|---|---|---|
| Bromacil & MBC | 12 & 960/A | Alva | | 1 | 1 |
| MBC | 500 & 1000/A | Fort Gibson | 1 | 1 | 1 |
| DSMA | 2.5 & 5.0/A | Meeker | 1 | 1 | 1 |
| Dalapon | 10 & 15/A | | | | |
| CMA | 1.5 & 2.5/A | | | | |
| Diuron | 2.0 & 4.0/A | | | | |
| Prometone 25E | 40/A | Ada | 1 | 1 | |
| Dalapon & TCA | 12.5/A | Texoma | 1 | 1 | |
| Dalapon | 7.5/A | | | | |
| DSMA | 2.5 & 5.0/A | | | | |
| MSMA | 2 & 3/A | | | | |
| Bromacil & DSMA | 3 & 5/A | | | | |
| Bromacil & MSMA | 3 & 3/A | | | | |
| Diuron & DSMA | 3 & 5/A | | | | |
| Diuron & MSMA | 3 & 3/A | | | | |
| Bromacil & MBC | 0 & 250/A | Stillwater | | 1 | |
| Bromacil & MBC | 2 & 250/A | | | | |
| Bromacil & MBC | 4 & 250/A | | | | |
| Bromacil & MBC | 6 & 250/A | | | | |
| Bromacil & MBC | 8 & 250/A | | | | |
| Bromacil & MBC | 0 & 500/A | | | | |
| Bromacil & MBC | 2 & 500/A | | | | |
| Bromacil & MBC | 4 & 500/A | | | | |
| Bromacil & MBC | 6 & 500/A | | | | |
| Bromacil & MBC | 8 & 500/A | | | | |
| DSMA | 3 & 5/100 gal. | Mulhall | | | 1 |
| Dalapon | 10 & 15/A | Perkins | | | 1 |
| MBC | 1.5 & 2.5/100 sq.ft. | | | | |
| CMA | 1.5 & 2.5/A | Pawnee | | 1 | 1 |
| DSMA | 3 & 5/100 gal. | Sand Springs | | | 1 |
| Dalapon | 10 & 15/A | | | | |
| MBC | 1.5 & 2.5/100 sq.ft. | | | | |

SH 33 near Perkins, both in north-central Oklahoma. In 1964 two additional experiments were begun: one on US 64 near Sand Springs in northeast Oklahoma, and one on SH 18 near Pawnee in north-central Oklahoma. The herbicides evaluated in these experiments are described in Table I.

All herbicides were applied on the basis of pounds of active ingredient (a.i.) per acre needed for each experiment, except for the Mulhall, Perkins, and Sand Springs experiments. These were treated on a volume basis as originally used (15), which involved spraying the foliage until run-off. In 1965 herbicides were applied with a two-gallon, hand-operated, pressure sprayer. In 1966 a change was made to a power-spray gun, using a John Bean pump with a capacity of 5 g.p.m. Half of the plots in each experiment were mowed, thereby providing two stages of johnsongrass growth: 12 to 18 inches tall (mowed plots), and seedhead stage (unmowed plots). Identical rates of herbicides were applied to both stages of growth at the same time.

The experiments began in 1965 and in 1966 were laid out in a randomized block design consisting of an arrangement of two treatments: herbicide and management. These studies consisted of 11 herbicide treatments (Table I) and one check plot for each of the two stages of growth, for a total of 24 treatments per replication. Each treatment was replicated four times on 10 by 10 feet plots, for a total of eight plots per herbicide and 96 plots per experiment. The check plots did not receive any herbicide treatment as they were used as a reference for determining the amount of johnsongrass control obtained from each herbicide. Those studies began in 1963 (15) and in 1964 were laid out in the same manner except for the plots near Sand Spring, which were $16\frac{1}{2}$ feet (one rod) square, and the plots at Pawnee, which were 10 by 12 feet.

The procedure for retreatment of the following season's growth was the same for all experimental work conducted since 1965, except for those experiments which were treated by volume. Retreatments were applied according to the individual need of each herbicide.

All experiments were evaluated in the fall of the year and again the following spring. This was achieved by actual plant count, using a one foot square quadrat. Ten readings per plot were taken for those experiments containing 10 by 10 feet and 10 by 12 feet plots; 20 readings per plot were taken for the rod square plots; and 50 readings per plot were taken for the 10 by 50 feet plots. A reading consisted of tossing the quadrat, at random, into the plot and counting each johnsongrass stem inside the quadrat.

# CHAPTER IV

## RESULTS AND DISCUSSION

The statistical analysis of the data collected from all experiments clearly shows a significant difference between treatments of johnsongrass with chemical herbicides. The "F" values are shown in Table II.

In some cases there is a significant difference between management practices, as can be seen in Table III, however, there is no indication of interaction between management and treatment, except in the Ada and Texoma studies. In those experiments, where management was significant but where no significant interaction occurred, the difference between the mowed and unmowed treatments essentially paralleled the amount of control for each herbicide treatment. Generally speaking, the mowed plots produced better control for all treatments due to the more thorough coverage of the foliage while the johnsongrass was in this 12 to 18 inch stage of growth.

It is believed the reason for this significant interaction between management and herbicides is that at the time of herbicide application the unmowed johnsongrass was in a mature stage of growth and was showing the effects of drought. The mowed johnsongrass was about 14 inches tall and growing well despite the droughty conditions of the area. It is thought that the metabolic rate of the young plants was much higher than that of the older, semi-dormant plants. This indicates that the

TABLE II

ANALYSIS OF VARIANCE "F" VALUES FOR TREATMENTS IN THE CONTROL OF JOHNSONGRASS BASED ON ACTUAL PLANT COUNT IN THE FALL AT TEN LOCATIONS FOR ONE OR MORE YEARS

| Location | "F" Values** | | |
|---|---|---|---|
| | 1967 | 1966 | 1965 |
| Ada | 26.3195 | | |
| Alva | | 8.5341 | 15.5702 |
| Fort Gibson | 27.8113 | 34.2163 | 26.5167 |
| Mulhall | | | 25.7230 |
| Meeker | 41.1999 | 19.0201 | 23.2024 |
| Sand Springs | | | 10.6349 |
| Pawnee | | 34.2580 | 9.1126 |
| Perkins | | | 7.5686 |
| Stillwater | | 78.4450 | |
| Texoma | | 13.1902 | |

**Significant at the 1% level of probability.

TABLE III

ANALYSIS OF VARIANCE "F" VALUES FOR MANAGEMENT IN THE CONTROL OF JOHNSONGRASS BASED ON ACTUAL PLANT COUNT IN THE FALL AT NINE LOCATIONS FOR ONE OR MORE YEARS

| Location | "F" Values | | |
|---|---|---|---|
| | 1967 | 1966 | 1965 |
| Ada | 57.2492** | | |
| Alva | | .2236 | 4.6524* |
| Fort Gibson | 1.7985 | .0288 | 27.9212** |
| Mulhall | | | .5825 |
| Meeker | 6.8292* | .5763 | 6.3042* |
| Sand Springs | | | 2.8932 |
| Pawnee | | 1.8717 | .8944 |
| Perkins | | | 6.2254* |
| Texoma | | 176.2449** | |

* Significant at the 5% level of probability.
**Significant at the 1% level of probability.

younger plants would have absorbed the herbicide more readily than the older plants, thus producing the significant difference between the mowed and unmowed plants.

Many of the herbicides used produced the desired control, however, all treatments except the arsenicals killed the existing bermudagrass. It is on this basis that these herbicides which killed the bermudagrass are arbitrarily deemed not practical for the selective control of johnsongrass. The results of the experiments at Fort Gibson, Alva, Ada, and Texoma are the basis for this conclusion. The Meeker experiment did not have bermudagrass present from its initiation in 1965. By the summer of 1967, the DSMA and CMA treated plots at Fort Gibson were 100 percent covered with bermudagrass. The Alva experiment was showing essentially the same pattern of bermudagrass cover. At neither location was there bermudagrass present in the dalapon, diuron, or bromacil-MBC treated plots. The MBC plots had some bermudagrass moving in from the highway shoulders.

The Ada and Texoma locations showed bermudagrass cover increasing in the arsenical treated plots as opposed to little or no bermudagrass present in the plots treated with other herbicides. The bromacil-arsonate combinations were showing signs of live bermudagrass whereas the prometone, dalapon, dalapon-TCA, and the diuron treated plots had none of the bermudagrass that had been present when the experiments were begun.

The results of the experiment near Stillwater yielded no significant difference among rates of bromacil-MBC in the control of johnsongrass. All treatments produced excellent control but only the 250 pound per acre rate of MBC without bromacil allowed the bermudagrass to survive to a desirable degree.

The MBC, bromacil-MBC, and the bromacil-arsenical herbicide treatments need more investigation as to their toxicity to bermudagrass before they can be totally eliminated for the selective control of johnsongrass.

Of the three arsenicals used in this study, only DSMA and MSMA gave the desired results. Both rates of CMA were very erratic in their control of johnsongrass, with the control from the 2.5 pound per acre rate ranging from a high of 99 percent to a low of 50 percent. On the whole, the 2.5 pound per acre rates averaged less than 80 percent control and the 1.5 pound rate control was considerably lower.

The statistical data presented in Table IV shows 5 "F" values that indicate a significant difference between the two rates of DSMA used in this study. It is believed that these differences are not due to the rates of herbicides used but rather to environmental effects and the methods of application. The data for Fort Gibson in 1966 shows a significant difference due to a large number of live plants in the mowed 2.5 pound per acre plots. When the plant count was taken, three of the four mowed plots had a large amount of seedling johnsongrass present; the rest of the DSMA plots did not. It was noted that in those plots with the large amount of seedling growth there was little or no bermudagrass present, whereas the other DSMA plots had bermudagrass present. It is therefore surmised that this canopy of bermudagrass suppressed the germination of johnsongrass seed.

In 1966 the evaluation of the mowed areas at Fort Gibson (Table V) showed 68 percent control, with the remaining three readings all over 90 percent. The three plots with the large amount of seedling growth

TABLE IV

THE "F" VALUES OBTAINED FROM THE COMPARISON PERFORMED ON THE DATA COLLECTED FROM THE TWO RATES OF DSMA USED FOR ONE OR MORE YEARS AT NINE LOCATIONS

| Location | 1967 | 1966 | 1965 |
|---|---|---|---|
| Ada | 8.17** | | |
| Alva | | .1159 | .0041 |
| Fort Gibson | .1287 | 3.7256** | .1656 |
| Mulhall | | | 3.2188* |
| Meeker | .1091 | .0080 | .0003 |
| Sand Springs | | | .2016 |
| Pawnee | | .3005 | .5706 |
| Perkins | | 5.6977** | 2.254 |
| Texoma | 23.60** | | |

* Significant at the 5% level of probability.
**Significant at the 1% level of probability.

TABLE V

THE PERCENT CONTROL OF JOHNSONGRASS PRODUCED BY THE TWO RATES OF DSMA FOR ONE OR MORE YEARS AT NINE LOCATIONS

| | | Mowed | | | Unmowed | | |
|---|---|---|---|---|---|---|---|
| Location | Rate a.i. | 1967 | 1966 | 1965 | 1967 | 1966 | 1965 |
| Ada | 2.5/A | 92 | | | 65 | | |
| | 5.0/A | 98 | | | 94 | | |
| Alva | 2.5/A | | 70 | 78 | | 82 | 86 |
| | 5.0/A | | 93 | 87 | | 62 | 85 |
| Fort Gibson | 2.5/A | 93 | 68 | 89 | 99 | 90 | 79 |
| | 5.0/A | 99 | 92 | 85 | 99 | 94 | 76 |
| Mulhall | 3/100 gal. | | 55 | 56 | | 16 | 63 |
| | 5/100 gal. | | 52 | 78 | | 36 | 73 |
| Meeker | 2.5/A | 95 | 97 | 93 | 88 | 98 | 77 |
| | 5.0/A | 90 | 99 | 91 | 90 | 98 | 83 |
| Sand Springs | 3/100 gal. | | 49 | 54 | | 13 | 55 |
| | 5/100 gal. | | 41 | 44 | | 56 | 59 |
| Pawnee | 2.5/A | | 82 | 88 | | 88 | 86 |
| | 5.0/A | | 91 | 74 | | 88 | 77 |
| Perkins | 3/100 gal. | | 55 | 53 | | 52 | 41 |
| | 5/100 gal. | | 64 | 81 | | 53 | 70 |
| Texoma | 2.5/A | 72 | 88 | | 57 | 53 | |
| | 5.0/A | 93 | 93 | | 89 | 81 | |

present were responsible for the low percent control, thus, this seedling growth was responsible for the significant difference between rates for 1966.

The experiments at Ada and Texoma also showed significant differences between rates of DSMA but it is believed to be due to the stage of growth and drought factors described earlier. The significant difference between rates of DSMA in the Mulhall experiment was brought about by the method of application. In this experiment the herbicides were applied by volume, spraying the foliage until run-off. This uneven application tends to produce variations in control, which can cause a significant difference between rates.

On the basis of this data and knowledge at hand, there does not appear to be a valid statistical difference between rates of DSMA used. As seen in Table V, the 5 pound per acre rate generally has the higher percent of control, however, the difference is not great enough to warrant its use rather than the 2.5 rate.

The statistical data in Table VI shows a significant difference between the rates of MSMA for both the Ada and Texoma experiments. On the basis of only one year's data from the Ada experiment and two from Texoma plus the fact that neither the mowed nor unmowed treatments have given the desired results when using the 2.0 pound per acre rate of MSMA as shown in Table VII, it is concluded that the 3.0 pound rate is superior to the 2.0 pound rate for the control of johnsongrass.

Three of the four experiments initiated in 1963 and 1964 were retreated in 1965 following the same procedures used by Sinkler (15). The fourth experiment, Pawnee, was treated on the acre basis. Consistent results were obtained in the experiment treated on the acre basis

TABLE VI

THE "F" VALUES OBTAINED FROM THE COMPARISON PERFORMED ON THE DATA COLLECTED FROM THE TWO RATES OF MSMA USED FOR ONE OR MORE YEARS AT TWO LOCATIONS

| Location | "F" Values 1967 | 1966 |
|---|---|---|
| Ada | 9.40** | + |
| Texoma | 17.47** | 4.69** |

**Significant at the 1% level of probability.
+No reading taken due to an early frost.

TABLE VII

THE PERCENT CONTROL OF JOHNSONGRASS PRODUCED BY THE TWO RATES OF MSMA FOR ONE OR MORE YEARS AT TWO LOCATIONS

| Location | Rate a.i./A | Mowed | | Unmowed | |
|---|---|---|---|---|---|
| | | 1967 | 1966 | 1967 | 1966 |
| Ada | 2.0 | 78 | | 43 | |
| | 3.0 | 94 | | 68 | |
| Texoma | 2.0 | 48 | 86 | 50 | 44 |
| | 3.0 | 89 | 93 | 78 | 70 |

as compared to the erratic results obtained from the experiment sprayed on the volume basis. Further, all work initiated since 1965 has been done on the acre basis and the results have been reasonably consistent. It is therefore concluded that spraying johnsongrass on the acre basis will produce better control of the plant, especially when using the arsenical herbicides.

DSMA produced 90 percent control at the Fort Gibson and Meeker experiments. The first year's results reflected, primarily, the control of rhizomatous johnsongrass. This was determined by visual observation and random sampling of plants within the test plots in April 1966. By June the DSMA plots were infested with seedling johnsongrass. The continuous germination of seed made it necessary to treat twice more in 1966 and twice in 1967, however, the second treatment in 1967 was made only to prevent the production of new rhizomatous plants from the small amount of seedling plants in the plots.

The Alva experiment showed somewhat lower control than the Fort Gibson and Meeker experiments due to local floods, one in September 1965 and the second in the spring of 1966, which moved new soil and johnsongrass seed into the area thus causing a large increase in the seedling johnsongrass population. This increase resulted in erratic plant numbers and a lower percent control of johnsongrass.

The results of the Ada and Texoma experiments show the same pattern for DSMA as those found in the Fort Gibson and Meeker studies. MSMA, used for the first time in these experiments, yielded much the same results as the DSMA.

Based on these findings, it is thought that either DSMA or MSMA, used in conjunction with an effective pre-emergence herbicide, will give excellent control of johnsongrass within two years after initial treatment. This, together with a substantial cover of bermudagrass, should prevent reinfestation of johnsongrass within the treated areas, however, new research must be conducted in order to substantiate this theory.

## CHAPTER V

## SUMMARY AND CONCLUSIONS

In 1965 a detailed study of the selective control of johnsongrass through the use of chemical herbicides was begun. After carefully observing the results in the field and analyzing in detail the data collected, it was concluded that the methanearsonate herbicides, DSMA and MSMA, are best suited for use in controlling johnsongrass along Oklahoma highways.

DSMA plus 1% surfactant, when applied at 2.5 pounds per acre two to three times per year, will produce over 90 percent control within three years after initial application. Best results are obtained when the johnsongrass is treated while in a stage of growth between 12 and 18 inches in height and actively growing and when the sun is shining and the temperature is 80° F or higher.

In most cases DSMA will eliminate 90 percent of the rhizomatous johnsongrass during the first year. With this dense cover of foliage removed, the johnsongrass seed present in the area will be able to germinate. This constant supply of seed will necessitate the use of the herbicide for one to two more years, in which time the major portion of the seed population should be exhausted.

It has been noted that as this canopy of foliage was removed, bermudagrass present within the plots began to flourish and where there was no bermudagrass present previously, it soon began to move into the open areas from nearby sources such as the shoulder of the highway. MSMA with surfactant will give similar results, in all respects, when used at a rate of 3.0 pounds per acre.

The number of applications per year may vary from one area of the state to another, depending on the weather conditions prevailing at the time of application, however, DSMA and MSMA can be used effectively throughout the state for the selective control of johnsongrass.

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Experience: Worked on a dairy farm during summers from 1952-1957; worked as a carpenter's helper during summers from 1958-1962; worked on a golf course the summer of 1963; worked as a painter the summer of 1964; employed as a research assistant by the Department of Agronomy while a graduate student at Oklahoma State University.