12-1982

Evaluation of Sethoxydim & MBR 22359 for Control of Rhizome Johnsongrass (Sorghum Halepense) in Soybeans (Glycine Max)

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1982

EVALUATION OF SETHOXYDIM AND MBR 22359 FOR CONTROL OF RHIZOME JOHNSONGRASS (*SORGHUM HALEPENSE*) IN SOYBEANS (*GLYCINE MAX*)

A Thesis

Presented to

the Faculty of the Department of Agriculture

Western Kentucky University

Bowling Green, Kentucky

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

E. Craig Musselman

December 1982

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EVALUATION OF SETHOXYDIM AND MBR 22359 FOR CONTROL
OF RHIZOME JOHNSONGRASS (*SORGHUM HALEPENSE*)
IN SOYBEANS (*GLYCINE MAX*)

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ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to the following:

Dr. James P. Worthington for his guidance, counseling and assistance during my graduate study and in preparation of this thesis.

Dr. Ray E. Johnson for his critical reading of the manuscript and for serving as a member on the graduate committee.

Dr. Alvin Bedel for his critical reading of the manuscript and for serving as a member on the graduate committee.

Mr. Jose Lopes and Mr. Julio Beingolea for their assistance in conducting the field research.

Mrs. Debbie Gabbard for typing the final manuscript copy.

Miss Elisa Jamison for her encouragement, advice, and support during my graduate study, and for typing and reading of the thesis.

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EVALUATION OF SETHOXYDIM AND MBR 22359 FOR CONTROL OF RHIZOME JOHNSONGRASS (<u>SORGHUM HALEPENSE</u>) IN SOYBEANS (<u>GLYCINE MAX</u>)

E. Craig Musselman December 1982 65 pages

Directed by: J.P. Worthington, A. Bedel, R.E. Johnson

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Johnsongrass (*Sorghum halepense*) is one of the most troublesome weeds in the southeastern United States. Several herbicides have been developed to combat johnsongrass, and many new experimental herbicides with high johnsongrass control potential are presently being tested. Two of these new experimental herbicides for johnsongrass control in soybeans (*Glycine max*) are sethoxydim and MBR 22359.

Field experiments were conducted in 1981 and 1982 to evaluate the effectiveness of MBR 22359 preemergence and post-emergence, sethoxydim in single and split applications, trifluralin in combination with mefluidide, or with glyphosate or sethoxydim in the wick, and alachlor in combination with glyphosate or sethoxydim in the wick for rhizome johnsongrass control in soybeans. In 1982 fluchloralin was also tested for rhizome johnsongrass control in soybeans.

In both years MBR 22359 was applied at 2.2, 3.4, and 4.5 kg/ha preemergence, and at 1.1 and 2.2 kg/ha postemergence. In 1981 sethoxydim was applied in single applications at 0.3, 0.4, and 0.7 kg/ha early postemergence, 0.7 kg/ha late post-emergence, and in split applications early postemergence and late postemergence respectively at 0.2 plus 0.2, 0.3 plus 0.3, 0.4 plus 0.4, and 0.4 plus 0.2 kg/ha. In 1982 sethoxydim was

applied in single applications at 0.2, 0.3, 0.4, and 0.6 kg/ha early postemergence, and in split applications early postemergence and late postemergence respectively at 0.2 plus 0.1, 0.2 plus 0.2, 0.3 plus 0.1, 0.3 plus 0.2, and 0.4 plus 0.2 kg/ha. In 1981 and 1982 trifluralin at 1.1 kg/ha was applied in combination with mefluidide at 0.3 kg/ha early postemergence, mefluidide at 0.3 kg/ha early postemergence plus mefluidide at 0.3 kg/ha late postemergence, mefluidide at 0.3 kg/ha early postemergence in combination with glyphosate plus water (1:2, v/v) directed postemergence, sethoxydim plus oil plus water (2:1:3, v/v) directed postemergence, or with glyphosate plus water (1:2, v/v) directed postemergence in the rope wick applicator. Alachlor was applied at 3.4 kg/ha in combination with sethoxydim plus oil plus water (2:1:3, v/v) or with glyphosate plus water (1:2, v/v) directed postemergence in the rope wick applicator. In 1982 fluchloralin was applied at the rate of 2.2 kg/ha.

Sethoxydim single and split application treatments at all rates employed excellent rhizome johnsongrass control in 1981 and 1982. No soybean injury was noted and good yields were obtained where sethoxydim was applied.

MBR 22359 preemergence treatments provided good to excellent rhizome johnsongrass control. Soybean injury and yield reductions were noted with the MBR 22359 postemergence and the 4.5 kg/ha preemergence treatments in 1981. No significant differences in yields were found between any of the herbicide treatments in 1982.

Trifluralin combinations and alachlor combinations provided poor to fair rhizome johnsongrass control in both years. Soybean injury was noted for the trifluralin combination treatments that contained mefluidide. Yields were generally not as high for the trifluralin combinations and alachlor combinations as they were for the sethoxydim, and the lower rate MBR 22359 preemergence treatments in 1981. Fluchloralin provided extremely poor rhizome johnsongrass control in 1982.

INTRODUCTION

Soybeans are one of the most important agronomic crops in Kentucky. To insure high economic returns, weed control is a major concern to soybean producers in Kentucky and in the southeastern United States. Weed competition has been found to have adverse effects on soybean yields (7,15,49,54). Weeds can depress soybean yields by competing for the available light, nutrients, and moisture (16,49). Without adequate weed control soybean seed quality and quantity are greatly reduced (42,49). Profitable soybean production in the southeastern United States is largely dependent on good weed control.

Johnsongrass is a perennial grass that grows prolifically and reproduces from both vegetative and seed propagules. Croplands infested with johnsongrass can create an additional expense to the American farmer in the form of an average 10 to 15% lower crop yields, increased tillage operations, and higher herbicide costs due to increased rates and additional treatments (57).

Seedling johnsongrass can initiate a rhizome spur within eighteen days after emergence (32). Rhizome production occurs throughout the season but increases rapidly after johnsongrass flowers. At the end of the growing season an average plant can produce 8,070 grams and 64 meters of rhizomes. This rhizome initiation and growth are major contributing factors to the problem of controlling johnsongrass.

This rhizome johnsongrass study was initiated to evaluate the effectiveness of two experimental herbicides: sethoxydim and MBR 22359. Sethoxydim was applied postemergence as single, split, or wick combination treatments. MBR 22359 was applied either as a preemergence or postemergence treatment. These new experimental herbicides were compared to a number of herbicides now being used by farmers. Trifluralin in combination with mefluidide, glyphosate or sethoxydim, alachlor in combination with glyphosate or sethoxydim, sethoxydim applied as single or split applications, MBR 22359 preemergence and postemergence, and fluchloralin were compared for the percent of rhizome johnsongrass control they incurred in conventionally tilled soybeans.

REVIEW OF LITERATURE

History and Growth Habit of Johnsongrass.

Johnsongrass is listed as one of the world's ten worst weeds (25), and of all plants introduced into the United States, johnsongrass is one of the most troublesome (10, 44,48,56,67). It has been estimated to have cost American agriculture billions of dollars (44,51). Infested cropland creates additional expense to the farmer in the form of an average 10 to 15% lower crop yields, increased number of tillage operations, and higher herbicide costs due to increased rates and additional treatments (57).

McWhorter (37) found johnsongrass indigenous to the Mediterranean region of the world. It is generally agreed that johnsongrass was introduced into the United States prior to 1875, but the exact date is unknown. Over forty common names were used in nineteenth century literature referring to johnsongrass, thereby making it impossible to know the specific plant to which an author referred. Knowledge of johnsongrass's growth habit augments the belief that early references using common names were actually referring to *Sorghum halepense*.

Johnsongrass is a perennial grass that reproduces prolifically from both vegetative and seed propagules (63).

Vegetative propagule (rhizome) initiation and growth are major contributing factors to the problem of controlling johnsongrass. Rhizomes are fleshy underground stems which develop rapidly and function as organs for carbohydrate storage and as reproductive structures. Rhizomes produce vegetative shoots from axillary and terminal buds.

McWhorter (32) found plants initiated a rhizome spur eighteen days after emergence of plants from seed. After formation of the spur, rhizome development was relatively slow and apparently subordinate to much more rapid foliar growth. At an average of 27 days after plant emergence, seed stalks began to emerge, and at 46 days after plant emergence, plants were in full bloom throughout the season. After the start of blooming, rhizome production increased rapidly, whereas the rate of leaf growth decreased progressively throughout the season. Near the end of the growing season, 152 days after emergence, an average plant produced approximately 8,070 grams and 64 meters of rhizomes.

Rhizomes are found in the upper portion of the soil profile. McWhorter (38) reported that approximately 80% of johnsongrass rhizomes produced in clay soil were in the top 7.5 cm, but 80% of the rhizomes in sandy loam occurred in the top 12.5 cm. Approximately 60% of the total dry weight of subterranean plant parts are found in the upper 15 cm of the soil (27). Root weight amounts to less than 10% of the total subterranean parts (27). Rhizomes make up the major weight.

The length of a rhizome section influences its germination and survival rate. McWhorter (38) found more plants emerged from short rhizomes (76 mm) than from long rhizomes (152 mm) when planted at a depth of 7.6 cm. Long rhizomes had a greater supply of food reserves available to sustain emergence than plants from shorter rhizomes, and those plants produced by long rhizomes were able to emerge from greater depths (38). The smaller the rhizome section, the faster the moisture loss, and the rhizome's viability decreased (48). Johnsongrass rhizomes 6.3 cm long lost moisture more rapidly than did longer rhizomes stored at various moisture levels (48). Visual observations have indicated that intensive disking can control johnsongrass via two methods: (a) the cutting of the extensive rhizome systems into comparatively smaller sections and (b) dehydration of these sections (48).

The optimum temperature for maximum rhizome growth is between 28 and 35 C (26,50). At temperatures of 39 C sprouting capacity of a rhizome is significantly lower (26), and exposure to 50 to 60 C temperatures can kill rhizome buds (38). Tests indicated rhizome buds could withstand 0 C, but exposure to -3 or -5 C would kill rhizomes (38). Rhizomes quit sprouting at approximately 10 C and sprouted slowly below 20 C temperatures (38). Rhizome development varies greatly throughout a year. McWhorter (39) reported that the levels of glucose, fructose, and sucrose in rhizomes were at a minimum 10 to 30 days after plant emergence and at a maximum when plants began flowering. In an individual plant study almost no rhizome development occurred in winter or early spring during cool periods when rhizomes were using part of their reserves for respiration (27). Maximum rhizome development will occur during the summer months when temperatures are warm.

The hard seed coat of johnsongrass enables the seed to be highly dormant (63). Light and temperature are determining factors in breaking seed dormancy and causing seed germination (63). Taylorson and McWhorter (63) found dark germination of various ecotypes was extremely low at a constant temperature. One week of continuous light increased germination only 4%. Temperature seemed to be the major factor in breaking the seed dormancy. Pretreatment of seeds for two weeks of 10 C temperature followed by a shift to 40 C for a two hour period was effective in breaking johnsongrass seed dormancy (63).

Johnsongrass varieties or ecotypes are highly variable. McWhorter (35) found mature leaf-blades of various ecotypes varied greatly in length, width, color and in the number of large and small vascular bundles. Plant height and culm density varied two- to four-fold in 55 morphologically distinct ecotypes. Some ecotypes grew in compact clumps while others produced low-spreading clumps. Extreme variability was found in seed production in which individual panicles of different ecotypes varied more than four-fold. Maximum variation in the growth habit of johnsongrass occurs under conditions of high fertility, adequate soil moisture (35), and variations in temperature and light intensity (50). Growth habits of various ecotypes can vary widely, but there is no apparent correlation between leaf length and width, plant height, width of clumps, or culm density and the level of control (36). Susceptibility of johnsongrass ecotypes to herbicides varies greatly (21), and possibly this factor partially accounts for the variability in johnsongrass control throughout the United States (35).

Weed Control in Soybeans.

The lack of adequate weed control in soybeans is one of the major factors responsible for low seed yields in the southeastern United States. Weeds depress yields by competing with soybeans for light, nutrients, and moisture (1,6,49). They reduce the quality and quantity of harvested soybean seed by delaying harvest and by decreasing the efficiency of equipment during harvest (49). Soybean production in the United States depends upon the use of effective weed control methods (17).

Soybean yield losses from weed competition are largely dependent on the stand of soybeans (14,45,68). Weber and Staniforth (68) found soybean yield reductions due to weeds were more than ten-fold with soybean stands of 3 plants per 30 cm of row than with stands of 9 and 15 plants per 30 cm. Thicker stands afford better competition against certain weeds. Narrow-row soybean stands have also been found to provide competition to weeds at an earlier stage of growth than those in wide rows (90 to 105 cm) by better distribution of roots and earlier and more complete shading of the soil surface (8).

Early weed competition can have an adverse effect on soybean yields (7,15). Eaton et al (15) found weeds seeded with soybeans or seeded 10 days later reduced yields 1010 and 480 kg/ha, respectively, but weeds planted 20, 30 or 40 days after soybeans did not significantly reduce yields. The number of pods per soybean plant (15) and seed weight were found to increase as weed competition decreased (7). Burnside and Moomaw (8) reported weeds can compete severely with young soybeans, whereas established soybeans compete well with young weeds.

Annual and perennial weeds can have an adverse effect on soybean yields (15,49,54). Soybean yields are affected differently by the weed species present at the time the crop is growing (42,54,60). Heavy infestations of johnsongrass have been determined to reduce yield of six soybean varieties 23 to 42% (49). McWhorter and Hartwig (49) found soybean varieties can differ in their response and competitiveness to johnsongrass. A reduction in soybean yield of 25 to 30% resulted from one smooth pigweed (Amaranthus hybridus) per 30 cm in 76 cm wide rows (54).

Weeds not only decrease the yield (42,54,60), but also increase the cost of growing soybeans (12). Weeds increase the harvesting and cleaning costs (12), delay maturity, decrease soybean height, and increase lodging (60).

Harvesting before weeds are desiccated by a frost can result in significant threshing and separation losses (54). Foreign material in soybeans was approximately 0.8% with 100% johnsongrass control and nearly 6% with no control (42). At least 70% johnsongrass control was required to avoid deductions from gross harvested weights caused by seed moisture levels exceeding 13% (42). With 100% johnsongrass control about 1.2% seed damage occurred, whereas without johnsongrass control 1.7% seed damage occurred (42). McWhorter and Anderson (42) reported that failure to control johnsongrass resulted in predicted soybean grades of 4.1, whereas 100% johnsongrass control was necessary to provide U.S. No. 1 grade soybeans. Soybean yields increased 4.8 to 6.2% for each 10% increase in johnsongrass control, and net returns in soybean production were nearly twice as great with 100% johnsongrass control as when johnsongrass was not controlled (42).

Chemical Control of Johnsongrass.

Johnsongrass is a persistent problem in farm crops. McWhorter and Baldwin (44) conducted a survey and reported johnsongrass present in 70 to 80% of all cotton fields in mid-August to early September even though most of the fields had been treated a number of times specifically to control johnsongrass. Johnsongrass was present in 80 to 90% of all southern states' soybean fields. Herbicides have been and are presently being developed to aid in the specific control of johnsongrass.

Preplant incorporated, preemergence, and postemergence herbicides are available for control of johnsongrass. Kentucky (24) recommended dalapon [2,2-dichloropropionic acid] and glyphosate [N-(phosphonomethyl)glycine] as foliar applied herbicides to control johnsongrass before crops are planted. Mefluidide [N-[2,4-dimethyl-5-[[(trifluoromethyl) sulfonyl]amino]phenyl]acetamide] is recommended as a post-emergence treatment for suppression of johnsongrass. Fluchoralin [N-(2-chloroethyl)-2,6-dinitro-N-propyl-4-(trifluoromethyl) aniline], profluralin [N-(cyclopropylmethyl)-*a*,*a*,*a*,-trifluoro-2,6-dinitro-N-propyl-p-toluidine], trifluralin [*a*,*a*,*a*-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine], and vernolate [S-propyl dipropylthiocarbamate] are recommended as preplant incorporated treatments (PPI) for seedling control. Alachlor [2-chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide] and metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxyl-1-methylethyl) acetamide] may be applied as preemergence or PPI applications for seedling johnsongrass control.

From a practical viewpoint the first major break-through in johnsongrass control occurred in the 1960's with the availability of the arsenical herbicides: DSMA [disodium methanearsonate], MSMA [monosodium methanearsonate] (21,44) and with the availability of trifluralin as a soil-incorporated preemergence treatment (44). The arsenicals are highly selective for johnsongrass control when applied in cotton as directed postemergence sprays and are still important herbicides to cotton producers (44).

Trifluralin

Trifluralin is a preemergence herbicide which should be soil incorporated within eight hours after application using equipment that breaks up clods and mixes the soil thoroughly (69). Surface applications of trifluralin are generally effective under dry conditions, but not under wet conditions. Trifluralin vaporization increases as soil moisture increases (62). Reduced volatilization of trifluralin when soil moisture is low may result from greater adsorption of herbicide molecules on the drier soil. Results have confirmed that trifluralin should be incorporated to reduce volatilization and to provide consistent weed control (59). In moist soil, colloids may become hydrated and adsorptive sites become less accessible to the hydrophobic trifluralin molecules. Unadsorbed trifluralin molecules can diffuse rapidly and are lost into the atmosphere. Standifer and Thomas (59) reported that trifluralin directly affects only plant root development. Foliar applications in combination with several surfactants had no apparent effect on plant growth.

Kentucky (24) recommends trifluralin be applied PPI at a 0.8 to 1.1 kg/ha rate for control of annual grasses and broadleaf weeds, and 1.7 to 2.2 kg/ha rate is to be applied PPI for two consecutive years for control of rhizome johnsongrass in soybeans. Trifluralin was registered in 1971 for control of rhizome johnsongrass in soybeans at a double rate (2x) of 1.1 to 2.2 kg/ha (41). McWhorter (44) reported that in southern states the 2x trifluralin treatment did not eliminate johnsongrass rhizomes during the first year of use, but it was effective in greatly reducing growth from johnsongrass rhizomes in the spring and in preventing rhizome production throughout the remainder of the growing season. Trifluralin after the first year of 2x rates 1.1 to 2.2 kg/ha controlled rhizome johnsongrass 54 and 64% respectively (10). After two years the same 2x rates gave 70 and 80% control respectively. This treatment has been used for nearly a decade and is still used for control of johnsongrass from both seed and rhizomes (44).

Millhollon (53) determined that control of rhizome johnsongrass by trifluralin was influenced by length of rhizomes, depth of rhizomes in relation to the zone of treated soil, and application rate. When planted 3.8 cm deep within a soil mixed with 1.7 and 3.4 kg/ha, rhizomes 2.5 cm long were controlled 95 to 100% by both rates. Control of 15 cm rhizomes were more rate dependent averaging 54 and 81% for the low and high rates respectively. Trifluralin provided less than 20% control when 15 cm rhizomes were planted 10 cm deep below the zone of treated soil. Only 10% of the shorter rhizomes survived at the 10 cm depth even in untreated soil. Concentration of trifluralin in the soil surrounding a rhizome apparently is a more important factor than depth of treated soil that roots and shoots must penetrate during growth (53). Trifluralin is toxic to roots that grow from rhizomes. Millhollon (53) reported that the stunting of roots occurred during the period that stored food in the parent rhizomes was being depleted. Rhizomes within the treated soil zone were usually killed, but many rhizomes below the zone survived. The majority of rhizomes must be in the treated soil for effective control (53).

Trifluralin has been found to affect growth, nodulation, and anatomy of soybeans (30). Trifluralin at 1.1 kg/ha rate significantly reduced leaf, stem, and petiole weights of eight-week-old plants (30). In seven-week-old plants, trifluralin caused pronounced changes in number and organization of palisade cells in leaves. Trifluralin reduced nodulation and seemed to inhibit utilization of cotyledonary reserves and the redistribution of organic and mineral constituents of unifoliate leaves (30). Hagood (20) reported that recommended rates of trifluralin did not cause a significant reduction in soybean yield, and the reduced soybean vigor in early growth stages was not sufficient to indicate the potential for yield reduction.

Fluchloralin

In recent years, herbicides that are closely related to trifluralin have been introduced for weed control in soybeans (41). Fluchloralin, one such herbicide, is chemically related to trifluralin but varies in chemical structure and in toxicity to johnsongrass and soybeans (41).

Fluchloralin should be incorporated in the same manner as trifluralin to reduce volatilization (24,41). Fluchloralin is recommended at rates of 0.8 to 1.1 kg/ha for control of annual grasses and broadleaf weeds, and rates of 1.7 to 2.2 kg/ha are recommended for control of johnsongrass from rhizomes (24). The latter rates are to be applied for two consecutive years (24). McWhorter (41) reported fluchloralin at 0.6 and 1.1 kg/ha rates controlled rhizome johnsongrass in southern states less than 80% after one year of use and provided greater than 80% control during the second year of use. The use of fluchloralin increased soybean yields from 980 kg/ha with no treatment up to 1620 kg/ha for a two year average on the 0.6 kg/ha rate and 1880 kg/ha on a two year average for the 1.1 kg/ha rate. Fluchloralin caused no soybean injury at high and low rates either in the first or second year of use (41). Beingolea and Worthington (3) applied fluchloralin in Kentucky at the rate of 2.2 kg/ha and obtained poor rhizome johnsongrass control. These differences in the control of johnsongrass may be due to differing soil moisture and temperature in the southern and southeastern states. Jacques and Harvey (28) reported that the phytotoxicity of fluchloralin was influenced by soil moisture content and temperature.

Alachlor

Alachlor can be applied as a preemergence, early post-emergence, or preplant incorporated herbicide for control of most annual grasses, certain broadleaf weeds, and yellow nutsedge (69). Rates of 2.2 to 3.4 kg/ha may be applied preplant or preemergence for control of these weeds (24). For rhizome control dalapon or glyphosate should be applied foliarly to johnsongrass at the 38 to 45 cm height prior to planting soybeans, followed by alachlor at 4.0 to 4.5 kg/ha rate applied PPI or preemergence for seedling johnsongrass (24).

Gebhardt (17) found alachlor (2.2 kg/ha) in combination with linuron [3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea] (0.70 kg/ha) gave, over a five year average, 55% control of giant foxtail (*Septoria faberi*) and velvetleaf (*Abutilon theophrasti*). Alachlor plus linuron with one cultivation gave 75% control of weeds, and with two cultivations 87% control was obtained. Cultivations have been found to be effective in increasing weed control and yields when herbicide rate or effectiveness has been reduced (17).

Preplant with shallow incorporation or preemergence applications of alachlor at 3.4 to 4.5 kg/ha effectively controlled yellow nutsedge (2). Postemergence applications of alachlor were not effective in controlling yellow nutsedge (2). High rates of alachlor were found to cause slight to moderate foliar malformation in soybeans. However, recovery was rapid, and neither stand nor yield reduction was observed (20).

Temperature and humidity can affect the weed control potential of alachlor (22). Hargrove and Merkle (22) found alachlor degradation occurs under conditions of low relative humidity and high temperature. These factors provide a possible explanation for field observations which have indicated that poor weed control may result if hot, dry weather occurs following applications of alachlor.

Alachlor is readily broken down in water (70) and by microorganisms in the soil (64). Alachlor was found to be rapidly degraded in water into numerous compounds (70). No parent compounds were detected in organisms, and there was no evidence to indicate that their metabolites or degradation products were magnified in the food chain. The degradation of alachlor by the common soil fungus *Chaetomium globosum* produced chloride and four identifiable organic metabolites (64). Pure cultures of *Fusarium roseum* and species of *Penicillum*, *Phoma*, *Alternaria*, *Paecilomyces*, and *Trichoderma* were unable to effectively degrade alachlor (64).

Glyphosate

Glyphosate can be applied to johnsongrass foliage prior to planting or after crop emergence. In cotton and soybeans several different application methods of glyphosate may be utilized after crop emergence (44). The most popular methods of application are spot treatments or treatments applied by specialized equipment such as recirculating sprayers and rope wicks (44).

Glyphosate applied as a foliar spray controls rhizomatous johnsongrass at rates between 1.1 and 3.4 kg/ha (55). More complete control was observed with higher rates. Stage-of-growth studies showed glyphosate was more effective in controlling johnsongrass when applied in the boot to full seed head stage than when johnsongrass was only 45 to 60 cm in height (55). There was a trend toward increased response of johnsongrass to glyphosate as the time from foliar application to plowing increased. Kell and Riech (29) reported that the major area of accumulation of ^{14}C-glyphosate at both a three day and a six day harvest was in the growing point and other areas of meristematic growth. Absorption and translocation of glyphosate increased from 20% at the three day harvest to 85% at the six day harvest. The presence or absence of light had little or no effect on absorption of ^{14}C-glyphosate.

"Spot treatment" or "spot spraying" refers to an application of a herbicide spray to a restricted area, usually less than 1 meter in diameter. Spot treatments are usually applied with single hand-held nozzle sprayers and are most often utilized for the spraying of clumps of johnsongrass that grow from rhizomes.

McWhorter and Barrentine (47) tested several herbicides to determine which herbicide and what rate was most effective in controlling johnsongrass with utilization of spot treatment applications. Dalapon, TCA ester [(ethyleneglycol) bis-(trichloroacetate)] , MSMA, and glyphosate were evaluated for their effectiveness as spot treatments applied to johnsongrass 30, 75, or 100 cm tall from rhizomes. Glyphosate at concentrations of 6 or 12 g/L of water was the most effective treatment regardless of height. A single application provided excellent-to-complete seasonal control within two weeks after application. Repeated applications of dalapon, TCA ester, and MSMA would be needed for season-long control at 12 and 24 g/L concentrations.

The recirculating sprayer was specifically designed for applying glyphosate via horizontal spray streams onto tall growing weeds and not on the desirable crop. The spray solution not intercepted by tall weeds during over-the-top application is collected in open pans and returned to the spray tank for reuse.

McWhorter (40) reported that glyphosate applied at 1.2 to 2.2 kg/ha with a recirculating sprayer provided 75 to 99% johnsongrass control. Soybean injury following treatment was 5 to 35%, but soybean yields increased 675 to 1680 kg/ha when compared to untreated plots. Treatments were 10 to 20% more effective when applied at 93 to 187 L/ha than when applied at 374 to 748 L/ha. Seventy to 80% of the herbicide solution applied with the recirculating sprayer was recovered in a spray trap for reuse. The addition of 0.25 to 0.50% surfactant increased soybean injury and johnsongrass control.

Several problems do exist when using a recirculating sprayer: (a) treatments cannot be applied until July or August when johnsongrass is taller than the crop; (b) treatments are often injurious to the crop due to heavy weed growth which can cause excessive splash and spatter onto the crop (44).

At present, the largest, most extensively adopted group of selective over-the-top applicators of glyphosate utilize a wiping concept rather than spraying (4). These wiper applicators or rope wicks apply glyphosate to weed escapes by rubbing the weed with an absorbent material containing a herbicide solution. Rope wick applicators offer a number of advantages including low cost of the equipment, simplicity of use, and low cost for the treatment since little herbicide is applied (44).

The rope wick consists of a reservoir (usually PVC pipe) of herbicide solution into which ends of rope are placed and fed (4). Various absorbent media have been used including cellulose sponge and nylon carpet, but 95% of wipers now in use utilize rope as the absorbent medium. The rope wick conveys the herbicide solution to be applied to the weed through capillary action and gravitational flow.

Results in soybeans indicate that rhizome johnsongrass is highly responsive to specific design and component changes in wick applicators, particularly with increased weed density/ha (11). Derting (11) applied glyphosate in a water solution at (1:3, v/v) rate in different type wick applicators to johnsongrass. In 80% infestations, variation in rope segment length of 10, 15, and 20 cm resulted in 75, 50, and 40% control, respectively, from one pass at 3 km/hr. A standard pipe wick fitted with rubber grommets controlled johnsongrass 60% as compared to 40% johnsongrass control with a compression fitting.

Results with a rope wick were fairly good in 1979 (44). With the extremely high temperatures and dry conditions of 1980, results were not as good due to less translocation of glyphosate (44). A (1:2, v/v) solution of glyphosate in water should be applied at speeds of 4.8 km/hr or less to johnsongrass when it is a minimum of 15 cm above soybean plants (24). Better results were obtained when two applications were made in opposite directions (24).

McWhorter and Azlin (43) found environmental factors affected the toxicity of glyphosate to johnsongrass. Analysis indicated that glyphosate was more toxic to johnsongrass when applied at 20% soil moisture (near field capacity) than at 12% soil moisture (slightly above permanent wilting point). Glyphosate tended to control johnsongrass better at 100% rather than 45% relative humidity, and air temperature of 35 C was more favorable for control than 29 or 24 C. Their data indicated that combined conditions of low humidity and low soil moisture resulted in the least amount of johnsongrass controlled regardless of temperature. These results can aid the farmer in deciding upon the time in which glyphosate should be applied in order to receive maximum johnsongrass control.

Mefluidide

Mefluidide was introduced as a "highly active growth regulator" for use in reducing vegetative growth and seed-head production of cool and warm season grasses (46). Postemergence application of mefluidide has shown promise for controlling johnsongrass in soybeans (16). Kentucky (24) recommends mefluidide at 0.3 kg/ha plus a non-ionic surfactant be applied when soybeans are actively growing, when the second trifoliate leaf stage has expanded, and when johnsongrass foliage is less than 38 cm high. This treatment suppresses johnsongrass growth (24).

The addition of a surfactant to a herbicide treatment favors or improves emulsifying, dispersing, spreading, wetting, or other surface modifying properties of the herbicide solution (24). Surfactant molecules consist of two major chemical groups: one is fat-soluble (lipophilic), water-insoluble (hydrophobic), and nonpolar, while the second group is water-soluble (hydrophilic), fat-insoluble, and polar (34). Surfactants are classified according to ionic activity as anionic, cationic, or non-ionic depending on the electrocharge of the surface active group. With non-ionic surfactants neither positive nor negative ions are produced in any quantity. Most non-ionic surfactants are not subject to hydrolysis by acidic or alkaline aqueous solutions and do not form salts with metal ions which makes them equally effective in hard and soft water.

Mefluidide applied postemergence to two to five trifoliate soybeans and 15 to 38 cm johnsongrass at rates of 0.3, 0.6, and 1.1 kg/ha gave 81, 87, and 93% johnsongrass control, respectively (16). Less consistent control was obtained when applications were made to johnsongrass taller than 38 cm. Increasing rates of mefluidide improved johnsongrass control, but also produced more soybean injury (19). Applications of mefluidide at 1.1 kg/ha plus a non-ionic surfactant caused 25 to 35% injury. Soybean height was reduced when mefluidide was applied at 1.0 kg/ha, but fresh weight was not reduced (56). The height reduction was accompanied by leaf crinkling, which was apparent one week after application. Reduction in grain yield occurred when 1.1 kg/ha was applied at the 2nd, 5th, and 10th trifoliate leaf stage and seven days prior to bloom (23). Soybean tolerance has been good when treated with 0.6 kg/ha of mefluidide or less (16). Glenn and Rieck (19) found optimum rates of mefluidide needed to obtain maximum soybean yields were 0.3 and 0.6 kg/ha. Mefluidide at 0.50 kg/ha plus surfactant increased soybean yields 250% (19).

Mefluidide activity on rhizome johnsongrass resulted in twisting and withering of the vegetation to near the soil line (16). Gates et al (16) found regulation of regrowth was obtained for a period of approximately three to six weeks, and during this period of regrowth suppression, competition from a good soybean canopy resulted in high levels of johnsongrass control.

Environmental conditions can affect the absorption and translocation of mefluidide in soybeans and johnsongrass (52). Results indicated that absorption and translocation of the radiolabel of ^{14}C-mefluidide in soybeans and johnsongrass were greater at 32C than at 22C and greater at 100% than at 40% relative humidity. Movement of mefluidide in johnsongrass was affected most by variations in temperature, whereas movement of mefluidide in soybeans was most often affected by variations in relative humidity. McWhorter (33) stated that many variables such as relative humidity, plant water stress, rate of growth, and water pH determined the effectiveness of foliar-applied herbicides and surfactant-herbicide mixtures. Regardless of the effect of such variables, it is assumed that a surfactant increases herbicide effectiveness by increasing the amount of herbicide absorbed into the plant (33).

Bloomberg and Wax (5) found certain soybean cultivars were more susceptible to reduced height, stem diameter, seed yield, and pod number per plant when treated with mefluidide at 0.5 kg/ha plus 0.5% (v/v) surfactant than when treated with mefluidide alone. Mefluidide plus surfactant was generally more deleterious to all observed parameters of soybean development than mefluidide alone (5). Tolerant soybean varieties to mefluidide include Beeson, Hark, and Williams, and susceptible varieties include Altona, Amsoy 71, Hurrelbrink, Hodgson, and Prize (5).

Researchers have indicated that beneficial interactions can result between mefluidide and other herbicides (18,56). An interaction between bentazon [3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide] and mefluidide appears to result in greater tolerance of soybeans to mefluidide (56). No soybean injury occurred when mefluidide was applied in combination with bentazon at 1.0 and 0.13 kg/ha, respectively. The addition of bentazon to mefluidide reduced soybean foliage crinkling caused by the application of mefluidide alone. The combination of the two herbicides plus a surfactant not only reduced required rates and the expense, but also reduced the risk of soybean injury. Gibson et al (18) reported that mefluidide showed a potential to increase the efficacy of acifluorfen [5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoic acid] and bentazon on broadleaf and grass weeds in soybeans. The combination treatments controlled larger weeds and additional species when compared to aciflurofen or bentazon treatments applied alone. Reduced herbicide rates and greater flexibility in timing of applications are also possible (18).

Sethoxydim

Sethoxydim [(2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio) propyl]-3-hydroxy-2-cyclohexen-1-one] is a new selective postemergence herbicide which controls a broad spectrum of annual and perennial grass weeds (31). In grass plants sethoxydim is absorbed very rapidly by the foliage, and within an hour the majority of the herbicide is in the plant (31). This characteristic is especially desirable for a postemergence herbicide when rainfall is possible shortly after application. Addition of a concentrated crop oil or oil surfactant to a sethoxydim spray solution increases efficacy of the herbicide (31,66).

Sethoxydim applied to annual grasses at 0.3 kg/ha rate with an oil concentrate provided 95 to 100% control (66). The addition of an oil concentrate to the 0.3 kg/ha rate generally provided control equal to that of 0.6 kg/ha rate of sethoxydim applied alone (66).

Numerous application rates of sethoxydim have been tested to establish adequate rates for control of johnsongrass (9). In several states, sethoxydim rates ranging from 0.2 to 0.7 kg/ha for a single application and 0.2 plus 0.2, 0.3 plus 0.2, 0.3 plus 0.3, 0.4 plus 0.2, 0.4 plus 0.4, 0.6 plus

0.6 kg/ha for split applications have been tested for rhizome johnsongrass control (9). When split applications were tested, the second application was made 14 to 21 days after the initial treatment. Crop oil concentrate at a rate of 2.4 L/ha was used in all treatments. Optimum spray volume for application was 187 to 234 L/ha (31).

Sethoxydim at 0.3 kg/ha rate resulted in season long control of 95% or better when rhizome johnsongrass was 46 cm tall or less at the time of application. Rhizome johnsongrass taller than 46 cm at application required 0.4 kg/ha of sethoxydim or more to provide 95% control. The single rate application of 0.2 kg/ha resulted in partial control of rhizome johnsongrass, but gave excellent seedling johnsongrass control when seedlings were up to 20 cm tall. When rhizome johnsongrass was treated with 0.3 kg/ha, regrowth occurred in only a few cases. In comparison, a standard farm practice of a single or 2x rate of a dinitroanaline herbicide, plus one to two rope wick or recirculating sprayer application treatments of glyphosate, provided a range of rhizome johnsongrass control from 30 to 68% (9). Soybean yields did not vary significantly within sethoxydim treatments, but averaged 422 kg/ha greater when compared to the standard farm practice (9). Beingolea and Worthington (3) received good rhizome johnsongrass control with varying rates of sethoxydim applied early and late postemergence and reported poor rhizome johnsongrass control was obtained with the 2x trifluralin or fluchloralin.

Sethoxydim symptoms of phytotoxicity to grasses are leaf chlorosis and necrosis with occasional reddening of the above ground tissue (31). A decaying (browning or blackening) of the tissue occurs at the nodes of the grass stem. Optimum environmental conditions for best control occur with good soil moisture, high temperatures, and high humidity (31). If such conditions do not exist, grass control will generally be slower and may not reach the maximum level of control.

Postemergence grass control is possible in a multitude of broadleaf crops including soybeans and cotton. Sethoxydim offers a new dimension in weed control in the southeastern U.S. (31,44). Sethoxydim causes no soybean injury and has no activity on broadleaf weeds at rates as high as 2.2 kg/ha (66). Sethoxydim can be utilized in no-till (44) and in solid seeded soybean plantings (31).

MBR 22359

MBR 22359 is a new selective preemergence herbicide which is presently being tested for control of rhizome johnsongrass (13). Excellent johnsongrass control was obtained from MBR 22359 applied preemergence at rates ranging from 1.7 to 3.4 kg/ha (13). Umeda and Kapusta (65) reported MBR 22359 at 2.2 and 3.4 kg/ha rates provided 80% johnsongrass control. At the end of the growing season the final control was slightly better than 50%. MBR 22359 at 1.1 kg/ha or less did not effectively control johnsongrass (65).

MBR 22359 applied at 1.7 to 3.4 kg/ha to 25 cm tall johnsongrass caused minimal injury; however, it provided good to excellent height and heading reduction (13). Simkins and Doll (58) found MBR 22359 applied postemergence at 2.0 kg/ha provided excellent quackgrass (*Agropyron repens*) control. Substantial soybean injury resulted from applications of MBR 22359 at 0.5 and 2.0 kg/ha applied postemergence. MBR 22359 applied preemergence did not provide good quackgrass control, and soybean yield reductions occurred where quackgrass control was poor or when soybean injury occurred (58).

MATERIALS AND METHODS

Field experiments were conducted on the Western Kentucky University Farm at Bowling Green, Kentucky, during the summers of 1981 and 1982. The soil type was a Pembroke silty clay loam. The experimental design was a randomized complete block with four replications.

The plot areas were plowed with a moldboard plow in 1981, with a chisel plow in 1982, and were disked after plowing. All plots received two diskings at right angles to one another. Mitchell soybeans were planted in 76 cm rows on May 23, 1981, and on May 12, 1982.

Plots consisted of two treated rows with a check row on each side. Each plot was 7.6 m long. Herbicide treatments were applied with a hand-held CO_2 sprayer at the rate of 187 L/ha and a pressure of 2.1 kg/cm^2; five treatments were applied with a hand-held rope wick applicator (1.5 m long) at a speed of 4.8 km/hr. Plots were wicked two times in opposite directions in 1981 and one time in 1982.

All sethoxydim treatments applied with the hand-held sprayer contained concentrated crop oil in the herbicide solution which was applied at the rate of 2.3 L/ha. Sethoxydim treatments applied as wick applications contained concentrated crop oil at a concentration of 17% of the total herbicide solution. Mefluidide and MBR 22359 postemergence treatments contained a non-ionic surfactant at a concentration of 0.5% of the total herbicide solution.

1981

For rhizome johnsongrass control MBR 22359 was applied preemergence at rates of 2.2, 3.4, and 4.5 kg/ha; MBR 22359 was applied early postemergence at rates of 1.1 and 2.2 kg/ha. Sethoxydim was applied early postemergence at rates of 0.3, 0.4, and 0.7 kg/ha. One sethoxydim single application treatment was applied late postemergence at the rate of 0.7 kg/ha. Combination treatments of sethoxydim were applied early and late postemergence respectively, at rates of 0.2 plus 0.2, 0.3 plus 0.3, 0.4 plus 0.4, and 0.4 plus 0.2 kg/ha. All trifluralin treatments were applied preplant incorporated at the rate of 1.1 kg/ha. Trifluralin was applied in combination with mefluidide at the rate of 0.3 kg/ha early postemergence, and with a split application treatment of mefluidide at 0.3 kg/ha early postemergence and 0.3 kg/ha late postemergence. Trifluralin was applied in combination with mefluidide at 0.3 kg/ha rate early postemergence and with glyphosate plus water in a (1:2, v/v) solution directed postemergence in the rope wick applicator. Trifluralin in combination with glyphosate plus water in a (1:2, v/v) solution or with sethoxydim plus oil plus water in a (2:1:3, v/v/v) solution were applied directed postemergence in the rope wick applicator. Alachlor was applied preemergence at a 3.4 kg/ha rate in combination with glyphosate plus water in a (1:2, v/v) solution or with sethoxydim plus oil plus water in a (2:1:3, v/v/v) solution applied as directed postemergence rope wick treatments.

The trifluralin treatment was applied and incorporated on May 23. Preemergence treatments (MBR 22359 and alachlor) were applied on May 24. MBR 22359, sethoxydim, and mefluidide early postemergence treatments were applied on June 23 when rhizome johnsongrass was 38 to 63 cm tall and soybeans were at the 4 trifoliate leaf stage of growth. Sethoxydim late postemergence and all rope wick application treatments were applied on July 8 when johnsongrass was approximately 86 to 91 cm tall, and the mefluidide late postemergence treatment was applied on July 18.

Visual ratings for rhizome johnsongrass control were made on July 8, July 23, and August 6, six, eight, and ten weeks, respectively, after planting of soybeans. Ratings were reported as a percentage of the johnsongrass stand controlled. Soybean height was also measured on these dates. The soybeans were harvested on October 25. Yield data were obtained by harvesting 6 m of two rows in each treatment with a combine. Samples were cleaned in an air-screen cleaner, weighed, and adjusted to 13% moisture.

Percent johnsongrass control, soybean height, and yield data were analyzed and the means were separated by Duncan's multiple range test (61). The analysis of variance tables are listed in the Appendix.

1982

MBR 22359, trifluralin combination treatments, and alachlor combination treatments were the same as previously described for 1981. Sethoxydim was applied early postemergence at rates of 0.2, 0.3, 0.4, and 0.6 kg/ha. Combination sethoxydim treatments were applied early and late postemergence respectively at rates of 0.2 plus 0.1, 0.2 plus 0.2, 0.3 plus 0.1, 0.3 plus 0.2, and 0.4 plus 0.2 kg/ha. Fluchloralin was applied preplant incorporated at the rate of 2.2 kg/ha.

Preplant incorporated treatments (trifluralin and fluchloralin) were applied on May 11, and preemergence treatments (MBR 22359 and alachlor) were applied on May 13. MBR 22359 early postemergence treatments were applied on June 7 when the majority of the rhizome johnsongrass was approximately 28 cm in height and ranged from 8 to 46 cm in height. Sethoxydim and mefluidide early postemergence treatments were applied on June 11 when the majority of the johnsongrass was approximately 38 cm in height and ranged from 10 to 61 cm in height. Soybeans were in the 3 to 4 trifoliate leaf stage of growth. Rope wick applications were made on June 30. Johnsongrass was an average of 61 cm in height. Sethoxydim and mefluidide late postemergence treatments were applied on July 6 when the average johnsongrass plant was 71 cm tall.

Visual ratings for rhizome johnsongrass control were made on June 30, July 13, and July 27 approximately six, eight, and ten weeks, respectively, after planting of soybeans.

Ratings were reported as a percentage of the johnsongrass stand controlled. Soybean height was also measured on these dates. Soybeans were harvested on October 16. Yield data were obtained by harvesting 6 m of two rows in each treatment with a combine. Samples were weighed and adjusted to 13% moisture.

Percent johnsongrass control, soybean height, and yield data were analyzed and the means were separated by Duncan's multiple range test (61). The analysis of variance tables are listed in the Appendix.

RESULTS AND DISCUSSION

Rhizome johnsongrass control.

1981

The sethoxydim split applications and sethoxydim 0.4 and 0.7 kg/ha early postemergence single applications provided significantly higher johnsongrass control than the MBR 22359 1.1 kg/ha postemergence and the alachlor and trifluralin combination treatments at ten weeks after planting (Table 1). No significant differences were found between the single or split application sethoxydim, MBR 22359 preemergence, and the MBR 22359 2.2 kg/ha postemergence treatments at ten weeks. Although no significant differences were found among these treatments, the sethoxydim split applications provided an average of 99% johnsongrass control; the sethoxydim single applications provided 96% control; and the MBR 22359 treatments provided an average of 91% johnsongrass control.

The 0.3 kg/ha sethoxydim single application treatment was the lowest sethoxydim rate tested, and it provided the least amount of johnsongrass control (94%). Sethoxydim 0.7 kg/ha early postemergence treatment provided 99% johnsongrass control, while the 0.7 kg/ha late postemergence treatment provided 95% johnsongrass control. In the two week period between the times of early postemergence and late postemergence treatments, johnsongrass had grown approximately 40 cm. This

Table 1. Influence of herbicides on rhizome johnsongrass control and on soybean yields in 1981.

Treatments	Rate[a]	Time[b]	Percent johnsongrass control[c]			Soybean yields kg/ha[c]
			Week 6	Week 8	Week 10	
MBR 22359	2.2	Pre	85a	85ab	87abc	1697a-e
MBR 22359	3.4	Pre	91a	91a	94ab	1646b-e
MBR 22359	4.5	Pre	89a	95a	96ab	1452de
MBR 22359+surfactant[d]	1.1	EP	29c	66bc	69cde	1488cde
MBR 22359+surfactant	2.2	EP	29c	79abc	87abc	1482cde
Sethoxydim+oil[e]	0.3	EP	92a	94a	94ab	1869a-d
Sethoxydim+oil	0.4	EP	94a	97a	98a	1949abc
Sethoxydim+oil	0.7	EP	95a	99a	99a	2081ab
Sethoxydim+oil	0.7	LP	0d	77abc	95ab	1824a-e
Sethoxydim+oil	0.2	EP	91a	97a	99a	2010ab
Sethoxydim+oil	0.2	LP				
Sethoxydim+oil	0.3	EP	95a	100a	99a	2098ab
Sethoxydim+oil	0.3	LP				
Sethoxydim+oil	0.4	EP	94a	99a	99a	2164a
Sethoxydim+oil	0.4	LP				
Sethoxydim+oil	0.4	EP	95a	100a	100a	2019ab
Sethoxydim+oil	0.2	LP				
Trifluralin	1.1	PPI	52b	64bc	62def	1446de
Mefluidide+surfactant	0.3	EP				

(continued)

Table 1. (continued)

Treatments	Rate[a]	Time[b]	Percent johnsongrass control[c]			Soybean yields kg/ha[c]
			Week 6	Week 8	Week 10	
Trifluralin	1.1	PPI	63b	56c	77bcd	1364e
Mefluidide+surfactant	0.3	EP				
Mefluidide+surfactant	0.3	LP				
Trifluralin	1.1	PPI	56b	60c	59def	1404de
Mefluidide+surfactant	0.3	EP				
Glyphosate+water	(1:2, v/v)	Wick				
Alachlor	3.4	Pre	0d	17d	46f	1474cde
Sethoxydim+oil+water	(2:1:3, v/v/v)	Wick				
Alachlor	3.4	Pre	0d	22d	60def	1681a-e
Glyphosate+water	(1:2, v/v)	Wick				
Trifluralin	1.1	PPI	11c	29d	50ef	1410de
Sethoxydim+oil+water	(2:1:3, v/v/v)	Wick				
Trifluralin	1.1	PPI	14c	31d	62def	1443de
Glyphosate+water	(1:2, v/v)	Wick				

[a]kg/ha active ingredient, or ratio of the solution.

[b]Time of application: Pre-preemergence, EP-early postemergence, LP-late postemergence, PPI-preplant incorporated, Wick-postemergence wick.

[c]Means within each column followed by the same letter are not significantly different at the 1% level according to Duncan's multiple range test.

[d]Non-ionic surfactant at 0.5% of the solution.

[e]Concentrated crop oil at 2.4 L/ha or in a ratio of the solution.

increase in plant size may be responsible for the variation in control between the 0.7 kg/ha late postemergence and early postemergence treatments.

The MBR 22359 postemergence, sethoxydim 0.7 kg/ha late postemergence, and alachlor and trifluralin wick combinations provided significantly less johnsongrass control at six weeks after planting than all other treatments. These treatments varied in the percentage of johnsongrass control they provided at the six, eight, and ten week ratings.

The sethoxydim late postemergence 0.7 kg/ha treatment had not been applied when the six week ratings were made. No johnsongrass control (0%) was recorded at six weeks. Control was 77% approximately two weeks after application and 95% four weeks after application.

Postemergence applications of MBR 22359 four weeks after planting resulted in limited visual effects of control at the six week rating period. Control was 29% for both treatments at six weeks, and 69 and 87%, respectively, for 1.1 and 2.2 kg/ha rates at ten weeks.

Trifluralin and alachlor had been applied prior to the six week ratings, but the rope wick treatments containing glyphosate or sethoxydim had not been applied. Thus, control was low at six weeks. The trifluralin treatments provided a small percent of johnsongrass control at six weeks, but alachlor provided 0% johnsongrass control.

Johnsongrass control tended to increase throughout the season, primarily during the six to eight week period, with the MBR 22359 postemergence treatments, and after the sethoxydim and the rope wick treatments were applied. At the final season's rating (10 weeks) these treatments provided more johnsongrass control than they had at six weeks. The remaining treatments had less variation over the six, eight, and ten week ratings.

The combination of trifluralin plus mefluidide split application (early postemergence and late postemergence) treatment provided significantly more johnsongrass control than the alachlor plus sethoxydim and the trifluralin plus sethoxydim treatments at ten weeks. No significant differences were found between the trifluralin plus mefluidide split applications (early postemergence and late postemergence) and the remaining trifluralin and alachlor combinations and the MBR 22359 1.1 kg/ha postemergence treatment.

Rhizome johnsongrass control ranged from 46 to 100% among the different treatments at ten weeks after planting. Sethoxydim treatments provided 95 to 100% johnsongrass control; MBR 22359 preemergence and the MBR 22359 early postemergence at 2.2 kg/ha provided 87 to 96% johnsongrass control. There was a highly significant difference between MBR 22359 preemergence at the higher rate and the MBR 22359 early postemergence at 1.1 kg/ha. No other significant differences were found between the MBR 22359 treatments.

The trifluralin and alachlor combination treatments provided poor to fair (46 to 77%) control of johnsongrass. Various combinations with trifluralin resulted in 50 to 77%

johnsongrass control. The alachlor combinations controlled johnsongrass 46 and 60%. Trifluralin and alachlor applied in combination with glyphosate in the rope wick controlled more johnsongrass than did the same rates of trifluralin and alachlor in combination with sethoxydim in the rope wick. Glyphosate in the wick provided 60 and 62% control in combination with alachlor and trifluralin, respectively, while sethoxydim in the wick provided 46 and 60% control in combination with alachlor and trifluralin, respectively.

Sethoxydim applied early postemergence (EP) and late postemergence (LP), respectively at 0.4 plus 0.4 kg/ha provided significantly higher soybean yields than MBR 22359 3.4 and 4.5 kg/ha preemergence, MBR 22359 postemergence, trifluralin combinations, and the alachlor plus sethoxydim combination (Table 1). No significant differences were found between the sethoxydim, MBR 22359 2.2 kg/ha preemergence, and alachlor plus glyphosate treatments. Although no significant differences were found, the sethoxydim treatments provided at least a 172 kg/ha yield increase when compared to the MBR 22359 preemergence or alachlor plus glyphosate combination.

The split applications of sethoxydim (EP and LP) provided slightly higher yields than the single applications, but there were no significant differences between these treatments. Sethoxydim at the 0.4 plus 0.4 kg/ha rate provided a slightly better soybean yield than all other treatments.

No significant differences in soybean yields were found among the MBR 22359, alachlor, and trifluralin treatments.

The MBR 22359 at 2.2 and 3.4 kg/ha preemergence and alachlor plus glyphosate combination provided the highest yields of this group.

MBR 22359 postemergence and treatments containing mefluidide reduced soybean vigor throughout the six, eight, and ten week periods. Leaf crinkling was visually apparent within two weeks after application of these herbicides, but had disappeared by the end of the growing season.

Postemergence applications of MBR 22359 reduced soybean height significantly at ten weeks (Table 2). MBR 22359 applied postemergence reduced soybean height more than any other treatments in the experiment. Mefluidide treatments generally reduced soybean height 12 cm, while the MBR 22359 postemergence applications reduced soybean height approximately 25 cm when compared to the other soybeans in the experiment. Soybeans were significantly shorter when treated with MBR 22359 postemergence, trifluralin plus mefluidide, and the trifluralin plus mefluidide split application (early postemergence and late postemergence) treatments.

MBR 22359 4.5 kg/ha preemergence tended to reduce soybean height at six and eight weeks, but not at ten weeks after planting. Soybean height reduction had disappeared by ten weeks, and no significant differences were found among the MBR 22359 preemergence, sethoxydim, and trifluralin and alachlor single wick combinations.

<u>1982</u>

Sethoxydim split applications (EP and LP respectively) at 0.2 plus 0.2, 0.3 plus 0.2, and 0.4 plus 0.2 kg/ha rates

Table 2. Influence of herbicides on height of soybeans in 1981.

Treatments	Rate[a]	Time[b]	Soybean height (cm)[c]		
			Week 6	Week 8	Week 10
MBR 22359	2.2	Pre	48b-g	79abc	100ab
MBR 22359	3.4	Pre	44c-g	73a-f	100ab
MBR 22359	4.5	Pre	36g	67c-f	93a-d
MBR 22359+surfactant[d]	1.1	EP	43c-g	62ef	75e
MBR 22359+surfactant	2.2	EP	42d-g	61f	73e
Sethoxydim+oil[e]	0.3	EP	47b-g	74a-e	97a-d
Sethoxydim+oil	0.4	EP	55a-d	77a-d	98abc
Sethoxydim+oil	0.7	EP	53a-e	78abc	102ab
Sethoxydim+oil	0.7	LP	65a	80abc	102ab
Sethoxydim+oil Sethoxydim+oil	0.2 0.2	EP LP	56abc	83a	106a
Sethoxydim+oil Sethoxydim+oil	0.3 0.3	EP LP	53a-e	77a-d	100ab
Sethoxydim+oil Sethoxydim+oil	0.4 0.4	EP LP	51a-f	77a-d	103ab
Sethoxydim+oil Sethoxydim+oil	0.4 0.2	EP LP	60ab	83a	107a
Trifluralin Mefluidide+surfactant	1.1 0.3	PPI EP	38fg	67c-f	85cde

(continued)

Table 2. (continued)

Treatments	Rate[a]	Time[b]	Soybean height (cm)[c]		
			Week 6	Week 8	Week 10
Trifluralin	1.1	PPI	40efg	65def	83de
Mefluidide+surfactant	0.3	EP			
Mefluidide+surfactant	0.3	LP			
Trifluralin	1.1	PPI	42d-g	68b-f	89bcd
Mefluidide+surfactant	0.3	EP			
Glyphosate+water	(1:2, v/v)	Wick			
Alachlor	3.4	Pre	56abc	81ab	102ab
Sethoxydim+oil+water	(2:1:3, v/v/v)	Wick			
Alachlor	3.4	Pre	57abc	81ab	105a
Glyphosate+water	(1:2, v/v)	Wick			
Trifluralin	1.1	PPI	51a-f	77a-d	99abc
Sethoxydim+oil+water	(2:1:3, v/v/v)	Wick			
Trifluralin	1.1	PPI	53a-e	76a-d	102ab
Glyphosate+water	(1:2, v/v)	Wick			

[a]kg/ha active ingredient, or ratio of the solution

[b]Time of application: Pre-preemergence, EP-early postemergence, LP-late postemergence, PPI-preplant incorporated, Wick-postemergence wick.

[c]Means within each column followed by the same letter are not significantly different at the 1% level according to Duncan's multiple range test.

[d]Non-ionic surfactant at 0.5% of the solution.

[e]Concentrated crop oil at 2.4 L/ha, or in a ratio of the solution.

provided significantly higher johnsongrass control than the MBR 22359 postemergence, MBR 22359 2.2 kg/ha preemergence, alachlor combinations, fluchloralin, the trifluralin plus mefluidide combination, and all trifluralin wick combination treatments at 10 weeks after planting (Table 3). No significant differences were found between the sethoxydim single and split applications, MBR 22359 3.4 and 4.5 kg/ha preemergence, and the trifluralin plus melfuidide split combination (early postemergence and late postemergence) treatment at ten weeks.

No significant differences were found between the single or split application sethoxydim treatments at six or ten weeks. The 0.2 kg/ha early postemergence treatment provided significantly less johnsongrass control than the 0.3 and 0.4 kg/ha single application, and the 0.3 plus 0.1, 0.3 plus 0.2, and 0.4 plus 0.2 kg/ha split applications at eight weeks. No significant differences were found among the 0.2 and 0.6 kg/ha single, and the 0.2 plus 0.1, and 0.2 plus 0.2 kg/ha split applications at eight weeks.

The sethoxydim 0.2 kg/ha rate was the lowest rate tested in the experiment, and it provided the least (84%) amount of johnsongrass control among the sethoxydim treatments at ten weeks. The other single application sethoxydim treatments of 0.3, 0.4, and 0.6 kg/ha provided 92, 94, and 92% control, respectively. Johnsongrass control increased between the time the initial and final ratings were made for all the sethoxydim treatments except the 0.2 kg/ha single application. Control of johnsongrass was equal for the 0.2 kg/ha rate at six and ten weeks.

Table 3. Influence of herbicides on rhizome johnsongrass control and on soybean yields in 1982.

Treatments	Rate[a]	Time[b]	Percent johnsongrass control[c] Week 6	Week 8	Week 10	Soybean yields kg/ha[c]
MBR 22359	2.2	Pre	85ab	75b-e	81bcd	2127a
MBR 22359	3.4	Pre	89a	80a-d	88abc	2180a
MBR 22359	4.5	Pre	87ab	85abc	95ab	2107a
MBR 22359+surfactant[d]	1.1	EP	64b	51g	59e	2275a
MBR 22359+surfactant	2.2	EP	70ab	66d-g	82bcd	1856a
Sethoxydim+oil[e]	0.2	EP	84ab	72c-f	84a-d	2172a
Sethoxydim+oil	0.3	EP	90a	90ab	92ab	2182a
Sethoxydim+oil	0.4	EP	91a	91ab	94ab	2077a
Sethoxydim+oil	0.6	EP	90a	89abc	92ab	2120a
Sethoxydim+oil Sethoxydim+oil	0.2 0.1	EP LP	79ab	85abc	97ab	2230a
Sethoxydim+oil Sethoxydim+oil	0.2 0.2	EP LP	82ab	89abc	98a	2285a
Sethoxydim+oil Sethoxydim+oil	0.3 0.1	EP LP	86ab	91ab	97ab	1863a
Sethoxydim+oil Sethoxydim+oil	0.3 0.2	EP LP	86ab	93a	98a	2360a
Sethoxydim+oil Sethoxydim+oil	0.4 0.2	EP LP	90a	96a	98a	2189a

(continued)

Table 3. (continued)

Treatments	Rate[a]	Time[b]	Percent johnsongrass control[c]			Soybean yields kg/ha[c]
			Week 6	Week 8	Week 10	
Trifluralin	1.1	PPI	64b	57fg	60e	1688a
Mefluidide+surfactant	0.3	EP				
Trifluralin	1.1	PPI	70ab	60efg	83a-d	2005a
Mefluidide+surfactant	0.3	EP				
Mefluidide+surfactant	0.3	LP				
Trifluralin	1.1	PPI	65b	56g	64e	1857a
Mefluidide+surfactant	0.3	EP				
Glyphosate+water	(1:2, v/v)	Wick				
Alachlor	3.4	Pre	15c	46h	69de	2221a
Sethoxydim+oil+water	(2:1:3, v/v/v)	Wick				
Alachlor	3.4	Pre	5c	44h	65e	2123a
Glyphosate+water	(1:2, v/v)	Wick				
Trifluralin	1.1	PPI	16c	55g	73cde	2066a
Sethoxydim+oil+water	(2:1:3, v/v/v)	Wick				
Trifluralin	1.1	PPI	6c	56g	76cd	1828a
Glyphosate+water	(1:2, v/v)	Wick				
Fluchloralin	2.2	PPI	17c	5i	7f	1815a

(continued)

Table 3. (continued)

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[a]kg/ha active ingredient, or ratio of the solution.

[b]Time of application: Pre-preemergence, EP-early postemergence, LP-late postemergence, PPI-preplant incorporated, Wick-postemergence wick.

[c]Means within each column followed by the same letter are not significantly different at the 1% level according to Duncan's multiple range test.

[d]Non-ionic surfactant at 0.5% of the solution.

[e]Concentrated crop oil at 2.4 L/ha or in a ratio of the solution.

The sethoxydim split applications (EP and LP) provided excellent johnsongrass control: control ranged from 97 to 98%. Split applications of sethoxydim provided an average of 98% control, while the single applications provided an average of 90% johnsongrass control when the season's final ratings were made.

No significant differences were found among MBR 22359 preemergence treatments at the six, eight, or ten week ratings. No significant differences were found between the MBR 22359 2.2 kg/ha postemergence and the MBR 22359 preemergence at six and ten weeks. There was a significant difference between the MBR 22359 2.2 kg/ha postemergence and the MBR 22359 4.5 kg/ha preemergence at eight weeks. The preemergence application provided a higher percentage of johnsongrass control.

MBR 22359 postemergence applied at 1.1 kg/ha controlled significantly less johnsongrass at ten weeks than all other MBR 22359 treatments. There was a highly significant difference between the MBR 22359 1.1 kg/ha postemergence and the MBR 22359 preemergence treatments at eight weeks. No significant differences were found between the two MBR 22359 postemergence applications at eight weeks. A highly significant difference was found between the MBR 22359 1.1 kg/ha postemergence and MBR 22359 3.4 kg/ha preemergence treatment at six weeks. The preemergence MBR 22359 application provided more johnsongrass control. No other significant differences were found between the MBR 22359 applications at six weeks.

MBR 22359 preemergence and postemergence treatments controlled johnsongrass from 59 to 95% when the final ratings were made on July 27. The preemergence treatments provided good to excellent johnsongrass control: control ranged from 81 to 95%. As the rates of the MBR 22359 preemergence applications increased, so did the johnsongrass control. The high rate 2.2 kg/ha postemergence treatment provided good (82%) control, while the 1.1 kg/ha postemergence treatment provided poor (59%) johnsongrass control.

Fluchloralin and the alachlor and trifluralin single wick combinations provided significantly less johnsongrass control at the six week ratings than all other treatments in the experiment. The low percent of johnsongrass control obtained with alachlor and trifluralin combinations also occurred at six weeks in 1981. In both years the rope wick applications of glyphosate and sethoxydim were made on the same day the six week ratings were made. Effects of the wick applications were visible at the eight and ten week ratings. Johnsongrass control increased throughout the season. The trifluralin rope wick combinations with glyphosate and sethoxydim provided 76 and 73% control, respectively, at ten weeks. Alachlor wick combinations with glyphosate and sethoxydim provided 65 and 69% johnsongrass control, respectively, at ten weeks.

The fluchloralin at 2.2 kg/ha double rate (2x) provided significantly less johnsongrass control at the eight and ten week ratings than all other treatments in the experiment.

McWhorter (41) found a 2x rate of fluchloralin provided less than 80% control after one year of use, and greater than 80% johnsongrass control after two years of use. Beingolea and Worthington (3) found the 2x rate of fluchloralin provided 43% control after one year of use, and only 10% johnsongrass control after two years of use in Kentucky. Fluchloralin provided poor johnsongrass control throughout the 1982 season. Control was 7% at the ten week rating.

The trifluralin plus mefluidide split combination (early postemergence and late postemergence) treatment provided significantly higher johnsongrass control at ten weeks than the other trifluralin-mefluidide combinations. No significant differences were found between these treatments at six and eight weeks. The trifluralin-mefluidide combinations provided 60 to 83% johnsongrass control at ten weeks. The trifluralin plus mefluidide split combination (early postemergence and late postemergence) provided good (83%) johnsongrass control. The trifluralin plus mefluidide combination treatment provided poor (60%) control, and the trifluralin plus mefluidide plus glyphosate treatment provided 64% johnsongrass control.

No significant differences in soybean yields were found between any of the herbicides in 1982 (Table 3). Treatments that controlled a high percentage of johnsongrass and did not reduce soybean vigor or height, did not produce significantly higher yields than those treatments which provided poor johnsongrass control and did reduce height. Yield variation did occur among treatments, but so much variation occurred within a treatment that no significant differences can be reported. An uneven broadleaf weed population throughout the experiment might have been responsible for the great variation in yield within a treatment. Broadleaf weed infestations were not measured in either 1981 or 1982. Standiforth and Weber (60) found broadleaf weeds can reduce soybean yields more than grass weeds. If an uneven distribution or unequal population of broadleaf weeds occurred in the experiment, their increased population provides possible explanation for the absence of any significant differences in yields.

The MBR 22359 2.2 kg/ha postemergence and the trifluralin plus mefluidide plus glyphosate combination caused a significant reduction in soybean height at six weeks (Table 4). No significant differences were found among the MBR 22359 postemergence, trifluralin-mefluidide combinations, and the trifluralin plus glyphosate treatment at eight weeks. Soybeans within these treatments were generally shorter than all other soybeans in the experiment at eight weeks.

The MBR 22359 postemergence at the 2.2 kg/ha rate significantly reduced the height of soybeans at ten weeks. The height of soybean plants treated with this herbicide was significantly less when compared to all other treatments with the exception of the trifluralin plus mefluidide plus glyphosate treatment. In 1981 more interaction was found between the mefluidide combination and MBR 22359 postemergence treatments and soybean height. The MBR 22359 1.1 kg/ha postemergence treatment and the remaining mefluidide combinations

Table 4. Influence of herbicides on height of soybeans in 1982.

Treatments	Rate[a]	Time[b]	Soybean height (cm)[c] Week 6	Week 8	Week 10
MBR 22359	2.2	Pre	33abc	60ab	88ab
MBR 22359	3.4	Pre	32abc	56ab	88ab
MBR 22359	4.5	Pre	30abc	56ab	83abc
MBR 22359+surfactant[d]	1.1	EP	30abc	51bc	84abc
MBR 22359+surfactant	2.2	EP	28bc	46c	71d
Sethoxydim+oil[e]	0.2	EP	34ab	61ab	86abc
Sethoxydim+oil	0.3	EP	36a	61ab	90a
Sethoxydim+oil	0.4	EP	34ab	60ab	86abc
Sethoxydim+oil	0.6	EP	32abc	57ab	84abc
Sethoxydim+oil Sethoxydim+oil	0.2 0.1	EP LP	34ab	62a	86abc
Sethoxydim+oil Sethoxydim+oil	0.2 0.2	EP LP	34ab	59ab	88ab
Sethoxydim+oil Sethoxydim+oil	0.3 0.1	EP LP	33abc	58ab	86abc
Sethoxydim+oil Sethoxydim+oil	0.3 0.2	EP LP	32abc	58ab	85abc
Sethoxydim+oil Sethoxydim+oil	0.4 0.2	EP LP	34abc	60ab	85abc
Trifluralin Mefluidide+surfactant	1.1 0.3	PPI EP	30abc	55abc	81abc

(continued)

Table 4. (continued)

Treatments	Rate[a]	Time[b]	Soybean height (cm)[c] Week 6	Week 8	Week 10
Trifluralin	1.1	PPI	30abc	55abc	80bc
Mefluidide+surfactant	0.3	EP			
Mefluidide+surfactant	0.3	LP			
Trifluralin	1.1	PPI	28c	47c	77cd
Mefluidide+surfactant	0.3	EP			
Glyphosate+water	(1:2, v/v)	Wick			
Alachlor	3.4	Pre	36a	63a	85abc
Sethoxydim+oil+water	(2:1:3, v/v/v)	Wick			
Alachlor	3.4	Pre	33abc	58ab	84abc
Glyphosate+water	(1:2, v/v)	Wick			
Trifluralin	1.1	PPI	36a	62a	88ab
Sethoxydim+oil+water	(2:1:3, v/v/v)	Wick			
Trifluralin	1.1	PPI	33abc	55abc	82abc
Glyphosate+water	(1:2, v/v)	Wick			
Flurchloralin	2.2	PPI	32abc	60ab	85abc

[a]kg/ha active ingredient, or ratio of the solution.

[b]Time of application: Pre-preemergence, EP-early postemergence, LP-late postemergence, PPI-preplant incorporated, Wick-postemergence wick.

[c]Means within each column followed by the same letter are not significantly different at the 1% level according to Duncan's multiple range test.

[d]Non-ionic surfactant at 0.5% of the solution.

[e]Concentrated crop oil at 2.4 L/ha, or in a ratio of the solution.

did not significantly reduce soybean height in 1982 as in 1981.

Summary

The purpose of this study was to determine which herbicides could effectively control rhizome johnsongrass and at the same time prevent a reduction in soybean yields. Sethoxydim postemergence treatments provided good to excellent johnsongrass control in both 1981 and 1982. No height reduction of soybeans occurred when they were treated with single or split applications of sethoxydim. Yields of soybeans were generally higher when treated with sethoxydim than when treated with the trifluralin combinations or alachlor combinations in 1981. No significant differences were found in yield in 1982.

MBR 22359 preemergence treatments provided good to excellent control of johnsongrass. The yields were not as high with the MBR 22359 applications as they were with the sethoxydim applications even though the percentage johnsongrass control was almost equal in both years of the study. A possible loss of vigor could have occurred in the soybeans that were treated with MBR 22359. The high rate MBR 22359 (4.5 kg/ha) preemergence treatment and the MBR 22359 postemergence treatments reduced soybean yields in 1981 even though control of johnsongrass was an average 84%. No significant differences in yield were found in 1982.

Trifluralin combinations, alachlor combinations, and the fluchloralin treatment provided fair to poor control of johnsongrass. Yields were generally lower in these treatments than in the sethoxydim and MBR 22359 treatments.

Mefluidide and MBR 22359 applied postemergence reduced soybean vigor in both years. Stunted growth and leaf crinkling were visually apparent in June and July of both years of the experiment.

Farmers are constantly striving to control johnsongrass in their soybean fields in Kentucky. The herbicides now available do not provide equal johnsongrass control or allow yields as high as the sethoxydim or MBR 22359 preemergence (2.2 and 3.4 kg/ha) herbicides could provide. Greater johnsongrass control was found in both years when these new herbicides were used. The trifluralin combinations, alachlor combinations, and the double rate of fluchloralin provided fair to poor johnsongrass control and generally resulted in lower yields than the MBR 22359 2.2 and 3.4 kg/ha preemergence and the sethoxydim single and split (EP and LP) application treatments.

APPENDIX

Table 1. Analysis of variance for 1981 rhizome johnsongrass control six weeks after planting.

Source of variation	df	SS	MS	F
Total	79	118,425		
Replications	3	787.50	262.50	2.225^{ns}
Treatments	19	110,912.50	5,837.50	49.47**
Error	57	6,725	117.98	

Table 2. Analysis of variance for 1981 rhizome johnsongrass control eight weeks after planting.

Source of variation	df	SS	MS	F
Total	79	69,180		
Replications	3	277.50	92.50	.699^{ns}
Treatments	19	61,367.50	3,229.86	24.43**
Error	57	7,535	132.19	

Table 3. Analysis of variance for 1981 rhizome johnsongrass control ten weeks after planting.

Source of variation	df	SS	MS	F
Total	79	32,310.90		
Replications	3	44.55	14.85	.169^{ns}
Treatments	19	27,263.15	1,434.90	16.34**
Error	57	5,003.20	87.77	

^{ns}Not significant.

**Significant at the 1% level.

Table 4. Analysis of variance on height of soybeans six weeks after planting in 1981.

Source of variation	df	SS	MS	F
Total	79	1,215.95		
Replications	3	139.05	46.35	7.536**
Treatments	19	725.95	38.20	6.21**
Error	57	350.95	6.15	

Table 5. Analysis of variance on height of soybeans eight weeks after planting in 1981.

Source of variation	df	SS	MS	F
Total	79	875.49		
Replications	3	19.14	6.38	1.17ns
Treatments	19	546.24	28.75	5.28**
Error	57	310.11	5.44	

Table 6. Analysis of variance on height of soybeans ten weeks after planting in 1981.

Source of variation	df	SS	MS	F
Total	79	1,602.88		
Replications	3	19.04	6.35	.875ns
Treatments	19	1,168.14	61.48	8.43**
Error	57	415.70	7.29	

nsNot significant.

**Significant at the 1% level.

Table 7. Analysis of variance for 1981 soybean yields.

Source of variation	df	SS	MS	F
Total	79	2,726.06		
Replications	3	804.23	268.07	23.93**
Treatments	19	1,283.26	67.54	6.03**
Error	57	638.57	11.20	

Table 8. Analysis of variance for 1982 rhizome johnsongrass control six weeks after planting.

Source of variation	df	SS	MS	F
Total	87	88,698.86		
Replications	3	1,239.76	413.25	3.53*
Treatments	21	80,086.36	3,813.63	32.58**
Error	63	7,372.74	117.03	

Table 9. Analysis of variance for 1982 rhizome johnsongrass control eight weeks after planting.

Source of variation	df	SS	MS	F
Total	87	46,221.99		
Replications	3	233.85	77.95	1.27^{ns}
Treatments	21	42,128.74	2,006.13	32.75**
Error	63	3,859.40	61.26	

^{ns}Not significant.

*Significant at the 5% level.

**Significant at the 1% level.

Table 10. Analysis of variance of 1982 rhizome johnsongrass control ten weeks after planting.

Source of variation	df	SS	MS	F
Total	87	40,684.72		
Replications	3	570.40	190.13	3.49*
Treatments	21	36,685.47	1,746.92	32.10**
Error	63	3,428.85	54.42	

Table 11. Analysis of variance on height of soybeans six weeks after planting in 1982.

Source of variation	df	SS	MS	F
Total	87	159.72		
Replications	3	28.04	9.35	8.66**
Treatments	21	63.47	3.02	2.79**
Error	63	68.21	1.08	

Table 12. Analysis of variance on height of soybeans eight weeks after planting in 1982.

Source of variation	df	SS	MS	F
Total	87	499.82		
Replications	3	61.91	20.63	6.99**
Treatments	21	251.82	11.99	4.06**
Error	63	186.09	2.95	

nsNot significant.

*Significant at the 5% level.

**Significant at the 1% level.

Table 13. Analysis of variance on height of soybeans ten weeks after planting in 1982.

Source of variation	df	SS	MS	F
Total	87	464.45		
Replications	3	42.40	14.13	4.53**
Treatments	21	225.20	10.72	3.43**
Error	63	196.85	3.12	

Table 14. Analysis of variance for 1982 soybean yields.

Source of variation	df	SS	MS	F
Total	87	3,330.05		
Replications	3	661.65	220.55	6.75**
Treatments	21	608.79	28.99	.88^{ns}
Error	63	2,059.61	32.69	

^{ns}Not significant.

**Significant at the 1% level.

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