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To the Graduate Council:

I am submitting herewith a thesis written by Kenneth W. Kemp entitled "Growing Corn, Cotton, and Soybeans in Soil Heavily Infested with Johnsongrass." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

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GROWING CORN, COTTON, AND SOYBEANS IN SOIL HEAVILY INFESTED WITH JOHNSONGRASS

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Kenneth W. Kemp

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CHAPTER I

INTRODUCTION

Johnsongrass (Sorghum halapense L.) was first introduced into the United States from Turkey in 1830 by Governor Means of South Carolina. Colonel William Johnson was the first to cultivate the grass extensively and it was named for him (27). Although some economic uses have been found for Johnsongrass, it has become one of the most serious weeds in row crops in the southern states.

Johnsongrass is usually found on the better farmland in Tennessee and is usually in direct competition with corn (Zea mays L.), cotton (Gossypium hirsutum L.), and soybeans (Glycine max L.), the major agronomic crops of this state.

The rapid rate of seed production and the persistence of viable seed in the soil enable Johnsongrass to spread by seedlings even after rhizomes have been almost eradicated (29). This unique character of Johnsongrass has made it one of the most despised weeds in the South.

Another characteristic of Johnsongrass which makes it troublesome in crop production is that it usually emerges early in the spring and grows at the same time as corn and cotton. Since both corn and cotton must be planted early in order to obtain high yields, Johnsongrass competes directly with them.

Studies by Overton and Andrews (28) indicated that repeated diskings of fallow soil reduce the number and vigor of Johnsongrass

rhizomes; however, these practices do not allow for the growth of a crop. Either mechanical or chemical fallow will prevent any crop from being grown concurrently in the treated area, thus eliminating income from the area.

The objective of this experiment was to determine the possibility of controlling Johnsongrass effectively by chemical or mechanical means or by a combination of the two and, at the same time, producing corn, cotton, and soybeans economically.

CHAPTER II

REVIEW OF LITERATURE

In a study of Johnsongrass morphology, Mississippi researchers (38) found that Johnsongrass plants produced, on the average, 212 feet of rhizomes and nearly one-and-one-half pounds of seed per season. They also found that young seedlings produced rhizomes from three weeks after emergence until maturity. The researchers stated that soon after Johnsongrass growth starts, the quantity of glucose and sucrose in the cutin of the plant drops to a low level; and at this stage of growth, Johnsongrass is most susceptible to chemical control.

McWhorter and Hartwig (27) reported that Johnsongrass may reduce crop yields by as much as 80 percent in the South and may occasionally cause complete crop failure. In Mississippi they found that ten diskings at four to six day intervals followed by planting soybeans in early June resulted in more effective Johnsongrass control and gave higher soybean yields than earlier planting dates with fewer diskings. The ten diskings at four to six day intervals controlled 90 percent of the Johnsongrass rhizomes. McWhorter and Hartwig discovered that intensive diskings controlled Johnsongrass by cutting extensive rhizomes into comparatively small sections and dehydrating these sections; this in turn initiated shoot development and depletion of food reserves.

Of the herbicides used for Johnsongrass control, 2, 2-dichloropropionic acid (dalapon) gave the best results when used postemergence

on Johnsongrass. Hicks (20) stated that an August application of dalapon at 3.7 or 7.4 pounds acid equivalent per acre significantly reduced the surviving rhizomatous Johnsongrass population in the spring following fall treatment. However, Hicks observed that the seedling plants which emerge after layby presented a continuing problem until the Johnsongrass seed in the soil had been depleted.

Hauser and Thompson (19) stated that dalapon is effectively and consistently translocated from Johnsongrass foliage to rhizomes. Translocation of dalapon was not affected critically by low soil moisture, reduced sunlight, or the use of additional wetting agent in the spray solution.

Experiments conducted by Foy and Miller (12) with dalapon and 1, 2-dihydro-3, 6-pyridazinedione (maleic hydrazide) revealed that dalapon provided more effective control of Johnsongrass. Maleic hydrazide gave satisfactory control when applied early to vigorous young regrowth after mowing but was otherwise ineffective.

Frans (13) concluded that there was no difference between 5-ethyl di-N, N-propylthiocarbamate (EPTC) and dalapon at 6 and 10 pounds per acre active ingredient, respectively, in the effectiveness of Johnsongrass control. However, Frans did observe damage to cotton from EPTC on clay soils when the cotton was planted the day of herbicide treatment or one week later.

Hicks and Fletchall (21) observed that EPTC prevented the emergence of Johnsongrass seedlings and severely retarded the growth and elongation of new shoots. The use of EPTC increased corn yields

but did not result in an appreciable degree of rhizomatous Johnsongrass control.

McWhorter (26) found that monosodium acid methanearsonate (MSMA) killed Johnsongrass foliage in greenhouse experiments; however, he did not get any indication that MSMA was translocated in the Johnsongrass plant.

Guse and Schwer (16) reported good Johnsongrass seedling control with alpha, alpha, alpha-trifluoro-2, 6-dinitro-N, N-dipropyl-para-toluidine (trifluralin) at 0.5 to 1.5 pound active ingredient per acre preplant incorporated. They also indicated that trifluralin was not effective in the control of rhizomatous growth in Johnsongrass.

Colby (9) and Peters et al. (30) found 3-amino-2, 5-dichloro-benzoic acid (amiben), applied at the rate of 3 pounds per acre active ingredient, to be successful in the control of Johnsongrass seedlings but not effective in rhizome control.

Many studies have been conducted to determine the effectiveness of mechanical fallow alone. These studies are concerned mainly with the elimination of a high percentage of the rhizomes and not with seedling control.

Overton and Andrews (28) found that two diskings every two weeks for five weeks gave 90 to 95 percent control of rhizomes. However, the repeated diskings prevented growth of any row crop and did not allow for any income from the area under treatment.

In Ohio Burt and Willard (7) found that plowing soils before September 15 (one month before frost) would control 70 to 95 percent

of the Johnsongrass rhizomes if 40 to 60 pounds per acre of trichloroacetic acid (TCA) or sodium chlorate at 100 to 200 pounds per acre was applied in September. Although they reported a high percentage of rhizome control, they recognized the importance of early plowing and early chemical treatment.

Intensive diskings plus soil sterilants have been quite successful in the control of Johnsongrass during one growing season; however, the primary interest of the weed scientist is to control Johnsongrass during the growing season and at the same time obtain a high yield from the respective crops grown in Johnsongrass infested fields (20).

Herbicide Review

Dalapon. Dalapon is a systemic herbicide which in herbicidally active on grass species at relatively low rates of application. It decomposes at 174 to 176° C and is soluble in water at 45 grams per 100 milliliters at 25° C. It is a quite stable compound, but dalapon solutions are corrosive to metals (14).

The herbicidal activity of dalapon is not adversely affected by reduced sunlight or low soil moisture, but an increase in soil pH from 4.5 to 6.5 or above decreases the absorption of dalapon. Dalapon is an effective protein precipitant (19).

Standifer and Ennis (33) treated quackgrass (Agropyron repens L.) with dalapon and found that within 30 minutes enough dalapon had entered the plant to kill the treated shoot and was translocated through an

attached rhizome to kill an untreated shoot. They also found that the maximum amount of absorption and translocation did not occur until 24 hours or longer after application. Another observation was that dalapon was absorbed more rapidly under conditions of high humidity than under low humidity.

According to Watson (41), dalapon is absorbed by and transported through living grass tissue; and it is absorbed by roots following application to the soil. Watson also stated that dalapon has a short residual effect in the soil.

Leasure (25) mentioned that dalapon, when properly used to take advantage of its systemic properties, should not be applied in sufficient concentration or in phytotoxic mixtures to cause acute foliage burn. He also noted that dalapon is not metabolized in the plant; but upon passing through the roots into the soil, it may be metabolized rapidly and, therefore, has a short residual effect as was reported by Watson.

Hicks (20) found significant reduction of Johnsongrass stands if dalapon was applied either at 3.7 or 7.4 pounds acid equivalent per acre.

Foy and Miller (12) obtained good control of Johnsongrass rhizomes if dalapon was applied at 4 to 7 pounds acid equivalent per acre in the early spring. They indicated best results were obtained if the Johnsongrass plants were 10 to 12 inches in height when treated.

Hicks and Fletchall (21) reported good rhizome control but no permanent control when dalapon was applied at 10 to 14 pounds per acre. They found dalapon retarded rhizome growth at these rates.

Amiben. Amiben is a selective herbicide which is taken up by the roots of plants. The crystalline form has a melting point of 201° C and is soluble in water at 700 ppm; however, it is insoluble in carbon tetrachloride, benzene, chloroform, ether, ethyl alcohol, methyl alcohol, and acetone (14).

Amiben is considered relatively safe to humans. Summarized data (14) indicate this material to have an acute oral LD-50 (lethal dose to 50 percent of population) of 3,500 to 5,620 milligrams per kilogram of body weight for rats.

Plants which are susceptible to amiben have been found to translocate more of the chemical than do tolerant plants, although it is taken up by the roots of both. Colby (9) also noted that soybeans possess considerable tolerance to amiben even when exposed directly to the herbicide.

Swan and Slife (35) stated that soybeans grown in soil treated with 3 pounds acid equivalent per acre of amiben were not retarded in their growth, whereas soybeans grown in soil treated with 6 pounds were. They found that soybeans grown with the 6 pound rate took up three to four times as much amiben as soybeans treated with one-half this rate; however, both rates gave good weed control.

Burnside and Colville (6) observed that amiben used in conjunction with tillage gave successful weed control. Lower rates could be used as tillage increased. However, without tillage, amiben rates of 2 to 4 pounds acid equivalent per acre were required to control the weeds in soybeans adequately. Peters et al. (30) found

that rotary hoeing did not reduce the effectiveness of amiben; it actually increased soybean yields.

Atrazine. 2-chloro-4-ethylamino-6-isopropylamino-s-triazine (atrazine) is a white solid material with a melting point of 173 to 175° C. It is almost insoluble in water but is quite soluble in methanol, ether and chloroform. Toxicological data indicate that atrazine has an acute oral LD-50 of 3080 milligrams per kilogram of body weight to rats (14).

Vengris (39) reported that atrazine is used extensively both as a preemergence and a postemergence herbicide to control annual weeds and grasses in corn.

Thomson (36) found atrazine to be a moisture-activated herbicide that is unique in corn as a preemergence herbicide. He also mentioned that corn and Johnsongrass completely metabolize atrazine so they are not injured by it. They decompose the atrazine molecule and release it through their respiration process. Thomson found that differences between cotton and oats in susceptibility to atrazine could be attributed to the differences in the rate of transport of the compound into leaves since cotton lost only about one-third as much water per gram of green leaf as oat plants. He concluded that it was the concentration of active atrazine in the leaf tissue, a factor that was the result of uptake, translocation, and breakdown, that determines the susceptibility of a plant to atrazine.

Castelfranco et al. (8) stated that corn and Johnsongrass accelerate the dissipation of atrazine from the soil. Since atrazine

at 2 to 4 pounds active ingredient per acre is detoxified by Johnsongrass, it is not expected that atrazine will control Johnsongrass at economically feasible rates.

Diuron. 3-(3, 4-dichlorophenyl)-1, 1-dimethylurea (diuron) in the crystalline form has a melting point of 158 to 159° C and is slightly soluble in water and oils. The acute oral LD-50 to rats is 3.4 grams per kilogram of body weight (14).

Diuron is a substituted urea compound used as a preemergence herbicide or as a layby treatment for cotton (36).

Hamilton et al. (17), using a preplanting application of diuron at 2 pounds active ingredient per acre, controlled annual weeds in cotton from April until midsummer.

Sheets (32) found that diuron at 2 pounds active ingredient per acre plus surfactant was an effective postemergence herbicide. He stated that the effectiveness of diuron depends on adequate soil moisture and sunlight, with the reduced effectiveness being a consequence of herbicide loss from soil by photodecomposition and volatilization. Sheets also mentioned that diuron is an effective inhibitor of the Hill reaction, an essential step in photosynthesis.

Experiments by Upchurch (37) dealing with soil moisture influence on herbicidal activity showed diuron to be more toxic under moist soil conditions than under dry soil conditions.

Thomson (36) found that diuron stayed near the soil surface due to its capacity to resist leaching since it has a low water solubility and is absorbed by the soil colloids. Diuron applied at

proper rates did not leach more than one inch. Jones (22) mentioned that diuron at high rates of application was persistent in the soil. He also stated that climatic differences from year to year exert a major influence upon persistence.

DNBP. 4, 6-dinitro-o-sec-butylphenol (DNBP) is a reddish brown liquid which is nearly insoluble in water; however, it is soluble in most organic solvents and oils. It is used both as a contact herbicide and as a preemergence soil treatment. DNBP has an acute oral LD-50 of 60 milligrams per kilogram of body weight for rats (14). According to Klingman (23), DNBP stimulates respiration in low concentrations and powerfully inhibits respiration at high concentrations.

Barrows (4) found that DNBP moved little within plants, and rapidly growing, succulent tissue was more susceptible to DNBP than was hardened growth.

In tests by Hanson (18), DNBP controlled morning glory and cocklebur. Practical control of seedlings of these species was obtained at 0.75 to 1.5 pounds active ingredient per acre while 1.5 to 3 pounds active ingredient per acre in repeat applications was required for larger plants. He stated that DNBP at 1.5 pounds active ingredient per acre appeared to control newly emerged annual grasses but larger grasses were not controlled.

Hanson (18) found soybeans to exhibit excellent tolerance to DNBP as a directed postemergence spray. Although various degrees of injury were observed, recovery was excellent. By the time of bloom and pod-set, there was no visual evidence of injury nor delay in maturity. He found that much of the injury from DNBP could probably

be attributed to poor mechanical practices used in the application of the chemical.

EPTC. EPTC, in the pure form, is a virtually clear liquid with a distinct aromatic odor. Although it is nearly insoluble in water, it is soluble in most organic solvents and oils. The boiling point of the pure chemical at 760 mm of mercury is 232° C, and it is a stable and non-corrosive chemical (14).

Accumulation of toxicological data indicates EPTC has an acute oral LD-50 of 1.63 grams per kilogram of body weight for rats. The acute oral LD-50 for rabbits was 10 grams per kilogram of body weight (14).

Researchers have shown the herbicidal activity of EPTC to be related to several factors. Soil moisture at time of application, depth of incorporation and time of incorporation are listed as determining factors to EPTC's herbicidal activity. Although the mode of action of EPTC is not definitely known, many researchers feel that EPTC is an anti-metabolite and blocks vital reactions in the root cells and causes immediate local injury.

Antognini (3) found that soil moisture at the time of application played a decisive role in the variability of field results. He found poor weed control to be associated with wet soil at the time of application.

Shear (31), using EPTC at the 2 and 4 pounds per acre rate without incorporation, obtained poor weed control as compared to incorporated treatments.

Klingman et al. (24) found EPTC to give almost perfect weed control if immediately incorporated into the upper two inches of soil. The most effective incorporation was achieved by mounting the spray nozzle directly in front of the motors on a power-driven rotary cultivator. Less effective weed control was obtained when EPTC was incorporated with a tandem disk or sweep-type cultivator.

Waldrep and Freeman (40) showed that EPTC incorporated to a depth of one-half inch gave no injury in the greenhouse or under field conditions. Deeper incorporation with a rototiller under field conditions gave significant reduction in height of the corn plants.

Linuron. 3-(3, 4-dichlorophenyl)-1-methoxy-1-methylurea (linuron) in the solid state has a melting point of 93 to 94° C. It is slightly soluble (75 ppm) in water, partially soluble in acetone, alcohol, benzene, toluene, and xylene (14).

Toxicological data show linuron to have an acute oral LD-50 of 1500 milligrams per kilogram of body weight for rats (14).

Linuron is a substituted urea selective herbicide applied both pre and postemergence. Sufficient soil moisture must be present for linuron to move into the root zone where it is absorbed by weed seedling roots and inhibits the Hill reaction. It has proven to be a highly effective and versatile herbicide (36). It is equally effective for the control of seedlings of both grass and broadleaf weeds (42).

Although linuron applied postemergence alone has given good burn of weed foliage, greenhouse tests have shown the contact herbicidal activity of linuron can be significantly increased on the tougher weeds by the addition of surfactants to the spray mixture (42).

Weed et al. (42) reported that linuron at 1.5 to 2.0 pounds active ingredient per acre plus 0.5 percent surfactant applied as a directed postemergence spray provided effective, safe control of annual weeds and seedling grasses throughout the growing season in corn.

MSMA. MSMA is an organic arsenic compound used as a selective contact herbicide applied postemergence to the crop. MSMA, in the pure state, is a colorless solid with a melting point of 115 to 119° C. It is soluble in water and has an acute oral LD-50 of 1800 milligrams per kilogram of body weight for female albino rats (36).

MSMA is effective only when used as a contact herbicide (2). Thomson (36) recommends using 2 to 5 pounds active ingredient per acre to obtain best weed control results when using MSMA as a contact herbicide.

Although soil conditions do not affect the activity of MSMA since it is a contact herbicide, sunlight, temperature, and cloudiness do have an influence upon the effectiveness of MSMA. Temperatures below 60° F tend to retard the action of MSMA while temperatures above 65° F tend to increase its effectiveness. Cloudy weather can reduce the action of MSMA. Experiments showed that MSMA sprayed on

Johnsongrass in bright sunlight exhibited more herbicidal action than when sprayed under shady or cloudy conditions when the temperature was the same in each case (40).

McWhorter (26) found that MSMA killed Johnsongrass foliage in field and greenhouse experiments. He also found that control of regrowth following treatment increased with increasing rates but there was no indication of MSMA translocation in the Johnsongrass plants. McWhorter believed MSMA should be considered only as a supplement to certain other herbicides rather than as a direct competitor. He also believed MSMA should be used only in dry weather and then only in the control of Johnsongrass in cotton and non-crop areas.

Research reported by the Ansul Company (1) shows that MSMA is effective in controlling Johnsongrass at all stages of growth through burning of the top growth and suppression of regrowth. Complete coverage of the foliage is completely necessary in order to get effective control.

Trifluralin. Pure trifluralin crystallizes in yellow-orange prisms which melt at 48.5 to 49° C. It has a molecular weight of 335.28 and is readily soluble in most organic solvents; however, its solubility in water is less than 5 ppm at 27° C. Toxicological evaluation of trifluralin indicates the acute oral LD-50 to be 710,000 milligrans per kilogram of body weight for rats. Although its mode of action is not fully understood, trifluralin is believed to be an inhibitor of cell division or mitosis (11).

The herbicidal activity of trifluralin is increased greatly when it is incorporated in the soil. Many soil incorporating implements are suitable for use with trifluralin; however, power-driven equipment produces superior results with rotovation two to four inches deep being the most effective method of soil incorporation. Trifluralin is extremely resistant to leaching and is not leached from the weed-seed germination zone by heavy rainfall; however, the persistence of trifluralin in the soil has not been a problem as several factors are responsible for its disappearance from the soil. These factors include microbiological decomposition, volatilization, and degradation by ultraviolet light. Research conducted in the Midwest has shown that small grains seeded in the fall on fields where trifluralin had been used to control weeds in the previous crops have not been injured by residues of the herbicide (11).

Experiments by Standifer and Thomas (34) showed that trifluralin was taken up by the first internodal tissue of Johnsongrass seedlings and had little effect on the internodal stem tissue of shoots from rhizomes. They believe trifluralin must be incorporated deeper than the primary rhizomes in order to get control of Johnsongrass rhizomes, but they also realize incorporation to that depth is not mechanically feasible.

Guse and Schwer (16) obtained good Johnsongrass seedling control when trifluralin was applied at the rate of 0.5 pound active ingredient per acre. They found cotton to be more tolerant to trifluralin than were soybeans, but yield reduction was not significant in either crop.

Gentner (15) in his study of herbicidal properties of trifluralin analogs found trifluralin was the most active member of the series, but several of its analogs also displayed a high order of toxicity to weeds but a lower order of toxicity to crops.

Herbicidal oil. Stoddard solvent or varsol is a petroleum distillate of low flammability. It is normally clear and smells like sweet refined naphtha. Most Stoddard solvents have a gravity A.P.I. of 42° or above, a minimum flash point of 100° F and an aromatic content of 8 to 20 percent (10).

Klingman (23) stated that herbicidal oils have gained commercial use as weed killers mostly since 1940. He mentioned that herbicidal oils act as contact herbicides and are translocated little within plants. Crafts (10) reported that oil toxicity results from the denaturation of the plant cells resulting from solubilization by the oil.

As a selective weed killer, varsol is used to control both grass and broadleaf weeds. As a directed spray, varsol effectively controls weeds in cotton.

Buchanan and Dickens (5) stated that herbicidal oil at five to seven gallons per acre used as a postemergence directed spray gave satisfactory results when used in cotton less than ten inches tall. Herbicidal oils must be used when the cotton is small in order to avoid injury to the cotton and to get good weed control.

Woodall (43) mentioned that herbicidal oil at five to seven gallons per acre applied after cotton plants were two to three inches

tall gave promising results. He cautioned that herbicidal oils work more effectively when plants are dry and the air temperature is above 60° F but not exceeding 85° F.

CHAPTER III

MATERIALS AND METHODS

This Johnsongrass control experiment was concerned with an attempt to grow corn, cotton, and soybeans effectively in soil heavily infested with Johnsongrass. An effective and feasible method of controlling Johnsongrass has not been found.

Since Johnsongrass grows both from rhizomes and seed, it must be understood that an effective control for only one year will not be sufficient to inhibit growth in the following years. Seedling Johnsongrass can emerge from viable seed already present in the soil.

Fifty-three treatments were evaluated in an attempt to control Johnsongrass. The treatments and herbicides used were those which had given some prior indication of controlling Johnsongrass. Since only limited research on Johnsongrass control has been conducted in Tennessee, it was necessary to use many different treatments and herbicides.

Location

This experiment was conducted at the Middle Tennessee Experiment Station at Spring Hill, Tennessee, during the summer of 1966, on land which had been acquired the previous year.

The experiment was conducted in a Huntington silt loam soil which had not been cultivated for three years prior to this experiment. The

last attempt at cultivation was made in the spring of 1964 when the field was planted with corn. Soon after germination and emergence of the crop that year, it became apparent that there was such a thorough and uniform infestation of vigorously growing Johnsongrass that it would not be economically feasible to control this weed. Therefore, the crop was abandoned. The uniform infestation of Johnsongrass in this field accounted for its selection as the site for this experiment.

Design of Experiment

A randomized complete block design with three replications was used. Plots were 12 rows wide and 42 feet long with rows three and one-half feet apart. The experiment covered more than eight acres of land.

Herbicides Used in Experiment

The herbicides used in this experiment were those which had given some prior indication of controlling Johnsongrass when applied at rates recommended by the manufacturer. These included dalapon, MSMA, trifluralin, linuron, EPTC, atrazine, DNBP, amiben, diuron, and herbicidal oil.

Field work was initiated when the Johnsongrass was 8 to 12 inches tall. The entire experimental area, except for the plots which were to receive no herbicidal treatments, was sprayed with dalapon. At this growth stage, maximum control of the growing plant, including its rhizomes, was anticipated. After waiting four days, plots were plowed and a conventional seedbed was prepared.

Prior to planting the respective crops, preplant herbicides were applied to certain plots. Trifluralin was used as a preplant incorporated treatment in all three crops. EPTC was used as a preplant incorporated treatment in corn and cotton.

Atrazine was used as a preemergence broadcast herbicide on corn. Linuron was used similarly on soybeans, and diuron on cotton.

After the crops had emerged, specified herbicides were used as postemergence applications when grass and broadleaf weeds reached five to six inches in height. Herbicides used as postemergence directed applications were dalapon and MSMA on all crops, linuron on corn and soybeans, herbicidal oil on cotton and soybeans, and DNBP on soybeans. Tables I through IV show the different treatments, the herbicides and rates used.

Herbicide Applications

Because of unavoidable circumstances, it was not possible to make the initial dalapon application until June 21, 1966. Normally, the Johnsongrass would have been beyond the most susceptible stage of growth by that time. However, the field was disked once to kill the first growth of the plants, and the resulting regrowth was quite uniform and at the desired height of 8 to 12 inches when sprayed. Four days after spraying the plots were turned and disked.

Current recommendations for use of dalapon indicate that 14 days should elapse after its application before cotton is planted, and 21 days should elapse before either corn or soybeans are planted.

TABLE I

TREATMENTS AND RATES USED IN THE 1966 EXPERIMENTS ON CORN AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL, TENNESSEE

Treatment	Rate, active lbs./A.
Cultivated check	-
Dalapon postemergence + trifluralin incorporated preplant + atrazine preemergence + dalapon postemergence directed	7.4 + 0.5 + 1.0 + 1.5
Dalapon postemergence + trifluralin incorporated preplant + atrazine preemergence + MSMA postemergence directed	7.4 + 0.5 + 1.0 + 2.0
Dalapon postemergence + trifluralin incorporated preplant + atrazine preemergence + linuron postemergence directed	7.4 + 0.5 + 1.0 + 2.0
Dalapon postemergence + trifluralin incorporated preplant + atrazine preemergence + cultivated middles	7.4 + 0.5 + 1.0
Dalapon postemergence + EPTC incorporated preplant + dalapon postemergence directed	7.4 + 3.0 + 2.0
Dalapon postemergence + EPTC incorporated preplant + MSMA postemergence directed	7.4 + 3.0 + 2.0
Dalapon postemergence + EPTC incorporated preplant + linuron postemergence directed	7.4 + 3.0 + 2.0
Dalapon postemergence + EPTC incorporated preplant + cultivated middles	7.4 + 3.0

TABLE I (continued)

Treatment	Rate, active lbs./A.
Dalapon postemergence + MSMA postemergence directed	7.4 + 2.0
Dalapon postemergence + dalapon postemergence directed	7.4 + 1.5
Dalapon postemergence + linuron postemergence directed	7.4 + 2.0
Dalapon postemergence + atrazine preemergence + cultivated middles	7.4 + 2.0
Dalapon postemergence + atrazine preemergence + dalapon postemergence directed	7.4 + 2.0 + 1.5
Dalapon postemergence + atrazine preemergence + MSMA postemergence directed	7.4 + 2.0 + 2.0
Dalapon postemergence + atrazine preemergence + linuron postemergence directed	7.4 + 2.0 + 2.0

TABLE II

TREATMENTS AND RATES USED IN THE 1966 EXPERIMENTS ON COTTON AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL, TENNESSEE

Treatment	Rate, active lbs./A.
Cultivated check	-
Dalapon postemergence + spot treatment with dalapon	7.4 + 1 lb./10 gallons water
Dalapon postemergence + dalapon postemergence directed	7.4 + 1.5
Dalapon postemergence + MSMA postemergence directed	7.4 + 2.0
Dalapon postemergence + trifluralin incorporated preplant + MSMA postemergence directed	7.4 + 0.75 + 2.0
Dalapon postemergence + trifluralin incorporated preplant + dalapon postemergence directed	7.4 + 0.75 + 1.5
Dalapon postemergence + trifluralin incorporated preplant + cultivated middles	7.4 + 0.75
Dalapon postemergence + trifluralin incorporated preplant + herbicidal oil postemergence directed	7.4 + 0.75 + 40.0
Dalapon postemergence + EPTC incorporated preplant + diuron preemergence + MSMA postemergence directed	7.4 + 3.0 + 1.0 + 2.0

TABLE II (continued)

Treatment	Rate, active lbs./A.
Dalapon postemergence + EPTC incorporated preplant + diuron preemergence + dalapon postemergence directed	7.4 + 3.0 + 1.0 + 1.5
Dalapon postemergence + EPTC incorporated preplant + diuron preemergence + herbicidal oil postemergence	7.4 + 3.0 + 1.0 + 40.0
Dalapon postemergence + EPTC incorporated preplant + diuron preemergence + cultivated middles	7.4 + 3.0 + 1.0

TABLE III

TREATMENTS AND RATES USED IN THE 1966 EXPERIMENTS ON SOYBEANS AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL, TENNESSEE

Treatment	Rate, active lbs./A.
Cultivated check	-
Dalapon postemergence + spot treatment with dalapon	7.4 + 1 lb./10 gallons water
Dalapon postemergence + dalapon postemergence directed	7.4 + 1.5
Dalapon postemergence + MSMA postemergence directed	7.4 + 2.0
Dalapon postemergence + DNBP postemergence directed	7.4 + 3.0
Dalapon postemergence + trifluralin incorporated preplant + MSMA postemergence directed	7.4 + 0.75 + 2.0
Dalapon postemergence + trifluralin incorporated preplant + dalapon postemergence directed	7.4 + 0.75 + 1.5
Dalapon postemergence + trifluralin incorporated preplant + cultivated middles	7.4 + 0.75
Dalapon postemergence + linuron preemergence + DNBP postemergence directed	7.4 + 0.5 + 4.0
Dalapon postemergence + linuron preemergence + cultivated middles	7.4 + 0.5

TABLE III (continued)

Treatment	Rate, active lbs./A.
Dalapon postemergence + linuron preemergence + dalapon postemergence directed	7.4 + 0.5 + 1.5
Dalapon postemergence + linuron preemergence + MSMA postemergence directed	7.4 + 0.5 + 2.0
Dalapon postemergence + linuron preemergence + linuron postemergence directed	7.4 + 0.5 + 2.0
Dalapon postemergence + herbicidal oil postemergence directed	7.4 + 40.0
Dalapon postemergence + amiben preemergence	7.4 + 3.0
Dalapon postemergence + amiben preemergence + dalapon postemergence directed	7.4 + 3.0 + 1.5
Dalapon postemergence + amiben preemergence + MSMA postemergence directed	7.4 + 3.0 + 2.0

TABLE IV

TREATMENTS AND RATES USED IN THE 1966 EXPERIMENTS WITHOUT ROW CROPS AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL, TENNESSEE

Treatment	Mechanical practices used	Chemical practices used and rate
Untreated check	-	-
Mechanical fallow	6 diskings at 1½ week intervals	-
Chemical fallow with dalapon	-	7.4 lbs. active ingredient/A.
Chemical fallow with dalapon + 100 lbs. nitrogen	-	7.4 lbs. active ingredient/A.
Chemical fallow with dalapon + mechanical fallow	Turned, disked three times at 1½ week intervals	7.4 lbs. active ingredient/A.
Chemical fallow with dalapon + mechanical fallow + 100 lbs. nitrogen	Turned, disked three times at 1½ week intervals	7.4 lbs. active ingredient/A.
Chemical fallow with MSMA	-	3.0 lbs. active ingredient/A. applied 2 times
Manage for maximum hay production	Cut 2 times for yield	-

To determine whether planting of soybeans and cotton could be made within a few days after the application of dalapon without injury to these plants, it was decided to make the dalapon application, plow three days later, and then plant soybeans and cotton as soon after plowing as possible.

The usefulness of this herbicide would be greatly increased if it could be shown that this waiting time is not necessary. A study of toxic residues in soybeans and cottonseed grown on crops planted under these conditions was beyond the scope of this investigation. Only phytotoxicity to the growing crop was under study.

Herbicides were applied to the cotton plots, and cotton was planted on June 28, seven days after the initial spraying and three days after plowing. The soybean plots were treated with the required herbicides and planted the following day on June 29, four days after plowing. Unseasonable and continued rains prevented treating and planting the corn plots until July 18, 23 days after plowing.

Since EPTC may cause injury to field crop seeds for several days after its incorporation into the soil, the manufacturer recommends that sowing be delayed for ten days. Therefore, corn and cotton, in the EPTC treated plots, were planted ten days after the dates indicated above.

Recommended rates of herbicides were used because prior experiments had shown that the herbicides, used at these rates, showed promise of controlling Johnsongrass.

All formulations were applied as aqueous sprays from a sprayer with a 21 2/3 foot boom. Dalapon was applied in 55 gallons of water per acre. All other applications were made at the 40 gallons per acre rate, with 40 pounds per square inch pressure for all applications.

Herbicides which were applied preplant and required incorporation into the soil were incorporated immediately after spraying by using a disk harrow which cut to a four to five inch depth and resulted in mixing the chemicals approximately to a two and one-half inch depth.

Cultural Aspects

Recommended varieties of crops were used and were planted according to accepted agronomic practices. Varieties used were Dixie 29 corn, Auburn M cotton, and Lee soybeans.

Plots which required cultivation were cultivated with a one-row sweep cultivator to maintain the best possible weed control. The plots treated with herbicides were not hoed or cultivated except when a combination of practices was under study.

Observations

Weed control ratings were made visually and recorded for each plot on August 16 and again on September 18. Ratings of both Johnsongrass and broadleaf weeds were made. Crop injury ratings were made on the same dates. The weed control ratings were made on a 0 to 10 scale with 0 being no weed control and 10 being complete control. Crop injury ratings were recorded on a 0 to 10 scale with 0 being no injury

and 10 being complete kill from the herbicides. This rating scale was used since it is accepted by the majority of weed science researchers.

The survival of Johnsongrass rhizomes was assessed in the spring of 1967 and recorded on a 0 to 10 scale with 0 being a complete infestation of Johnsongrass from rhizomes and 10 being no visible growth.

CHAPTER IV

RESULTS AND DISCUSSION

The results of the 1966 experiment are discussed by crops. Since crop injury from herbicides was only nominal, crop injury data will be mentioned only as they apply to specific herbicides and crops.

General Observations

The growing season was not optimum because of the low rainfall. The monthly mean rainfall for the Middle Tennessee Experiment Station area was 4.73 inches, but during this growing season it was only 3.95. Rainfall data for the season are given in the Appendix.

Corn was planted late due to the early disking and the period of time which elapsed before the Johnsongrass reached the necessary height for dalapon application; this may account for some of the good weed control which resulted from some of the herbicide treatments on this crop. Cotton treated with EPTC was also planted late, and this may have affected the weed control. Johnsongrass does not grow vigorously during the latter part of the growing season.

Since Johnsongrass reproduces both from seed and from rhizomes, an effective weed control program must eliminate the seedling plants as well as those growing from rhizomes in the soil. In addition, the rhizomes should be killed to prevent regrowth in the subsequent growing season. When weed control ratings were made on August 16, 1966,

most of the Johnsongrass was seedling plants. At the time of the second rating on September 8, 1966, rhizomatous plants formed a significant part of the weed population.

The final rating on April 21, 1967, was to assess the survival of overwintering rhizomes by rating the number and vigor of rhizomatous plants. Seedling plants were not a factor in this rating.

Soybeans

Although no single treatment was entirely satisfactory among those used on soybeans, several looked promising.

All treatments except the cultivated check were sprayed with dalapon at 7.4 pounds acid equivalent per acre when the Johnsongrass was eight to ten inches tall. Then, either preemergence or postemergence treatments or a combination of the two were used for subsequent grass kill. Data from Table V show the degrees of weed control resulting from soybean treatments.

Data in Table V indicate that trifluralin at 0.75 pound active ingredient per acre was reasonably effective in controlling the early seedling Johnsongrass. Figure 1 shows the effectiveness of trifluralin when followed by cultivation of the middles. Dalapon at 1.5 pounds active ingredient per acre and MSMA at 2 pounds active ingredient per acre were used as postemergence sprays following trifluralin. Neither was effective in controlling late emerging Johnsongrass seedlings.

Amiben used at 3 pounds acid equivalent per acre resulted in adequate Johnsongrass control when applied preemergence. However, the

TABLE V

AVERAGE JOHNSONGRASS CONTROL RATINGS OF TREATMENTS ON SOYBEANS AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL, TENNESSEE, 1966

Treatment	Rate, active lbs./A.	Ratings[a] 8-16-66	9-8-66	4-21-67
Cultivated check, no herbicide	-	2.3	4.3	6.0
Dalapon postemergence + spot treatment with dalapon	7.4 + 1 lb./10 gallons water	1.7	1.3	1.0
Dalapon postemergence + dalapon postemergence directed	7.4 + 1.5	2.7	1.7	4.7
Dalapon postemergence + MSMA postemergence directed	7.4 + 2.0	2.0	1.7	5.3
Dalapon postemergence + DNBP postemergence directed	7.4 + 3.0	2.7	1.7	0.7
Dalapon postemergence + trifluralin incorporated preplant + MSMA postemergence directed	7.4 + 0.75 + 2.0	4.7	5.3	8.0
Dalapon postemergence + trifluralin incorporated preplant + dalapon postemergence directed	7.4 + 0.75 + 1.5	4.0	4.7	5.0
Dalapon postemergence + trifluralin incorporated preplant + cultivated middles	7.4 + 0.75	8.7	8.3	5.0
Dalapon postemergence + linuron preemergence + DNBP postemergence directed	7.4 + 0.5 + 4.0	2.0	0.7	8.7

TABLE V (continued)

Treatment	Rate, active lbs./A.	Ratings[a] 8-16-66	9-8-66	4-21-67
Dalapon postemergence + linuron preemergence + cultivated middles	7.4 + 0.5	7.3	7.7	8.7
Dalapon postemergence + linuron preemergence + dalapon postemergence directed	7.4 + 0.5 + 1.5	5.0	5.0	5.3
Dalapon postemergence + linuron preemergence + MSMA postemergence directed	7.4 + 0.5 + 2.0	5.0	6.3	7.3
Dalapon postemergence + linuron preemergence + linuron postemergence	7.4 + 0.5 + 2.0	3.0	2.7	2.0
Dalapon postemergence + herbicidal oil postemergence directed	7.4 + 40.0	2.0	1.0	1.7
Dalapon postemergence + amiben preemergence + dalapon postemergence directed	7.4 + 3.0 + 1.5	7.3	7.0	8.7
Dalapon postemergence + amiben preemergence + MSMA postemergence directed	7.4 + 3.0 + 2.0	7.7	7.7	7.7

[a]A rating of 0 indicates no weed control; a rating of 10 indicates complete weed control.



Figure 1. Trifluralin applied preplant incorporated at the rate of 0.75 pound per acre plus cultivated middles. The final Johnsongrass control rating was 8.3.

postemergence applications of MSMA and dalapon were again ineffective although MSMA gave better weed control than dalapon. Figure 2 indicates the effectiveness of amiben when followed by MSMA as the postemergence herbicide.

Linuron at 0.5 pound active ingredient per acre gave good results when followed by cultivation of the middles.

When no preemergence application was made following the initial dalapon treatment, a single postemergence application of either MSMA, dalapon, or DNBP did not result in good grass control. This points out the necessity of a good preemergence herbicide followed by an effective postemergence herbicide or by cultivation. As pointed out before, dalapon at 7.4 pounds acid equivalent per acre gave adequate control of the rhizomatous growth of Johnsongrass, but dalapon at 1.5 pounds acid equivalent per acre was not effective on seedling Johnsongrass.

MSMA at 2 pounds active ingredient caused moderate injury to the soybeans. The average injury rating from this herbicide was 3.3. Unlike EPTC injury in corn, MSMA injury in soybeans did not disappear as the soybeans matured.

The planting of soybeans on June 29, eight days after the initial dalapon application, did not result in any crop injury.

Cotton

As with soybeans, all treatments except the cultivated check were sprayed with dalapon at 7.4 pounds acid equivalent per acre when



Figure 2. Amiben applied preemergence at the rate of 3 pounds per acre followed by MSMA at the rate of 2 pounds per acre postemergence directed. The final Johnsongrass control rating was 7.7.

the Johnsongrass was eight to ten inches tall. Then, either preemergence or postemergence treatments or a combination of the two were used for further grass kill. Data from Table VI show the degree of weed control resulting from treatments in cotton plots.

When dalapon at 7.4 pounds acid equivalent per acre was used postemergence to the Johnsongrass and followed by spot treatments of dalapon at 1 pound acid equivalent in 10 gallons of water or dalapon at 1.5 pounds acid equivalent per acre postemergence directed, the weed control was poor on both dates of rating, as shown by data in Table VI. This was also true for MSMA applied as a postemergence directed spray. The poor weed control from MSMA on the cotton plots could be explained by the late application after the grass and weeds had reached a stage of growth which was too far advanced for good control. It is now apparent that MSMA should have been applied earlier.

Of all the herbicides used on cotton, EPTC preplant incorporated at 3 pounds active ingredient per acre following an initial dalapon application gave the most outstanding results. Figure 3 shows the control received from EPTC plus cultivated middles. The excellent weed control from EPTC possibly could have been due to the later planting of the treatments. Since the manufacturer recommends a ten day interval between incorporation and planting, the EPTC treatments were planted ten days later than the others.

Although EPTC gave good early weed control, it was less adequate when the second weed rating was made. The poorer late control

TABLE VI

AVERAGE JOHNSONGRASS CONTROL RATINGS OF TREATMENTS ON COTTON AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL, TENNESSEE, 1966

Treatment	Rate, active lbs./A.	Ratings[a] 8-16-66	9-8-66	4-21-67
Cultivated check, no herbicide	-	2.0	2.3	4.0
Dalapon postemergence + spot treatment with dalapon	7.4 + 1 lb./10 gallons water	2.0	1.3	2.3
Dalapon postemergence + dalapon postemergence directed	7.4 + 1.5	2.0	1.7	3.0
Dalapon postemergence + MSMA postemergence directed	7.4 + 2.0	2.7	2.0	2.7
Dalapon postemergence + trifluralin incorporated preplant + MSMA postemergence directed	7.4 + 0.75 + 2.0	4.0	3.3	6.7
Dalapon postemergence + trifluralin incorporated preplant + dalapon postemergence directed	7.4 + 0.75 + 1.5	2.3	3.3	5.3
Dalapon postemergence + trifluralin incorporated preplant + cultivated middles	7.4 + 0.75	5.0	5.7	7.7
Dalapon postemergence + trifluralin incorporated preplant + herbicidal oil	7.4 + 0.75 + 40.0	2.0	1.7	3.3
Dalapon postemergence + EPTC incorporated preplant + diuron preemergence + MSMA postemergence directed	7.4 + 3.0 + 1.0 + 2.0	9.3	7.3	8.7

TABLE VI (continued)

Treatment	Rate, active lbs./A.	Ratings[a] 8-16-66	9-8-66	4-21-67
Dalapon postemergence + EPTC incorporated preplant + diuron preemergence + dalapon postemergence directed	7.4 + 3.0 + 1.0 + 1.5	9.9	7.3	8.7
Dalapon postemergence + EPTC incorporated preplant + diuron preemergence + herbicidal oil	7.4 + 3.0 + 1.0 + 40.0	7.7	7.0	8.3
Dalapon postemergence + EPTC incorporated preplant + diuron preemergence + cultivated middles	7.4 + 3.0 + 1.0	9.3	7.0	8.7

[a]A rating of 0 indicates no weed control; a rating of 10 indicates complete weed control.



Figure 3. EPTC applied preplant incorporated at the rate of 3 pounds per acre followed by cultivated middles. The final Johnsongrass control rating was 7.0.

was largely due to the fact that none of the postemergence herbicides used in conjunction with it gave adequate control.

MSMA at 2 pounds active ingredient per acre is a recommended postemergence spray for cotton, but the results of this experiment show that it resulted in poor control of seedling Johnsongrass. However, this may have been due to improper application time. Figure 4 shows weed control from EPTC plus MSMA postemergence directed.

Cultivating the middles of the cotton rows did not give good Johnsongrass control probably because of late seedling emergence after cultivation was discontinued.

Trifluralin at 0.75 pound active ingredient per acre has been cleared for preemergence control in cotton and is recommended, but did not give favorable results in this experiment. This lack of control may have been due to improper incorporation into the soil.

Like soybeans, the planting of cotton seven days after the initial dalapon application did not result in any crop injury.

Corn

Corn was not planted until July 18, 21 days after plowing. This late planting resulted in a heavy infestation of European corn borer (Pyrausta nubilalis L.) which damaged the crop. However, Johnsongrass control was not noticeably affected by the lateness of planting.

All treatments except the cultivated check were sprayed with dalapon at 7.4 pounds acid equivalent per acre when the Johnsongrass



Figure 4. EPTC applied preplant incorporated at the rate of 3 pounds per acre followed by MSMA at the rate of 2 pounds per acre applied postemergence directed. The final Johnsongrass control rating was 7.3.

was eight to ten inches tall. Then, either preemergence or postemergence treatments or a combination of the two were used for further grass kill. Data from Table VII show the degree of weed control resulting from the various treatments.

In the herbicide treatments on corn, as with soybeans and cotton, the initial application of dalapon gave excellent control of rhizomatous growth but did poorly on Johnsongrass seedlings when used later as a postemergence directed spray at 1.5 pounds acid equivalent per acre.

Since all treatments except the cultivated check were treated with dalapon initially, they will be discussed in relation to pre-emergence and postemergence application of herbicides.

Trifluralin, incorporated preplant, at 0.5 pound active ingredient per acre, gave excellent control of seedling Johnsongrass and did not injure corn. Of the three herbicides used postemergence in combination with trifluralin, linuron at 2 pounds active ingredient per acre gave the best late season control and did an excellent job of controlling the seedlings which ordinarily emerge after corn reaches 4 to 5 feet in height.

EPTC at 3 pounds acid equivalent per acre gave excellent control of Johnsongrass seedlings when used preplant incorporated. The postemergence treatments used with EPTC were the same as those used with trifluralin. Again, linuron gave the best Johnsongrass control, followed closely by the cultivated middles treatment. Dalapon

TABLE VII

AVERAGE JOHNSONGRASS CONTROL RATINGS OF TREATMENTS ON CORN AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL, TENNESSEE, 1966

Treatment	Rate, active lbs./A.	Ratings[a] 8-16-66	9-8-66	4-21-67
Cultivated check, no herbicide	-	8.0	7.0	8.3
Dalapon postemergence + trifluralin incorporated preplant + atrazine preemergence + dalapon postemergence directed	7.4 + 0.5 + 1.0 + 1.5	7.0	8.0	9.0
Dalapon postemergence + trifluralin incorporated preplant + atrazine preemergence + MSMA postemergence directed	7.4 + 0.5 + 1.0 + 2.0	9.0	9.0	9.3
Dalapon postemergence + trifluralin incorporated preplant + atrazine preemergence + linuron postemergence directed	7.4 + 0.5 + 1.0 + 2.0	8.7	10.0	9.7
Dalapon postemergence + trifluralin incorporated preplant + atrazine preemergence + cultivated middles	7.4 + 0.5 + 1.0	9.0	9.0	9.0
Dalapon postemergence + EPTC incorporated preplant + dalapon postemergence directed	7.4 + 3.0 + 1.5	9.3	6.7	7.7
Dalapon postemergence + EPTC incorporated preplant + MSMA postemergence directed	7.4 + 3.0 + 2.0	7.3	8.7	8.7
Dalapon postemergence + EPTC incorporated preplant + linuron postemergence directed	7.4 + 3.0 + 2.0	9.3	9.3	9.7

TABLE VII (continued)

Treatment	Rate active lbs./A.	Ratings[a] 8-16-66	9-8-66	4-21-67
Dalapon postemergence + EPTC incorporated preplant + cultivated middles	7.4 + 3.0	9.0	9.3	8.3
Dalapon postemergence + MSMA postemergence directed	7.4 + 2.0	2.3	7.0	8.7
Dalapon postemergence + dalapon postemergence directed	7.4 + 1.5	2.7	5.0	7.3
Dalapon postemergence + linuron postemergence directed	7.4 + 2.0	8.0	7.7	9.7
Dalapon postemergence + atrazine preemergence + cultivated middles	7.4 + 2.0	9.0	8.6	9.7
Dalapon postemergence + atrazine preemergence + dalapon postemergence directed	7.4 + 2.0 + 1.5	7.0	7.0	9.7
Dalapon postemergence + atrazine preemergence + MSMA postemergence directed	7.4 + 2.0 + 2.0	8.0	8.6	9.0
Dalapon postemergence + atrazine preemergence + linuron postemergence directed	7.4 + 2.0 + 2.0	8.3	9.3	9.7

[a]A rating of 0 indicates no weed control; a rating of 10 indicates complete weed control.

at 1.5 pounds acid equivalent per acre was less effective. Observations show that EPTC gave seedling control somewhat longer than did trifluralin.

MSMA used as a postemergence spray was not promising when no preplant or preemergence herbicide was used following the initial application of dalapon.

As shown in Table VII, page 46, atrazine at 2 pounds active ingredient per acre applied preemergence plus linuron at 2 pounds active ingredient per acre gave excellent Johnsongrass control. However, prior to the linuron application, the grass growth was vigorous and had not been retarded much, and linuron was possibly responsible for the good weed control. This points out the inability of atrazine to control Johnsongrass effectively when used preemergence. As with the other crops, corn must be treated with an effective preemergence herbicide if good Johnsongrass control is expected.

Cultivation gave good results when used in combination with effective preemergence herbicides. This could be explained by the excellent weed control dalapon at 7.4 pounds acid equivalent per acre did on reducing rhizome growth, thereby giving the cultivation treatments a better chance of being effective. Although cultivation practices checked the grass growth for the duration of the cultivation period, the newly emerged Johnsongrass seedlings were observed to be growing rapidly after cultivation was stopped.

The only chemical injury observed in corn was caused by EPTC. The injury was only slight, with the average injury being only 2.0, and the corn did not appear to be stunted for long. The corn,

following the first rain after emergence, began to make rapid growth, and the symptoms of EPTC injury gradually disappeared in two to three weeks. Figure 5 shows EPTC applied at 3 pounds active ingredient per acre and the resultant injury from the herbicide.

Uncropped Treatments

Figure 6 shows the luxurious growth of Johnsongrass when no chemical or mechanical treatments were used.

Data in Table VIII indicate that chemical fallow with dalapon at 7.4 pounds acid equivalent per acre plus mechanical fallow gave the best results of the uncropped treatments. Dalapon was applied June 21, and mechanical fallow began four days later when the plots were plowed and disked. Following a one and one-half week interval, the plots were again turned and disked. This procedure was repeated three times.

Mechanical fallow alone was also effective but less so than dalapon plus mechanical fallow. The use of dalapon was effective for rhizome control as was indicated by the comparison of the dalapon plus mechanical fallow and the mechanical fallow alone.

Chemical fallow with only dalapon at 7.4 pounds acid equivalent per acre did not give satisfactory results because the single application of dalapon, which did control rhizomes, permitted seedling emergence later in the season.

Chemical fallow with MSMA at 3 pounds active ingredient per acre was also somewhat effective and would probably have been even



Figure 5. EPTC applied preplant incorporated at the rate of 3 pounds per acre followed by linuron at the 2 pound per acre rate applied postemergence directed. The average injury rating was 2.0.



Figure 6. Uncultivated check without chemical or mechanical fallow. The average Johnsongrass control rating was 0.

TABLE VIII

AVERAGE JOHNSONGRASS CONTROL RATINGS OF TREATMENTS WITHOUT ROW CROPS AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL, TENNESSEE, 1966

Treatment	Mechanical practices used	Chemical practices rate, active lbs./A.	Rating[a] 8-16-66	9-8-66	4-21-67
Untreated check	-	-	0	0	0
Mechanical fallow	6 diskings at 1½ week intervals	-	8.7	8.3	8.3
Chemical fallow with dalapon	-	7.4	2.0	2.3	6.3
Chemical fallow with dalapon + 100 lbs. nitrogen	-	7.4	2.0	2.0	6.3
Chemical fallow with dalapon + mechanical fallow	Turned, disked three times at 1½ week intervals	7.4	8.7	8.7	8.7
Chemical fallow with dalapon + mechanical fallow + 100 lbs. nitrogen	Turned, disked three times at 1½ week intervals	7.4	9.0	9.0	8.7
Chemical fallow with MSMA applied two times	-	3.0	7.7	8.0	7.3
Manage for maximum hay production	Cut two times[b]	-	0	0	0

[a] A rating of 0 indicates no weed control; a rating of 10 indicates complete weed control.

[b] Johnsongrass yielded 460 lbs. dry weight per cutting.

more effective if the number of applications had been increased from two to three or more.

The treatments managed for maximum hay production yielded less than expected because of the low rainfall during the growing season.

Spring Rhizome Ratings

Spring Johnsongrass rhizome control from all treatments was somewhat erratic. This may be accounted for in part by the fact that growth from rhizomes was not uniform when ratings were taken, and some rhizomatous plants may not have emerged at the time of ratings.

Average spring rhizome control ratings in the cultivated check of the three crops ranged from 4.0 for cotton to 8.3 for corn. This points out the wide range of control as indicated by the ratings reported.

Soybeans. The spring rhizome control from the dalapon post-emergence plus linuron preemergence followed by DNBP postemergence directed treatment was better than would have been predicted from the ratings of the previous fall. All other ratings were comparable to the ratings made in the fall of 1966.

The dalapon postemergence treatments at 7.4 pounds acid equivalent per acre followed by amiben preemergence at 3 pounds active ingredient per acre plus dalapon postemergence directed at 1.5 pounds acid equivalent per acre gave outstanding weed control both in the 1966 ratings and in the spring of 1967.

Cotton. Spring rhizome control ratings for cotton were similar to the final 1966 ratings. The treatments with dalapon postemergence at 7.4 pounds acid equivalent per acre plus EPTC incorporated preplant at 3 pounds active ingredient per acre plus diuron preemergence at 1 pound active ingredient per acre gave the best weed control ratings in 1966 and in the spring of 1967.

From the ratings it is apparent that EPTC gave good weed control both during the growing season and in the spring of 1967.

Corn. All treatments used on corn plots gave good rhizome control, the difference between the highest and lowest ratings being only 2.4. This indicates that all treatments gave similar results when ratings were made in the spring of 1967.

These high spring ratings follow closely the high ratings received in the summer of 1966. The high ratings during the summer of 1966 were attributed to the late planting date of corn; however, the excellent control indicated by high spring ratings may also have been a result of the late planting date. Since the corn was not planted until late in the summer, the Johnsongrass rhizomes may have been controlled by extra diskings which were used to keep the grass under control.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objective of this experiment was to determine the possibility of controlling Johnsongrass effectively by chemical or mechanical means or by a combination of the two and, at the same time, producing corn, cotton, and soybeans economically.

The 1966 treatments on the respective crops were made using ten different materials: dalapon, amiben, atrazine, diuron, DNBP, EPTC, linuron, MSMA, trifluralin, and herbicidal oil. All herbicide treated plots were initially sprayed with dalapon when the Johnsongrass was 8 to 12 inches tall. Plots were plowed four days after the dalapon application. Certain herbicides were used for application prior to planting of the respective crops, others for preemergence and postemergence applications.

Check plots were cultivated with a one-row sweep cultivator in order to maintain the best possible weed control. Except when a combination of practices was under study, plots treated with herbicides were not hoed or cultivated.

The herbicidal effects on the Johnsongrass and the respective crops were evaluated by visual ratings to indicate the degree of weed control and the amount of injury sustained by the crops. Due to the lateness of planting, no crops were harvested for yield determinations.

Inadequate rainfall during the growing season adversely affected all crops and the resultant weed control from the respective herbicides.

Although this experiment involved only one year's results and the crops were planted late, certain conclusions may be drawn.

Although dalapon is recommended for use only when planting of cotton and soybeans can be delayed for 14 and 21 days, respectively, no plant injury resulted from planting four to five days after application.

Such findings when supplemented by more extensive research may indicate the desirability of revising the recommendations for this herbicide.

Soybeans

Treatment of soybean plots with a preemergence application of amiben resulted in adequate Johnsongrass control when followed by a postemergence application of MSMA.

A preplant application of trifluralin followed by cultivated middles resulted in excellent Johnsongrass control. However, trifluralin followed by postemergence applications of MSMA or dalapon did not. This points out the necessity for a good postemergence application in order to get effective Johnsongrass control.

Linuron applied preemergence, followed by cultivation of middles, was another treatment which resulted in good Johnsongrass control. However, linuron followed by a postemergence application of MSMA or dalapon was less satisfactory.

Other herbicide treatments used on soybeans did not result in effective Johnsongrass control; possibly this was the result of

ineffective preemergence herbicides or postemergence herbicides that were used.

Cotton

In general, the treatments used on cotton did not result in good Johnsongrass control. With the exception of EPTC treated plots, which were planted ten days later than others, the cotton treatments did not result in Johnsongrass control comparable to either corn or soybean treatments.

The EPTC treated plots gave excellent Johnsongrass control, with the EPTC application followed by either MSMA or dalapon postemergence directed resulting in the best weed control. The EPTC plus cultivated middles gave adequate weed control, but it was not outstanding among the treatments used on cotton.

Corn

Although corn was not planted until late in the growing season and was subjected to a heavy infestation of European corn borer, some treatments gave outstanding Johnsongrass control.

Trifluralin plus linuron gave excellent Johnsongrass control and did not injure corn. EPTC also gave excellent Johnsongrass control but some crop injury was observed.

In all treatments linuron gave outstanding Johnsongrass control, and linuron results were enhanced when an effective preemergence herbicide such as EPTC or trifluralin was used.

Cultivation in conjunction with an effective preemergence herbicide gave good Johnsongrass control, but Johnsongrass seedlings were observed after cultivation was terminated.

Uncropped Treatments

Chemical fallow with dalapon plus mechanical fallow proved to be the most effective means of controlling Johnsongrass. Mechanical fallow alone was also effective but less so than when used in conjunction with dalapon.

The application of MSMA two times was somewhat effective in the control of Johnsongrass, but the results were not as good as the chemical fallow with dalapon plus mechanical fallow.

Spring Rhizome Ratings

With minor exceptions, spring rhizome ratings were comparable to fall ratings. The erratic rhizome control observed in the few plots was possibly the result of the uneven emergence of plants from rhizomes.

General Observations

Johnsongrass control is a much more complex problem than the control of broadleaf weeds or annual grasses. Researchers have not found a herbicide which will give full season control of Johnsongrass. There are herbicides which give excellent seedling control, but none which will give excellent control of both rhizomes and seedlings. Even though complete Johnsongrass rhizome control could be accomplished,

the emergence of Johnsongrass seedlings during the growing season and in the following years would create a problem. This unique characteristic of Johnsongrass demands that at least two different herbicides be used in the full season control of Johnsongrass.

Although all crops used in this experiment were planted late in the growing season, none of the treatments which were used would prevent normal crop growth if crops were planted at recommended dates.

Some of the treatments used during this investigation were promising in the control of Johnsongrass and will merit further research. Further research should be conducted with the more promising treatments with a long-range plan for Johnsongrass control over a three to four year period.

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APPENDIX

TABLE IX

RAINFALL DATA FOR MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL, 1966

Date	May	June	July	August	September
1	1.22		.72		
2	.26		.01		
3				.47	.02
4					
5					
6		.35			
7		.02	.19	.96	
8		.14	.14		
9					
10					
11			.03		
12	.48			.95	
13	.02			.31	.09
14	.25	.90		2.56	
15				.03	.49
16	1.50		.06	.16	
17		.13			
18	.90			.15	.06
19				.61	.68
20					
21					
22					
23					
24					
25					
26					.02
27					
28			.08		.02
29		.02	1.07		
30		1.20	1.17	1.33	
31					
Total	4.63	2.76	3.47	7.53	1.38