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Efficacy of Soybean Herbicides on Annual Morninglory

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EFFICACY OF SOYBEAN HERBICIDES ON ANNUAL MORNINGGLORY

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DEDICATION

To my father, John Michael Ovesen, I dedicate this thesis. If it were not for his encouragement and involvement in agriculture, I would not have chosen to pursue such a career. He is and will continue to be my source of inspiration for my continuing work in this field.

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Field experiments were established in 2000 and 2001 at the Agricultural Research and Education Complex in Bowling Green, Kentucky to evaluate herbicide efficacy on annual morningglory (*Ipomoea* spp.) species and other weeds. A randomized complete block design was utilized in each study with each treatment being replicated three times. Plots consisted of four 76 cm rows, 9.1 m in length. The two center rows of each plot were treated, with the outside rows of each plot serving as a weedy check. Crop response, weed control, and grain yield data were collected.

Four different experiments were conducted. Two experiments utilized treatments of glyphosate and sulfosate alone and with tankmixes on glyphosate-tolerant soybeans. Two experiments examined various herbicide tankmixes applied to non-glyphosate-tolerant soybeans.

Soybean injury influenced by postemergence treatments of glyphosate and sulfosate alone and with chlorimuron-ethyl ranged from 0 to 5% four days after treatment (DAT) with the addition of chlorimuron-ethyl resulting in greater injury. Morningglory control 14 DAT ranged from 48 to 63% with sulfosate at 700 g ai/ha providing less control than glyphosate at 1120 g ai/ha. No treatment differences occurred 29 and 42

DAT. No statistical differences among treatments occurred among other weed species evaluated.

Soybean injury influenced by postemergence treatments of glyphosate and sulfosate alone and with fomesafen and chloransulam-methyl 4 DAT ranged from 0 to 17% with the addition of fomesafen resulting in greater injury than the addition of chloransulam-methyl. Morningglory control 14 DAT ranged from 60 to 88% with glyphosate + imazethapyr at 840 + 71 g ai/ha providing the least control and sulfosate + fomesafen at 700 + 201 g ai/ha providing greater control.

Soybean injury influenced by pre and postemergence treatments 7 DAT ranged from 0 to 30% in conventional soybeans. Applications of carfentrazone resulted in the greatest injury. Morningglory control 20 days after planting (DAP) ranged from 0 to 99% with chloransulam + sulfentrazone providing the highest control. Morningglory control 28 DAT ranged from 30 to 99% with s-metolachlor + metribuzin + acifluorfen + fenoxaprop-ethyl + fluazifop-P providing the least control. Common cocklebur control ranged from 13% to 97% 20 DAP with pendimethalin + imazethapyr providing the least control. Treatments containing aciflourfen + bentazon controlled common cocklebur > 80% 28 DAT.

Soybean injury influenced by preemergence and postemergence treatments 7 DAT in conventional soybeans ranged from 0 to 33% with sulfentrazone + clomazone + chlorimuron-ethyl + carfentrazone resulting in the greatest injury. Morningglory control 7 DAT ranged from 0 to 99% with sulfentrazone + clomazone plus chlorimuron-ethyl + carfentrazone having the greatest control. Morningglory control 28 DAT ranged from 82 to 94% with no differences among treatment.

CHAPTER I

INTRODUCTION

Since it was first introduced, soybean (*Glycine max*) has become a very important crop in the United States, second only to corn (*Zea mays)* in production. In 2000, 30.1 million ha of soybeans were planted in the United States and produced 75.7 million Mg of grain. The state of Kentucky planted 437,070 ha in 2000 and harvested 1.2 million Mg of grain (17). Soybeans provide a significant part of farm income in eight of the Mississippi River Valley states that together account for 75% of United States production (21).

Morningglory species (*Ipomoea* spp.) are some of the world's worst weeds and can be devastating to soybean crops. They are the second most troublesome weed species in Kentucky soybean (25). Morningglories are annual dicot weeds, and exhibit several characteristics that make them very damaging. Morningglories cause problems in soybeans and other crops because of their vining characteristic and their ability to compete for light, water, and nutrients. They climb neighboring plants in order to reach sunlight, which may inhibit harvesting operations. Morningglories can increase lodging, reduce yields, and reduce efficiency of mechanical or manual harvest operations (1).

The need for selective herbicides for morningglory was thought to be alleviated with glyphosate-tolerant soybeans; however, the University of Kentucky has reported that glyphosate does not always provide complete control of morningglory species (29). Several options exist for controlling morningglory in conventional soybeans. Thus, the objective of these studies were to determine (i) the efficacy of glyphosate and sulfosate on morningglory species infesting glyphosate-tolerant soybeans and (ii) the efficacy of herbicides on morningglory species infesting conventional (non-glyphosate-tolerant) soybeans.

CHAPTER II

LITERATURE REVIEW

Soybean History

Soybean is a native of Eastern Asia where it has been used as a human food and animal feed for thousands of years. Soybean was introduced into the United States as a forage crop in the early 1800's. Early in the 1900's, it was recognized for its oil content (6). During World War II it became a very important oilseed crop. Soybean uses, both agricultural and industrial, primarily depend on the high protein and oil content in the seed (21).

Weeds

The term "weed" has a different meaning to different individuals, and that definition can be very broad. "It is as difficult to define the term 'weed' to a scientist as it is to explain to a farmer why it should be necessary to define weed at all" (14). The best way to define a weed is to say it is a plant that is somewhere it is not wanted. Weeds are thought to be noxious because of their ability to compete with crops. Weeds compete for light, water, and nutrients and are hosts for diseases and insect pests. Harvested weeds, along with a crop, can be detrimental to harvested products. Weeds may produce seed that cannot be separated from the crop and may be inadvertently planted with a crop. Weed seeds or fruits may reduce quality of crop seed (14).

Weeds are classified in several different ways. One way is by their lifecycle. Perennials, annuals, and biennials are the three major weed life cycles. Annual weeds reproduce by seed that range in number of seed per plant from species to species. Seed dispersal and dormancy mechanisms are species dependent (14). "Successful weeds in soybeans are usually those with similar lifecycles and growth habits," according to Heatherly (12). No matter how extensively a producer tries to control weed species, they are still able to infest a crop field, and can adapt quickly to changing conditions. Lessening of weed control after several years of intense management can cause reinfestation of fields.

Weed Control

Herbicides are a commonly used weed control method; however, combinations of cultural, chemical, and mechanical control are also used. There are approximately thirty different soybean herbicide active ingredients currently available, and they often provide more complete weed control than cultivation. Thus it is possible to use reduced tillage systems with herbicides (12).

In nonchemical weed control methods, narrow rows (< 19 cm) help reduce weed competition in soybeans but makes cultivation impractical. Narrow rows provide a faster and greater degree of canopy closure that block sunlight to the weeds. The planting date may need to be altered so that weed and crop emergence patterns will be altered. "All production practices are directed toward creating the most favorable environment for the crop and the least favorable environment for weeds. Cultivation after soybean emergence can compliment chemical weed control. The main purpose of cultivation of row middles is to control weeds (12)." Crop rotation is another nonchemical method that can effectively suppress weed populations within an area. Suppression can be achieved by rotating corn with soybeans and inadvertently controlling species that are not normally controlled with soybean herbicide (12).

Chemical Weed Control

Between 1964 and 1982, herbicide usage increased to > 181 million kg of product per year; by 1992, it had declined to approximately 136 million kg per year. The decline in herbicide use was due to reduced hectarage and reduced herbicide application per hectare (12).

Producers may choose an active ingredient that they use repeatedly year after year with little consideration given to those weed species present. Weeds that survive may become more tolerant to the herbicide than the original population (12). The weeds that are more tolerant to a herbicide such as glyphosate may, in time, become the dominant weed species in that area. This situation is known as a weed shift.

The mode of action is different for every herbicide family. Mode of action and mechanism of action mean different things to different people, but both basically mean the biochemical response of plants to herbicides. The mode of action of an active ingredient begins the moment it is applied to the plant and continues until death of the plant (2). Rotating crops and mode of actions for different weed problems are important ways to avoid resistance in weed species. Resistance is the decreased response of a weed species to a mode of action or the survival of a weed species or population after an active ingredient dose lethal to a normal weed species (32).

Herbicides may be selective or nonselective. A nonselective herbicide affects most species of plants. A selective herbicide works only on certain species, such as grasses or broadleaves. Certain weeds and crops are able to metabolize a particular active ingredient to nontoxic compounds and thus the herbicide achieves selectivity. Environmental conditions, application rate, and method of application can also influence efficacy (2).

Herbicides are either systemic (translocated through the plant via xylem and/or phloem) or contact (not translocated through the plant). Stressful environmental conditions, such as lack of moisture, can negatively influence absorption and translocation, and thus efficacy (2).

Morningglory control in Soybeans

Holloway and Shaw reported that full–season competition by one ivyleaf morningglory (*Ipomoea hederacea)* plant per 15 cm of row reduced soybean yield by as much as 36%. Yields were reduced 49 to 58% when 40 ivyleaf morningglory plants per meter of row were allowed to compete full season. Control was needed for six to eight weeks after emergence to avoid yield loss. Several factors affect weed interference with crops, including planting date, variety characteristics, production practices, and environmental conditions. Soybeans are more competitive when they emerge prior to weed emergence. Holloway and Shaw found that nontreated ivyleaf morningglory remaining for longer than two weeks reduced soybean yield. Following treatment with chlorimuron and imazaquin, ivyleaf morningglory remained in a field for up to eight weeks before yield reduction occurred. Ivyleaf morningglory that survived a herbicide application of chlorimuron and imazaquin was less competitive than nontreated plants (13).

One factor affecting ivyleaf morningglory is that it can emerge from a soil depth of 15 cm, which is often below the depth of herbicide incorporation. Ivyleaf morningglory emergence decreases with deeper germination depths, which also delays emergence (23). Soil applied herbicides need some level of residual activity to be effective on late emerging weeds. Several provide only moderate control of morningglory species. Cole and Coats state that herbicides inhibiting nucleic acid metabolism and protein synthesis are more effective on morningglory than are photosynthesis inhibitors (8).

Murdock et al. reported that "acceptable control of morningglory species is difficult to achieve because of their tolerance to soil-applied herbicides and the inconsistent control of post emergence herbicides." Row spacing and cultivars affect the relationship between crops and weeds. Narrow row planting may increase herbicide effectiveness and may reduce weed growth and provide a shorter weed-free period. These effects are due to greater crop canopy and shading of the soil. Once the soil surface is shaded, weed emergence is decreased. Pitted morningglory (*Ipomoea lacunosa*) dry weight increased as row spacing increased with 0, 2, and 4 weeks of weed-free maintenance. Higher weights of pitted morningglory were found in 91 cm row spacing, which could have been caused by lack of quick canopy. A two-week weed-free period was needed to prevent seed yield loss in 30 and 61 cm rows (20).

Competition occurs when two or more plants are vying for the same nutrient and water supply. Monks and Oliver state "competitive stress created by close neighbors in plant stands may be expressed in increased mortality, reduced seed production, reduced growth rate, and delayed maturity." Weeds growing with soybeans were found to be smaller than weeds that were growing alone. Soybeans and weeds expanded in size until each was competing for the same environmental resources. After a full season of growth soybeans had reduced weed biomass by 90 to 97% (19).

Tank mixtures of bentazon and acifluorfen were found to provide > 90 % control of several morningglory species (tall, ivyleaf, pitted, scarlet (*Ipomoea coccinea)* and entireleaf (*Ipomoea hederacea* var. *integriuscula)*) (26). Barker et al. found that morningglory control by foliar-applied postemergence herbicides was dependent on species present, rate, and timing of herbicide application. Delaying herbicide application by just two weeks reduced efficacy. Bentazon + acifluorfen provided > 91 % control of all morningglory species (tall, ivyleaf, pitted, scarlet, and entireleaf) examined when applied four weeks after planting (3).

Competition between weeds and crops begin as soon as both are emerged and continue as long as they are both growing. The critical period is the particular amount of time that a crop can tolerate competition from a weed without yield being decreased. Greater weed presence (number of plants) of ivyleaf morningglory resulted in less soybean plant dry weight (9).

Wilson and Cole found that morningglories growing in 30 cm bands in the row, 61 cm bands between the rows, and both simultaneously, inflicted damage upon soybeans. Yields were reduced in all treatments where morningglories were present. There was no significant difference between treatments when morningglories were removed between rows or within rows. Where morningglories were not removed, soybean yield was reduced 52%. Morningglories significantly reduced the height of soybeans in all treatments, causing severe lodging and difficult harvesting. All plots containing morningglories yielded significantly less than weed free plots (30).

Oliver et al. found that as tall morningglory competition increased, soybean yields decreased. Full season competition resulted in as much as 66% yield reduction. Morningglory's climbing characteristic allows it to be able to compete longer than other weed species (22).

Glyphosate

Glyphosate is a nonselective herbicide that controls weeds via interruption of amino acid synthesis. However, only in the last several years has it been able to be used on crops, particularly on soybeans. Genetic engineering has allowed for the insertion of a gene into certain crops to provide resistance to glyphosate, and bring the benefits of its use to weed management in soybeans. Sulfosate is another active ingredient that may also be used on glyphosate-tolerant soybeans.

Glyphosate-tolerant varieties may result in less expense for herbicide weed control, but the technology may make total cost for weed control the same as for conventional varieties. Glyphosate-tolerant soybeans may be beneficial for areas that have problem weeds that conventional weed management systems may not control. In fields where morningglories are a problem, additional herbicides may be required to supplement the glyphosate-tolerant technology. Thus, in these instances additional production costs will be incurred (12).

According to Vidrine et al. glyphosate applied in sequential applications provided > 90% control 6 weeks after treatment (WAT) for all weed species examined, including morningglory. When glyphosate was utilized in a single postemergence application and no preemergence herbicide was applied, no weed was controlled successfully due to reinfestation. Glyphosate applied once postemergence with chlorimuron + metribuzin applied preemergence controlled all weeds > 90%. Soybean yields were higher when treated with either a preemergence followed by one postemergence application or with three postemergence applications. Yields were decreased when application times were delayed (27).

Glyphosate plus chlorimuron applied late postemergence provided 80% pitted morningglory control 28 DAT; however, by 40 DAT control was 69%. A sequential application of 420 g ai/ha glyphosate applied 21 days after 628 g ai/ha glyphosate provided 91% control of pitted morningglory 28 DAT. Glyphosate applied alone at 841 g ai/ha gave 81% and 73% control of pitted morningglory 28 and 40 DAT, respectively (15).

Bauman and White reported that ivyleaf morningglory control depended on the strengths and weaknesses of different herbicides. Glyphosate applied alone at 1121 g ai/ha provided 76% ivyleaf morningglory control 36 DAT. Flumetsulam applied at 44 g ai/ha preemergence followed by chloransulam at 21 g ai/ha + glyphosate at 561 g ai/ha applied early postemergence provided 94% control 36 DAT. (4)

Sequential applications of glyphosate at 561 g ai/ha provided better control than other treatments. Imazethapyr at 71 g ai/ha applied alone at an early postemergence application gave 24% ivyleaf morningglory control 28 DAT but increased to 66% 42 DAT. Glyphosate applied alone at 841 g ai/ha provided 60 and 65% control of ivyleaf morningglory 28 and 42 DAT, respectively. Sequential applications of glyphosate at 651 g ai/ha gave 86 and 78% control of ivyleaf morningglory 28 and 42 DAT, respectively

(5). One application of glyphosate at 1121 g ai/ha controlled ivyleaf morningglory > 95%. At 1121 g ai/ha and 561 g ai/ha sequential applications also controlled morningglory ≥ 95% (28).

According to Lich et al., "tankmixtures of glyphosate with a reduced rate of a selective herbicide could potentially provide an economical postemergence herbicide program that controls a broad spectrum of weeds." Also, a herbicide tank mixture with glyphosate could control weeds later in the season because of the potential for residual soil activity of the tankmixes. At 2 WAT growth reduction of ivyleaf morningglory ranged from 52 to 75 % depending on the rates of glyphosate and chlorimuron applied. Glyphosate at 211 g ai/ha + chlorimuron at 1.5 g ai/ha reduced ivyleaf morningglory dry weight by 57%, while glyphosate at 1680 g ai/ha + chlorimuron at 12 g ai/ha reduced ivyleaf morningglory dry weight 75%. At 2 WAT glyphosate + imazethapyr reduced dry weight from 12 to 76%. Glyphosate at 211 g ai/ha + imazethapyr at 18 g ai/ha reduced ivyleaf morningglory growth 57%, while glyphosate at 1680 g ai/ha + imazethapyr at 141 g ai/ha reduced growth of ivyleaf morningglory 76% (18).

When Starke and Oliver applied glyphosate at 210 g ai/ha, fomesafen at 210 g ai/ha, and imazethapyr at 35 g ai/ha alone, they found that control of pitted morningglory was ≤ 36% 28 DAT. Chlorimuron at 4.5 and 9 g ai/ha and sulfentrazone at 70 and 140 g ai/ha applied alone provided 47 to 86% control 28 DAT. Adding chlorimuron to glyphosate was antagonistic in only one of four herbicide combinations. All combinations containing imazethapyr and glyphosate were synergistic, and control ranged from 53 to 74%. The addition of chlorimuron at 4.5 and 9 g ai/ha with glyphosate at 210 and 420 g ai/ha controlled pitted morningglory 71 to 89% 28 DAT. The addition of fomesafen at 210 and 420 g ai/ha with glyphosate at 210 and 420 g ai/ha controlled pitted morningglory 31 to 49% 28 DAT (24).

Morningglory Control in Conventional Soybeans

Choate et al. reported that morningglory control was 90% with 841 g ai/ha chlorimuron-ethyl, 18 g ai/ha chloransulam-methyl, or bentazon + acifluorfen at 13 g ai/ha when applied postemergence following a preemergence application of 2131 g ai/ha metolachlor. All systems using preemergence and postemergence herbicides controlled morningglory ≥ 86%. Applications of postemergence chloransulam-methyl provided morningglory control equivalent to current commercial standards (7).

Youmans and Hellmer reported that imazamox at 280 g ai/ha controlled entireleaf morningglory 90%, ivyleaf morningglory 90%, and pitted morningglory 80% (DAT not given). Soybean response to imazamox at 280 or 351 g ai/ha averaged ≤ 5% (31).

The objective of Gossett and Toler was to compare the response of pitted, tall, ivyleaf morningglory to foliar-applied acifluorfen, chlorimuron, imazaquin, and imazethapyr. Early herbicide treatments provided greater morningglory control than late treatments. Each herbicide at the late treatment gave < 80% control of all morningglory species 4 WAT (10).

CHAPTER III

MATERIALS AND METHODS

Four field experiments were established during the summer of 2000 and 2001 at the Agricultural Research and Education Complex of Western Kentucky University, Bowling Green, Kentucky to evaluate the efficacy of preemergence and postemergence herbicides on morningglory (*Ipomoea* spp.) and other weed species. A randomized complete block design was utilized with treatments replicated three times. The experiments were established in areas naturally infested with morningglory and several other weed species. The studies will be referred to as A, B, C, and D. All studies were disked and harrowed prior to planting. Phosphorus, potassium, and calcium carbonate were applied according to soil test recommendations. Ratings were recorded on a scale of 0 to 100 with 0 equal to no weed control or no crop injury and 100 equal to complete control or crop death.

Experiment A and B

Soybeans (cv. 'Garst D484RR') were planted May 22, 2000 at a rate of 62 kg/ha into a conventionally tilled Pembroke silt loam with a pH of 6.4 and soil organic matter content of 1.2%. Plots consisted of four 9.1 m rows spaced 76 cm apart. Herbicides were applied on June 22, 2000 with a CO_2 backpack sprayer delivering 152 L/ha. All postemergence treatments in Experiment A included 11 g/L ammonium sulfate. Postemergence herbicide treatments utilized in Experiment A are shown in Table 1. All postemergence treatments for Experiment B included one or both of the following: 11g/L ammonium sulfate, 20 g/L ammonium sulfate, 0.5% v/v crop oil concentrate, and 0.125% v/v nonionic surfactant. Postemergence herbicide treatments used in Experiment B are shown in Table 2.

Soybean response was visually evaluated and recorded 4 and 14 days after treatment (DAT). Efficacy was visually evaluated 14, 28, and 42 DAT. Soybeans were harvested on October 15, 2000 and grain was adjusted to 15 % moisture. Weed control, crop response, and grain yield were obtained from the two center rows of each four-row plot. Data was subjected to analysis of variance, and means were separated using Duncan's Multiple Range Test (DMRT) $p \leq 0.05$.

Experiment C

Soybeans (cv. 'Garst D485') were planted May 30, 2001 at a rate of 150,731 seeds/ha into a conventionally tilled Pembroke silt loam with a pH of 6.6 and soil organic matter content of 1.65%. Plots consisted of four 9.1 m rows spaced 76 cm apart. Herbicides were applied with a CO_2 backpack sprayer delivering 154.5 L/ha. Preemergence herbicides were applied May 29, 2001 and postemergence herbicides were applied June 19, 2001. All postemergence treatments included one or both of the following: 1.0% v/v crop oil concentrate or 0.25% v/v nonionic surfactant. Preemergence and postemergence herbicide treatments are shown in Table 3.

Soybean response was visually evaluated and recorded 7 and 14 DAT. Efficacy was visually evaluated 7, 14, 23, 28, and 40 DAT. Weed control and crop response were

Table 1. Herbicide Treatments and Rates for Experiment A.

Treatment	**Application Rate (g ai /ha)**
glyphosate + AMS*	840
sulfosate + AMS	840
glyphosate + AMS	1120
sulfosate + AMS	1120
glyphosate + chlorimuron-ethyl + AMS	840 4.5
sulfosate + chlorimuron-ethyl + AMS	840 4.5
glyphosate + chlorimuron-ethyl + AMS	1120 4.5
sulfosate + chlorimuron-ethyl + AMS	1120 4.5

*ammonium sulfate at 11 g/L of solution

Table 2. Herbicide Treatments and Rates for Experiment B.

Treatment	**Application Rate**
glyphosate +	840 g ai/ha
imazethapyr +	71 g ai/ha
NIS^ +	0.125 % v/v
AMS*	20 g/L
glyphosate +	840 g ai/ha
chloransulam-methyl +	18 g ai/ha
COC** +	0.5 % v/v
AMS	11.16 g/L
sulfosate +	840 g ai/ha
chloransulam-methyl +	18 g ai/ha
COC +	0.5 % v/v
AMS	11.16 g/L
glyphosate +	840 g ai/ha
fomesafen +	198 g ai/ha
COC +	0.5 % v/v
AMS	11.16 g/L
sulfosate +	840 g ai/ha
fomesafen +	198 g ai/ha
COC +	0.5 % v/v
AMS	11.16 g/L
glyphosate +	1120 g ai/ha
AMS	11.16 g/L
sulfosate +	1120 g ai/ha
AMS	11.16 g/L

*ammonium sulfate

^nonionic surfactant

**crop oil concentrate

Table 3. Herbicide Treatments and Rates for Experiment C.

Treatment	Application Rate	Application Timing
pendimethalin+	1111 g ai/ha	preemergence
acifluorfen +	280 g ai/ha	postemergence
bentazon +	560 g ai/ha	postemergence
sethoxydim +	314 g ai/ha	postemergence
COC*	1.0 % v/v	
pendimethalin +	1111 g ai/ha	preemergence
imazamox +	35 g ai/ha	postemergence
acifluorfen +	140 g ai/ha	postemergence
NIS^	0.25 % v/v	postemergence
imazaquin +	134 g ai/ha	preemergence
pendimethalin +	840 g ai/ha	preemergence
bentazon +	560 g ai/ha	postemergence
acifluorfen +	280 g ai/ha	postemergence
NIS	0.25 % v/v	postemergence
imazaquin +	90 g ai/ha	preemergence
pendimethalin +	560 g ai/ha	preemergence
bentazon +	560 g ai/ha	postemergence
acifluorfen +	280 g ai/ha	postemergence
sethoxydim +	314 g ai/ha	postemergence
COC	1.0 % v/v	postemergence
s-metolachlor +	1100 g ai/ha	preemergence
metribuzin +	258 g ai/ha	preemergence
acifluorfen +	392 g ai/ha	postemergence
fenoxaprop-ethyl +	1673 g ai/ha	postemergence
fluazifop-P +	470 g ai/ha	postemergence
COC	1.0 % v/v	postemergence
chloransulam +	35 g ai/ha	preemergence
sulfentrazone +	275g ai/ha	preemergence
sethoxydim +	314 g ai/ha	postemergence
COC	1.0 % v/v	postemergence
pendimethalin +	1111 g ai/ha	preemergence
imazethapyr +	71 g ai/ha	postemergence
carfentrazone +	18 g ai/ha	postemergence
NIS	0.25 % v/v	postemergence

*crop oil concentrate

^nonionic surfactant

obtained from the two center rows of each four-row plot. Data was subjected to analysis of variance, and means were separated using DMRT $p \leq 0.05$.

Experiment D

Soybeans (cv. 'Garst D485') were planted May 30, 2001 at a rate of 150,731 seeds per hectare into a conventionally tilled Pembroke silt loam with a pH of 6.6 and soil organic matter content of 1.8%. Plots consisted of four 9.1 m rows spaced 76 cm apart. Herbicides were applied with a CO_2 backpack sprayer delivering 154.5 L/ha. Preemergence herbicides were applied May 29, 2001 and postemergence herbicides were applied June 22, 2001. All postemergence treatments included one or both of the following: 1.0% v/v crop oil concentrate, 0.25% v/v nonionic surfactant, or 2.5 % 28% urea-ammonium nitrate. Preemergence and postemergence herbicide treatments are shown in Table 4.

Soybean response was visually evaluated and recorded 7 and 14 DAT. Efficacy was visually evaluated 7, 14, 20, 28, and 40 DAT. Weed control and crop response were obtained from the two center rows of each four-row plot. Data was subjected to analysis of variance, and means were separated using DMRT $p \leq 0.05$.

Table 4. Herbicide Treatments and Rates for Experiment D.

Treatment	Application Rate	Application Timing
pendimethalin +	1111 g ai/ha	preemergence
imazethapyr	71 g ai/ha	postemergence
NIS^	0.25 % v/v	postemergence
28 % UAN*	2.5 % v/v	postemergence
sulfentrazone +	211 g ai/ha	preemergence
clomazone +	627 g ai/ha	preemergence
chlorimuron-ethyl +	9 g ai/ha	postemergence
carfentrazone	18 g ai/ha	postemergence
NIS	0.25 % v/v	postemergence
sulfentrazone +	104 g ai/ha	preemergence
chlorimuron-ethyl +	21 g ai/ha	preemergence
clomazone +	627 g ai/ha	preemergence
clethodim	101 g ai/ha	postemergence
COC**	1.0 % v/v	postemergence
dimethenamid-P +	740 g ai/ha	preemergence
acifluorfen	420 g ai/ha	postemergence
NIC	0.25 % v/v	postemergence
flumetsulam +	56 g ai/ha	preemergence
chloransulam-methyl +	18 g ai/ha	postemergence
clethodim	101 g ai/ha	postemergence
NIS	0.25 % v/v	postemergence
28% UAN	2.5 % v/v	postemergence
s-metolachlor +	1100 g ai/ha	preemergence
metribuzin +	258 g ai/ha	preemergence
acifluorfen +	560 g ai/ha	postemergence
fenoxaprop-ethyl	1673 g ai/ha	postemergence
COC	1.0 % v/v	postemergence
28 % UAN	2.5 % v/v	postemergence
chlorimuron-ethyl +	134 g ai/ha	preemergence
metribuzin +	23 g ai/ha	preemergence
clomazone +	627 g ai/ha	preemergence
chloransulam-methyl +	18 g ai/ha	postemergence
carfentrazone	18 g ai/ha	postemergence
NIS	0.25 % v/v	postemergence

*Urea ammonium nitrate

^nonionic surfactant

**crop oil concentrate

CHAPTER IV

RESULTS AND DISCUSSION

Experiment A

Soybean injury 4 DAT ranged from 0 to 5%, with treatments including chlorimuron-ethyl exhibiting 5% chlorosis (Table 5). No injury was observed 14 DAT from any treatment. Dry conditions may have reduced soybeans' ability to rapidly metabolize chlorimuron-ethyl, resulting in chlorosis and stunting. No injury from glyphosate and sulfosate was expected since glyphosate-tolerant soybeans are genetically engineered to withstand application of these active ingredients.

Ivyleaf morningglory control 14 DAT ranged from 48 to 63%. Glyphosate at 1120 g ai/ha provided better control than 840 g ai/ha sulfosate. Addition of chlorimuron-ethyl to either glyphosate or sulfosate did not improve control. Tall morningglory control 14 DAT ranged from 47 to 53% with no significant differences occurring between treatments. Morningglory control 29 DAT ranged from 67 to 85%, and control 42 DAT ranged from 60 to 70%. There were no differences in morningglory control among treatments 29 and 42 DAT (Table 6). Control of morningglory was less than expected but may be due to the lack of rainfall experienced throughout the growing season. Glyphosate and sulfosate are systemic and without adequate soil moisture may not have

Table 5. Soybean Injury as Influenced by Postemergence Treatment (Exp. A).

Treatment	Application Rate g ai /ha	Soybean Injury (%) 4 DAT	14 DAT
glyphosate + AMS^	840	0b*	0a
sulfosate + AMS	840	0b	0a
glyphosate + AMS	1120	0b	0a
sulfosate + AMS	1120	0b	0a
glyphosate + chlorimuron-ethyl + AMS	840 4.5	5a	0a
sulfosate + chlorimuron-ethyl + AMS	840 4.5	5a	0a
glyphosate + chlorimuron-ethyl + AMS	1120 4.5	5a	0a
sulfosate + chlorimuron-ethyl + AMS	1120 4.5	5a	0a

*Means sharing the same letter are not different (DMRT $p <= 0.05$)

^ammonium sulfate at 11 g/L

Table 6. Morningglory Control as Influenced by Postemergence Treatment (Exp. A).

		Control (%)					
	Application Rate	14 DAT		29 DAT		42 DAT	
Treatment	**g ai /ha**	**IPOHE****	**PHBPU*****	**IPOHE**	**PHBPU**	**IPOHE**	**PHBPU**
glyphosate + AMS^	840	62ab*	53a	78a	78a	65a	67a
sulfosate + AMS	840	48b	48a	73a	70a	62a	65a
glyphosate + AMS	1120	63a	50a	85a	78a	70a	68a
sulfosate + AMS	1120	51ab	50a	75a	75a	65a	68a
glyphosate + chlorimuron-ethyl AMS	840 4.5	50ab	47a	75a	71a	67a	67a
sulfosate + chlorimuron-ethyl AMS	840 4.5	56ab	48a	73a	70a	60a	61a
glyphosate + chlorimuron-ethyl AMS	1120 4.5	55ab	51a	77a	67a	65a	67a
sulfosate + chlorimuron-ethyl AMS	1120 4.5	58ab	50a	82a	72a	63a	66a

*Means sharing the same letter are not different (DMRT p <= 0.05)

^ammonium sulfate at 11 g/L

**IPOHE = *Ipomoea hederacea* (ivyleaf morningglory)

***PHBPU = *Ipomoea prupurea* (tall morningglory) been able to translocate effectively. Previous research has shown that glyphosate and sulfosate may not provide complete control of morningglory (4, 5, 15, 27, 29). Vidrine et al. found that a single application of 560 g ai/ha glyphosate did not successfully control morningglory (27). Johnson et al. reported that a late postemergence application of 840 g ai/ha glyphosate plus 5.6 g ai/ha chlorimuron provided 88% morningglory control early in the season but by the end of the season control had declined to 69% (15).

All treatments provided 99% control of common lambsquarters (*Chenopodium album*), smooth pigweed (*Amaranthus hybridus*), jimsonweed (*Datura stramonium*), and common cocklebur (*Xanthium strumarium*) 14 DAT (Table 7). Prickly sida (*Sida spinosa*) control 14 DAT ranged from 85 to 92% with all treatments providing statistically equivalent control (Table 7). All treatments provided ≥ 96% control of common cocklebur, common lambsquarters, jimsonweed, and smooth pigweed 29 and 42 DAT (Tables 8,9). Prickly sida control ranged from 84 to 94% 29 DAT with all treatments providing equivalent control (Table 8). Prickly sida control 42 DAT ranged from 93 to 97% (Table 9). Control of common cocklebur, common lambsquarters, jimsonweed, and smooth pigweed was at levels expected from glyphosate and sulfosate (29). Lich et al. reported that glyphosate with the addition of a tankmix provided control of a broad spectrum of weeds. Common lambsquarters dry weight reduction 56 DAT was ≥ 93% after an application of 420 g ai/ha glyphosate + 6 g ai/ha chlorimuron (18).

Grain yield ranged from 2318 to 3235 kg/ha. Plots treated with sulfosate at 840 g ai/ha, glyphosate + chlorimuron-ethyl at 840 + 4.5 g ai/ha, and sulfosate + chlorimuron-ethyl at 840 + 4.5 g ai/ha had significantly higher yield than plots treated with sulfosate alone at 1120 g ai/ha (Table 10). Yields are lower than the state average of 3365 kg/ha

Table 7. Weed Control 14 DAT as Influenced by Postemergence Treatment (Exp. A).

Treatment	Application Rate g ai /ha	Control (%) CHEAL**	SIDSP**	AMACH**	DATST**	XANST**
glyphosate + AMS^	840	99a*	87a	99a	99a	99a
sulfosate + AMS	840	99a	82a	99a	99a	99a
glyphosate + AMS	1120	99a	92a	99a	99a	99a
sulfosate + AMS	1120	99a	85a	99a	99a	99a
glyphosate + chlorimuron-ethyl AMS	840 4.5	99a	92a	99a	99a	99a
sulfosate + chlorimuron-ethyl AMS	840 4.5	99a	90a	99a	99a	99a
glyphosate + chlorimuron-ethyl AMS	1120 4.5	99a	90a	99a	99a	99a
sulfosate + chlorimuron-ethyl AMS	1120 4.5	99a	90a	99a	99a	99a

*Means sharing the same letter are not different (DMRT p <= 0.05)

^ammonium sulfate at 11 g/L

**CHEAL = *Chenopodium album* (common lambsquarters)

**SIDSP = *Sida spinosa* (prickly sida)

**AMACH = *Amaranthus hybridus* (smooth pigweed)

**DATST = *Datura stramonium* (jimsonweed)

**XANST = *Xanthium strumarium* (common cocklebur)

Table 8. Weed Control 29 DAT as Influenced by Postemergence Treatment (Exp. A).

	Application Rate	Control (%)				
Treatment	**g ai /ha**	**CHEAL****	**SIDSP****	**AMACH****	**DATST****	**XANST****
glyphosate + AMS^	840	96a*	92a	98a	99a	99a
sulfosate + AMS	840	99a	84a	99a	99a	99a
glyphosate + AMS	1120	99a	94a	99a	99a	99a
sulfosate + AMS	1120	99a	92a	99a	99a	99a
glyphosate + chlorimuron-ethyl AMS	840 4.5	98a	91a	99a	99a	99a
sulfosate + chlorimuron-ethyl AMS	840 4.5	99a	93a	98a	99a	99a
glyphosate + chlorimuron-ethyl AMS	1120 4.5	99a	91a	99a	99a	99a
sulfosate + chlorimuron-ethyl AMS	1120 4.5	99a	93a	99a	99a	99a

*Means sharing the same letter are not different (DMRT p <= 0.05)

^ammonium sulfate 11 g/L

**CHEAL = *Chenopodium album* (common lambsquarters)

**SIDSP = *Sida spinosa* (prickly sida)

**AMACH = *Amaranthus hybridus* (smooth pigweed)

**DATST = *Datura stramonium* (jimsonweed)

**XANST = *Xanthium strumarium* (common cocklebur)

Table 9. Weed Control 42 DAT as Influenced by Postemergence Treatment (Exp. A).

Treatment	Application Rate g ai /ha	Control (%) CHEAL**	SIDSP**	AMACH**	DATST**	XANST**
glyphosate + AMS^	840	98a*	93a	99a	99a	99a
sulfosate + AMS	840	99a	93a	96a	99a	99a
glyphosate + AMS	1120	99a	96a	99a	99a	99a
sulfosate + AMS	1120	99a	95a	99a	99a	99a
glyphosate + chlorimuron-ethyl AMS	840 4.5	99a	94a	99a	99a	99a
sulfosate + chlorimuron-ethyl AMS	840 4.5	99a	97a	99a	99a	99a
glyphosate + chlorimuron-ethyl AMS	1120 4.5	99a	95a	99a	99a	99a
sulfosate + chlorimuron-ethyl AMS	1120 4.5	99a	97a	99a	99a	99a

*Means sharing the same letter are not different (DMRT p <= 0.05)

^ammonium sulfate at 11 g/L

**CHEAL = *Chenopodium album* (common lambsquarters)

**SIDSP = *Sida spinosa* (prickly sida)

**AMACH = *Amaranthus hybridus* (smooth pigweed)

**DATST = *Datura stramonium* (jimsonweed)

**XANST = *Xanthium strumarium* (common cocklebur)

Table 10. Soybean Grain Yield as Influenced by Postemergence Herbicide Treatment (Exp. A).

Treatment	Application Rate g ai /ha	Grain Yield (kg/ha)
glyphosate + AMS^	840	2972ab*
sulfosate + AMS	840	3134a
glyphosate + AMS	1120	2878ab
sulfosate + AMS	1120	2318b
glyphosate + chlorimuron-ethyl + AMS	840 4.5	3040a
sulfosate + chlorimuron-ethyl + AMS	840 4.5	3235a
glyphosate + chlorimuron-ethyl + AMS	1120 4.5	2574ab
sulfosate + chlorimuron-ethyl + AMS	1120 4.5	2871ab

*Means sharing the same letter are not different (DMRT $p \le 0.05$)

^ammonium sulfate at 11 g/L

(17); however, yield differences are most likely due to variables other than herbicide application since injury was minor and soybean foliage recovered quickly from the chlorosis and temporary stunting.

Experiment B

Soybean injury 4 DAT ranged from 0 to 17%. Glyphosate + fomesafen at 840 + 198 g ai/ha and sulfosate + fomesafen at 840 + 198 g ai/ha injured soybean foliage more than other treatments. Glyphosate and sulfosate alone did not injure soybeans 4 DAT. Glyphosate + fomesafen and sulfosate + fomesafen treated plots exhibited ≤ 5% injury 14 DAT which was significantly higher than other treatments (Table 11). Fomesafen is a fast-acting contact herbicide that generally causes foliar leaf burn; however, soybeans recover quickly if environmental conditions are favorable for rapid growth. Previous research has indicated that injury incurred from applications of fomesafen and other diphenyl ethers does not negatively influence soybean grain yield (11).

Ivyleaf morningglory control 14 DAT ranged from 60 to 88%. Sulfosate + fomesafen at 840 + 198 g ai/ha provided greater control than all treatments except glyphosate + fomesafen at 840 + 198 g ai/ha. Tall morningglory control 14 DAT ranged from 63 to 87%. Sulfosate + fomesafen at 840 + 198 g ai/ha provided better control than did glyphosate at 1120 g ai/ha and glyphosate + imazethapyr at 840 + 71 g ai/ha. Ivyleaf morningglory control 29 DAT ranged from 80 to 91%. Glyphosate + chloransulam-methyl at 840 + 18 g ai/ha provided better control than sulfosate + fomesafen at 840 + 198 g ai/ha. Tall morningglory control 29 DAT revealed glyphosate + fomesafen at 840 + 198 g ai/ha provided less control than other treatments. Ivyleaf and tall morningglory control 42 DAT did not differ among treatment (Table 12).

Table 11. Soybean Injury as Influenced by Postemergence Treatment (Exp. B).

Treatment	Application Rate g ai/ha	Soybean Injury (%) 4 DAT	14 DAT
glyphosate +	840	6b*	0b
imazethapyr +	71		
NIS** +			
AMS^			
glyphosate +	840	9b	0b
chloransulam-methyl +	18		
COC[$] +			
AMS[#]			
sulfosate +	840	9b	0b
chloransulam-methyl +	18		
COC +			
AMS[#]			
glyphosate +	840	17a	5a
fomesafen +	198		
COC +			
AMS[#]			
sulfosate +	840	15a	4a
fomesafen +	198		
COC +			
AMS[#]			
glyphosate +	1120	0c	0b
AMS[#]			
sulfosate +	1120	0c	0b
AMS[#]			

*Means sharing the same letter are not different (DMRT p <= 0.05)
^ammonium sulfate at 20 g/L
**nonionic surfactant at 0.125 % v/v
[#]ammonium sulfate at 11 g/L
[$]crop oil concentrate at 0.5 % v/v

Table 12. Morningglory Control as Influenced by Postemergence Treatment (Exp. B).

		Control (%)					
	Application Rate	**14 DAT**		**29 DAT**		**42 DAT**	
Treatment	**g ai/ha**	**IPOHE****	**PHBPU*****	**IPOHE**	**PHBPU**	**IPOHE**	**PHBPU**
glyphosate + imazethapyr + NIS*** + AMS^	840 71	60d*	63b	83ab	90a	83a	83a
glyphosate + chloransulam-methyl + COC$ + AMS#	840 18	63cd	75ab	91a	94a	85a	82a
sulfosate + chloransulam-methyl + COC + AMS#	840 18	75bc	72ab	89ab	88a	83a	81a
glyphosate + fomesafen + COC + AMS#	840 198	84ab	78ab	90ab	75b	82a	82a
sulfosate + fomesafen + COC + AMS#	840 198	88a	87a	80b	90a	80a	78a
glyphosate + AMS#	1120	67cd	67b	88ab	90a	83a	82a
sulfosate + AMS#	1120	68cd	78ab	87ab	93a	82a	82a

*Means sharing the same letter are not different (DMRT p <= 0.05)

^ammonium sulfate at 20 g/L

***nonionic surfactant at 0.125 % v/v

**IPOHE = *Ipomoea hederacea* (ivyleaf morningglory)

***PHBPU = *Ipomoea purpurea* (tall morningglory)

#ammonium sulfate at 11 g/L

$crop oil concentrate at 0.5 % v/v

The addition of fomesafen improved control 14 DAT; however, all treatments provided equivalent control 29 DAT. Fomesafen is a contact herbicide that acts quickly and often provides more control early in the growing season compared to translocated herbicides such as glyphosate and sulfosate. Glyphosate and sulfosate may have provided less control early in the season because lack of moisture did not facilitate rapid translocation to the site of action. Previous research has shown that one application of 1121 g ai/ha glyphosate can provide ≥ 95% ivyleaf morningglory control 42 DAT (28); however, these data indicated that glyphosate and sulfosate alone controlled morningglory ≤ 83% 42 DAT when soil moisture was below normal for much of the growing season (data not shown).

Prickly sida control 14 DAT ranged from 83 to 95%. Sulfosate at 1120 g ai/ha provided better control than glyphosate + fomesafen at 840 + 198 g ai/ha and glyphosate + chloransulam-methyl at 840 + 18 g ai/ha. Jimsonweed and common cocklebur control 14 DAT revealed no significant differences among herbicide treatment. Smooth pigweed control 14 DAT revealed glyphosate + fomesafen at 840 + 198 g ai/ha and sulfosate + fomesafen at 840 + 198 g ai/ha provided less control than all other treatments (Table 13). Prickly sida control 29 DAT ranged from 84 to 97% with glyphosate + fomesafen providing less control than all other treatments except glyphosate + chloransulam-methyl and sulfosate + fomesafen (Table 14). Prickly sida control 42 DAT ranged from 88 to 97% with glyphosate + fomesafen and sulfosate + fomesafen providing less control than all other treatments (Table 15). Previous research has indicated that fomesafen does not provide complete control of prickly sida; however, glyphosate and sulfosate are expected to provide sufficient control and may not have due to foliage burn of the prickly sida

Table 13. Weed Control 14 DAT as Influenced by Postemergence Treatment (Exp.B).

	Application Rate	Control (%)			
Treatment	**g ai/ha**	**SIDSP****	**DATST****	**XANST****	**AMACH****
glyphosate + imazethapyr + NIS*** + AMS^	840 71	93ab*	99a	99a	99a
glyphosate + chloransulam-methyl COC$ + AMS#	840 18	83c	99a	99a	98a
sulfosate + chloransulam-methyl COC + AMS#	840 18	87abc	99a	99a	99a
glyphosate + fomesafen + COC + AMS#	840 198	85bc	99a	99a	88b
sulfosate + fomesafen + COC + AMS#	840 198	92abc	99a	99a	86b
glyphosate + AMS#	1120	93ab	99a	99a	99a
sulfosate + AMS#	1120	95a	99a	99a	99a

*Means sharing the same letter are not different (DMRT p <= 0.05)

**SISDP = *Sida spinosa* (prickly sida)

**DATST = *Datura stamonium* (jimsonweed)

**XANST = *Xanthium strumarium* (common cocklebur)

**AMACH = *Amaranthus hybridus* (smooth pigweed)

^ammonium sulfate at 20 g/L

***nonionic surfactant at 0.125 % v/v

#ammonium sulfate at 11 g/L

$crop oil concentrate at 0.5 % v/v

Table 14. Weed Control 29 DAT as Influenced by Postemergence Treatment (Exp. B).

	Application Rate		**Control (%)**		
Treatment	**g ai/ha**	**SIDSP****	**DATST****	**XANST****	**AMACH****
glyphosate + imazethapyr + NIS*** + AMS^	840 71	95a*	99a	99a	98a
glyphosate + chloransulam-methyl + COC$ + AMS#	840 18	88bc	99a	99a	94ab
sulfosate + chloransulam-methyl + COC + AMS#	840 18	92ab	99a	99a	99a
glyphosate + fomesafen + COC + AMS#	840 198	84c	99a	99a	90bc
sulfosate + fomesafen + COC + AMS#	840 198	87bc	99a	99a	87c
glyphosate + AMS#	1120	96a	99a	99a	99a
sulfosate + AMS#	1120	97a	99a	99a	99a

*Means sharing the same letter are not different (DMRT p <= 0.05)

**SISDP = *Sida spinosa* (prickly sida)

**DATST = *Datura stamonium* (jimsonweed)

**XANST = *Xanthium strumarium* (common cocklebur)

**AMACH = *Amaranthus hybridus* (smooth pigweed)

^ammonium sulfate at 20 g/L

***nonionic surfactant at 0.125 % v/v

#ammonium sulfate at 11 g/L

$crop oil concentrate at 0.5 % v/v

Table 15. Weed Control 42 DAT as Influenced by Postemergence Treatment (Exp. B).

	Application Rate		**Control (%)**		
Treatment	**g ai/ha**	**SIDSP****	**DATST****	**XANST****	**AMACH****
glyphosate +	840	97a*	99a	99a	99a
imazethapyr +	71				
NIS*** +					
AMS^					
glyphosate +	840	93b	99a	99a	98a
chloransulam-methyl +	18				
COC[$] +					
AMS[#]					
sulfosate +	840	93b	99a	99a	99a
chloransulam-methyl +	18				
COC +					
AMS[#]					
glyphosate +	840	88c	99a	99a	93b
fomesafen +	198				
COC +					
AMS[#]					
sulfosate +	840	88c	99a	99a	88c
fomesafen +	198				
COC +					
AMS[#]					
glyphosate +	1120	96ab	99a	99a	99a
AMS[#]					
sulfosate +	1120	96ab	99a	99a	99a
AMS[#]					

*Means sharing the same letter are not different (DMRT $p <= 0.05$)

**SISDP = *Sida spinosa* (prickly sida)

**DATST = *Datura stamonium* (jimsonweed)

**XANST = *Xanthium strumarium* (common cocklebur)

**AMACH = *Amaranthus hybridus* (smooth pigweed)

^ammonium sulfate at 20 g/L

***nonionic surfactant at 0.125 % v/v

[#]ammonium sulfate at 11 g/L

[$]crop oil concentrate at 0.5 % v/v

incurred from the fomesafen (29). Prickly sida foliage burn may have been so extreme as to limit translocation of glyphosate and sulfosate, thus reducing efficacy. Jimsonweed and common cocklebur control did not differ among treatment 29 and 42 DAT (Tables 14, 15).

Grain yield ranged from 2433 to 3107 kg/ha with no significant differences among treatments (Table 16). Yields are lower than average (3365 kg/ha) (17). Previous research has shown that diphenyl ethers do not negatively influence soybean grain yield (11), and glyphosate and sulfosate are not expected to cause yield reductions.

Experiment C

Soybean injury 7 DAT ranged from 0 to 30%. Imazethapyr + carfentrazone produced greater crop injury than all other treatments (30%) with sethoxydim producing significantly less injury than all other treatments (6%). Injury had decreased by 14 DAT, with imazethapyr + carfentrazone exhibiting significantly higher injury than all treatments except acifluorfen + fenoxaprop-ethyl + fluazifop-P and bentazon + acifluorfen (Table 17). Injury from bentazon, acifluorfen, and carfentrazone routinely causes partial dessication of soybean leaves. Kapusta et al. reported soybean grain yield was not reduced by injury incurred from applications of bentazon (0.8 and 1.1 kg/ha) and acifluorfen (0.4 and 0.6 kg/ha) (16). Sethoxydim selectively controls monocot species but has no activity on dicot species; thus it is expected to cause very little injury to soybean foliage. Sethoxydim application resulted in 6% injury 7 DAT but injury symptoms can be attributed to the crop oil concentrate adjuvant, which can cause temporary soybean leaf chlorosis.

Table 16. Soybean Grain Yield as Influenced by Postemergence Treatment (Exp. B).

Treatment	Application Rate g ai/ha	Grain Yield (kg/ha)
glyphosate +	840	2622a*
imazethapyr +	71	
NIS** +		
AMS^		
glyphosate +	840	2446a
chloransulam-methyl +	18	
COC[$] +		
AMS[#]		
sulfosate +	840	2460a
chloransulam-methyl +	18	
COC +		
AMS[#]		
glyphosate +	840	2520a
fomesafen +	198	
COC +		
AMS[#]		
sulfosate +	840	2433a
fomesafen +	198	
COC +		
AMS[#]		
glyphosate +	1120	2804a
AMS[#]		
sulfosate +	1120	3107a
AMS[#]		

*Means sharing the same letter are not different (DMRT p <= 0.05)

^ammonium sulfate at 20 g/L

**nonionic surfactant at 0.125 % v/v

[#]ammonium sulfate at 11 g/L

[$]crop oil concentrate at 0.5 % v/v

Table 17. Soybean Injury as Influenced by Postemergence Treatment (Exp. C).

	Application Rate	Control (%)	
Treatment	g ai/ha	7 DAT	14 DAT
Untreated		0e*	0c
acifluorfen +	280	18b	8b
bentazon +	560		
sethoxydim +	314		
COC^			
imazamox +	35	12c	6b
acifluorfen +	140		
NIS**			
bentazon +	560	18b	10ab
acifluorfen +	280		
NIS			
bentazon +	560	17bc	8b
acifluorfen +	280		
sethoxydim +	314		
COC			
acifluorfen +	392	17bc	9ab
fenoxaprop-ethyl +	1673		
fluazifop-P +	470		
COC			
sethoxydim +	314	6d	1c
COC			
imazethapyr +	71	30a	14a
carfentrazone +	18		
NIS			

*Means sharing the same letter are not different (DMRT p <= 0.05)

^crop oil concentrate at 1.0 % v/v

**nonionic surfactant at 0.25 % v/v

Morningglory control 20 days after planting (DAP) as influenced by preemergence treatments ranged from 35 to 99%. Plots receiving chloransulam + sulfentrazone, imazaquin (134 g ai/ha) + pendimethalin (840 g ai/ha), or imazaquin (90 g ai/ha) + pendimethalin (560 g ai/ha) provided greater control than pendimethalin alone, or s-metolachlor + metribuzin (Table 18). Pendimethalin is reported to be weak on morningglory as is s-metolachlor + metribuzin (29).

Morningglory control by pendimethalin + acifluorfen + bentazon + sethoxydim ranged from 48 to 93% from 20 DAP to 43 DAT but at 43 DAT provided only 63% control (Tables 19, 20). Pendimethalin + imazamox + acifluorfen controlled morningglory 47 to 90% with steady increases from 20 DAP to 23 DAT. Control began to decrease 28 DAT but had increased to 90% 43 DAT. This decrease in control could be due to the shading effect of the soybean canopy as it blocks sunlight to the weeds; thus reducing growth of the weed species. Murdock et al. reported that once the soil surface is shaded, weed emergence is decreased (20). Imazaquin (134 g ai/ha) + pendimethalin (840 g ai/ha) + bentazon (560 g ai/ha) + acifluorfen (280 g ai/ha) controlled morningglory 88 to 93% with control reaching a peak 28 DAT (99%) before declining to 93% 43 DAT. Morningglory control by imazaquin (90 g ai/ha) + pendimethalin (560 g ai/ha) + bentazon (560 g ai/ha) + acifluorfen (280 g ai/ha) + sethoxydim (314 g ai/ha) ranged from 74 to 93 % (Tables 18, 19, 20). Control peaked at 7 and 14 DAT and declined to 74% 28 DAT. However, control was 89% 43 DAT. S-metolachlor + metribuzin + acifluorfen + fenoxaprop-ethyl + fluazifop-P controlled morningglory 30 to 62%. Chloransulam + sulfentrazone + sethoxydim controlled morningglory 99% 20 DAP and 7 DAT and provided 91% control 43 DAT (Tables 18, 19, 20). Morningglory

Table 18. Morningglory Control as Influenced by Preemergence Treatments (Exp. C).

Treatment	**Application Rate (g ai/ha)**	**20 DAP**
untreated		0c*
pendimethalin	1111	48b
pendimethalin	1111	47b
imazaquin + pendimethalin	134 840	94a
imazaquin + pendimethalin	90 560	88a
s-metolachlor + metribuzin	1100 258	35b
chloransulam + sulfentrazone	35 275	99a
pendimethalin	1111	52ab

*Means sharing the same letter are not different (DMRT p <= 0.05)

Table 19. Morningglory Control as Influenced by Preemergence and Postemergence Treatments (Exp. C).

Treatment	**Application Rate (g ai/ha)**	**7 DAT**	**14 DAT**
untreated		0c	0d
pendimethalin+	1111	86a	82ab
acifluorfen +	280		
bentazon +	560		
sethoxydim +	314		
COC^			
pendimethalin +	1111	78a	76b
imazamox +	35		
acifluorfen +	140		
NIS**			
imazaquin +	134	88a	96a
pendimethalin +	840		
bentazon +	560		
acifluorfen +	280		
NIS			
imazaquin +	90	93a	93ab
pendimethalin +	560		
bentazon +	560		
acifluorfen +	280		
sethoxydim +	314		
COC			
s-metolachlor +	1100	55b	55c
metribuzin +	258		
acifluorfen +	392		
fenoxaprop-ethyl +	1673		
fluazifop-P +	470		
COC			
chloransulam +	35	99a	98a
sulfentrazone +	275		
sethoxydim +	314		
COC			
pendimethalin +	1111	98a	92ab
imazethapyr +	71		
carfentrazone +	18		
NIS			

*Means sharing the same letter are not different (DMRT p <= 0.05)

^crop oil concentrate at 1.0 % v/v

**nonionic surfactant at 0.25 % v/v

Table 20. Morningglory Control as Influenced by Preemergence and Postemergence Treatments (Exp. C).

Treatment	**Application Rate (g ai/ha)**	**23 DAT**	**28 DAT**	**43 DAT**
untreated		0e*	0d	0c
pendimethalin+	1111	93ab	82ab	63b
acifluorfen +	280			
bentazon +	560			
sethoxydim +	314			
COC^				
pendimethalin +	1111	81c	73b	90a
imazamox +	35			
acifluorfen +	140			
NIS**				
imazaquin +	134	97a	99a	93a
pendimethalin +	840			
bentazon +	560			
acifluorfen +	280			
NIS				
imazaquin +	90	85bc	74b	89a
pendimethalin +	560			
bentazon +	560			
acifluorfen +	280			
sethoxydim +	314			
COC				
s-metolachlor +	1100	47d	30c	62b
metribuzin +	258			
acifluorfen +	392			
fenoxaprop-ethyl +	1673			
fluazifop-P +	470			
COC				
chloransulam +	35	98a	94ab	91a
sulfentrazone +	275			
sethoxydim +	314			
COC				
pendimethalin +	1111	98a	99a	86ab
imazethapyr +	71			
carfentrazone +	18			
NIS				

*Means sharing the same letter are not different (DMRT $p <= 0.05$)

^crop oil concentrate at 1.0 % v/v

**nonionic surfactant at 0.25 % v/v

control by pendimethalin + imazethapyr + carfentrazone ranged from 52% to 99%. Pendimethalin provided 52% control 20 DAP and at 28 DAT pendimethalin + imazethapyr + carfentrazone controlled morningglory 99% (Table 18, 19). Morningglory control from pendimethalin is reported to be low according to the University of Kentucky Weed Control Recommendations for Kentucky Crops (29). Barker et al. reported that bentazon + acifluorfen provided > 90% morningglory control when applied 4 weeks after planting (WAP) (3). Choate et al. also reported that a treatment of bentazon + acifluorfen provided > 90% control when it followed a preemergence application of metolachlor (7).

Common cocklebur control 20 DAP ranged from 13 to 97%. Imazaquin (134 g ai/ha) + pendimethalin (840 g ai/ha), imazaquin (90 g ai/ha) + pendimethalin (560 g ai/ha), and chloransulam + sulfentrazone provided 90, 91, and 97% control of common cocklebur, respectively (Table 21). Pendimethalin and s-metolachlor + metribuzin provided ≤ 45% common cocklebur control 20 DAP. Common cocklebur control 7 DAT ranged from 62 to 96%. S-metolachlor + metribuzin + acifluorfen + fenoxaprop-ethyl + fluazifop-P provided less control than plots receiving an application of chloransulam + sulfentrazone or bentazon + acifluorfen. Common cocklebur control 43 DAT ranged from 22 to 92% with s-metolachlor + metribuzin + acifluorfen + fenoxaprop-ethyl + fluazifop-p providing the least control (Table 21). The tankmix of s-metolachlor + metribuzin followed by acifluorfen + fenoxaprop-ethyl + fluazifop-p controlled common cocklebur ≤ 62% throughout the season. All treatments controlled smooth pigweed and common lambsquarters > 95% at all evaluation dates (data not shown).

Table 21. Common Cocklebur Control as Influenced by Preemergence and Postemergence Treatments (Exp. C).

Treatment	**Application Rate g ai/ha**	**Control (%) 20 DAP**	**7 DAT**	**14 DAT**	**23 DAT**	**28 DAT**	**43 DAT**
untreated		0d*	0d	0d	0c	0c	0d
pendimethalin+	1111	20c	88ab	88ab	83a	81a	45c
acifluorfen +	280						
bentazon +	560						
sethoxydim +	314						
COC^							
pendimethalin +	1111	22c	69bc	74b	84a	86a	77ab
imazamox +	35						
acifluorfen +	140						
NIS**							
imazaquin +	134	90a	96a	94a	94a	95a	92a
pendimethalin +	840						
bentazon +	560						
acifluorfen +	280						
NIS							
imazaquin +	90	91a	96a	95a	94a	94a	88a
pendimethalin +	560						
bentazon +	560						
acifluorfen +	280						
sethoxydim +	314						
COC							
s-metolachlor +	1100	45b	62c	57c	37b	22b	22d
metribuzin +	258						
acifluorfen +	392						
fenoxaprop-ethyl +	1673						
fluazifop-P +	470						
COC							
chloransulam +	35	97a	95a	95a	87a	86a	85a
sulfentrazone +	275						
sethoxydim +	314						
COC							
pendimethalin +	1111	13cd	77abc	80ab	83a	82a	60bc
imazethapyr +	71						
carfentrazone +	18						
NIS							

*Means sharing the same letter are not different (DMRT $p <= 0.05$)

^crop oil concentrate at 1.0 % v/v

**nonionic surfactant at 0.25 % v/v

Experiment D

Soybean injury 7 DAT ranged from 0 to 33%. Treatments containing carfentrazone produced greater soybean injury (≥ 30%) than all other treatments. Injury had declined by 14 DAT; however, plots receiving an application of either 18 g ai/ha carfentrazone or 420 g ai/ha acifluorfen produced soybean injury greater than that of other treatments (Table 22).

Morningglory control 7 DAT ranged from 48 to 97%. Pendimethalin + imazethapyr controlled morningglory 83% 14 DAT but provided less control than other treatments. Treatments containing sulfentrazone and/or carfentrazone provided greater morningglory control 20 DAT than the pendimethalin + imazethapyr treatment. Morningglory control 28 and 42 DAT did not differ among treatments (Table 23).

Common cocklebur control 7 DAT ranged from 63 to 98%. Treatments containing carfentrazone provided greater common cocklebur control 7 DAT than all others with the exception of flumetsulam + chloransulam (Table 24). All treatments provided equivalent prickly sida and common lambsquarters control 7 DAT. Smooth pigweed control 7 DAT revealed pendimethalin + imazethapyr provided less control than other treatments. Common cocklebur control 14 DAT ranged from 47 to 96% with dimethenamid-p + acifluorfen providing the least amount of control (Table 25). Smooth pigweed, prickly sida, and common lambsquarters were controlled equally by all herbicide treatments 14 DAT. Dimethenamid-p + acifluorfen provided less common cocklebur control than other treatments 20 DAT (Table 26). Treatment did not influence control of smooth pigweed and common lambsquarters 20 DAT. Common cocklebur control 28 DAT revealed dimethenamid-p + acifluorfen provided the least control at 59%

Table 22. Soybean Injury as Influenced by Postemergence Treatment (Exp. D).

Treatment	Application Rate (g ai/ha)	Injury (%) 7 DAT	14 DAT
imazethapyr + NIS** + 28 % UAN^	71	12c*	2b
chlorimuron-ethyl + carfentrazone + NIS	9 18	33a	14a
clomazone + clethodim + COC$	627 101	5d	1b
acifluorfen + NIS	420	20b	9a
chloransulam-methyl + clethodim + NIS + 28 % UAN	18 101	3b	1b
acifluorfen + fenoxaprop-ethyl + COC + 28 % UAN	560 1673	17bc	2b
chloransulam-methyl + carfentrazone + NIS	18 18	30a	14a
untreated		0d	0b

*Means sharing the same letter are not different (DMRT p <= 0.05)

^Urea ammonium nitrate at 2.5 % v/v

**nonionic surfactant at 0.25 % v/v

$crop oil concentrate 1.0 % v/v

Table 23. Morningglory Control as Influenced by Preemergence and Postemergence Treatments (Exp. D).

Treatment	Application Rate (g ai/ha)	7 DAT	14 DAT	20 DAT	28 DAT	40 DAT
pendimethalin +	1111	48b*	83b	85b	93a	91a
imazethapyr +	71					
NIS** +						
28 % UAN^						
sulfentrazone +	211	99a	99a	99a	93a	93a
clomazone +	627					
chlorimuron-ethyl +	9					
carfentrazone +	18					
NIS						
sulfentrazone +	104	83a	98a	98a	92a	92a
chlorimuron-ethyl +	21					
clomazone +	627					
clethodim +	101					
COC$						
dimethenamid-P +	740	92a	96a	92ab	90a	90a
acifluorfen +	420					
NIS						
flumetsulam +	56	85a	92a	95a	88a	87a
chloransulam-methyl +	18					
clethodim +	101					
NIS +						
28 % UAN						
s-metolachlor +	1100	83a	92a	91ab	82a	84a
metribuzin +	258					
acifluorfen +	560					
fenoxaprop-ethyl +	1673					
COC +						
28 % UAN						
chlorimuron-ethyl +	134	97a	99a	98a	94a	91a
metribuzin +	23					
clomazone +	627					
chloransulam-methyl +	18					
carfentrazone +	18					
NIS						
untreated		0c	0c	0c	0b	0b

*Means sharing the same letter are not different (DMRT p <= 0.05)

^Urea ammonium nitrate at 2.5 % v/v

**nonionic surfactant at 0.25 % v/v

$crop oil concentrate 1.0 % v/v

Table 24. Weed Control 7 DAT as Influenced by Preemergence and Postemergence Treatments (Exp. D).

Treatment	Application Rate (g ai/ha)	Control (%) XANST**	AMACH**	SIDSP**	CHEAL**
pendimethalin +	1111	63d*	97b	91a	98a
imazethapyr +	71				
NIS*** +					
28 % UAN^					
sulfentrazone +	211	98a	99a	99a	99a
clomazone +	627				
chlorimuron-ethyl +	9				
carfentrazone +	18				
NIS					
sulfentrazone +	104	85bc	99a	96a	99a
chlorimuron-ethyl +	21				
clomazone +	627				
clethodim +	101				
COC$					
dimethenamid-P +	740	78c	99a	93a	99a
acifluorfen +	420				
NIS					
flumetsulam +	56	88ab	99a	99a	99a
chloransulam-methyl	18				
clethodim +	101				
NIS +					
28 % UAN					
s-metolachlor +	1100	82bc	99a	96a	99a
metribuzin +	258				
acifluorfen +	560				
fenoxaprop-ethyl +	1673				
COC +					
28 % UAN					
chlorimuron-ethyl +	134	97a	99a	99a	99a
metribuzin +	23				
clomazone +	627				
chloransulam-methyl	18				
carfentrazone +	18				
NIS					
untreated		0e	0c	0b	0b

*Means sharing the same letter are not different (DMRT p <= 0.05)

**CHEAL = *Chenopodium album* (common lambsquarters)

**SIDSP = *Sida spinosa* (prickly sida)

**AMACH = *Amaranthus hybridus* (smooth pigweed)

**XANST = *Xanthium strumarium* (common cocklebur)

^Urea ammonium nitrate at 2.5 % v/v

***nonionic surfactant at 0.25 % v/v

$crop oil concentrate 1.0 % v/v

Table 25. Weed Control 14 DAT as Influenced by Preemergence and Postemergence Treatments (Exp. D).

Treatment	Application Rate (g ai/ha)	Control (%) XANST**	AMACH**	SIDSP**	CHEAL**
pendimethalin +	1111	82bc*	99a	97a	99a
imazethapyr +	71				
NIS*** +					
28 % UAN^					
sulfentrazone +	211	96a	99a	99a	99a
clomazone +	627				
chlorimuron-ethyl +	9				
carfentrazone +	18				
NIS					
sulfentrazone +	104	68c	99a	99a	99a
chlorimuron-ethyl +	21				
clomazone +	627				
clethodim +	101				
COC$					
dimethenamid-P +	740	47d	99a	95a	98a
acifluorfen +	420				
NIS					
flumetsulam +	56	94ab	99a	99a	99a
chloransulam-methyl	18				
clethodim +	101				
NIS +					
28 % UAN					
s-metolachlor +	1100	77c	99a	96a	99a
metribuzin +	258				
acifluorfen +	560				
fenoxaprop-ethyl +	1673				
COC +					
28 % UAN					
chlorimuron-ethyl +	134	98a	99a	99a	99a
metribuzin +	23				
clomazone +	627				
chloransulam-methyl	18				
carfentrazone +	18				
NIS					
untreated		0e	0b	0b	0b

*Means sharing the same letter are not different (DMRT p=0.05)
**CHEAL = *Chenopodium album* (common lambsquarters)
**SIDSP = *Sida spinosa* (prickly sida)
**AMACH = *Amaranthus hybridus* (smooth pigweed)
**XANST = *Xanthium strumarium* (common cocklebur)

^Urea ammonium nitrate at 2.5 % v/v
***nonionic surfactant at 0.25 % v/v
$crop oil concentrate 1.0 % v/v

Table 26. Weed Control 20 DAT as Influenced by Preemergence and Postemergence Treatments (Exp. D).

Treatment	Application Rate (g ai/ha)	Control (%) XANST**	AMACH**	SIDSP**	CHEAL**
pendimethalin +	1111	91ab*	99a	94ab	98a
imazethapyr +	71				
NIS*** +					
28 % UAN^					
sulfentrazone +	211	97a	99a	98a	99a
clomazone +	627				
chlorimuron-ethyl +	9				
carfentrazone +	18				
NIS					
sulfentrazone +	104	83b	99a	94ab	99a
chlorimuron-ethyl +	21				
clomazone +	627				
clethodim +	101				
COC$					
dimethenamid-P +	740	60c	98a	88b	98a
acifluorfen +	420				
NIS					
flumetsulam +	56	97a	98a	98a	99a
chloransulam-methyl	18				
clethodim +	101				
NIS +					
28 % UAN					
s-metolachlor +	1100	81b	99a	92ab	98a
metribuzin +	258				
acifluorfen +	560				
fenoxaprop-ethyl +	1673				
COC +					
28 % UAN					
chlorimuron-ethyl +	134	98a	99a	99a	99a
metribuzin +	23				
clomazone +	627				
chloransulam-methyl	18				
carfentrazone +	18				
NIS					
untreated		0d	0b	0c	0b

*Means sharing the same letter are not different (DMRT p <= 0.05)
**CHEAL = *Chenopodium album* (common lambsquarters)
**SIDSP = *Sida spinosa* (prickly sida)
**AMACH = *Amaranthus hybridus* (smooth pigweed)
**XANST = *Xanthium strumarium* (common cocklebur)
^Urea ammonium nitrate at 2.5 % v/v
***nonionic surfactant at 0.25 % v/v
$crop oil concentrate 1.0 % v/v

(Table 27). Smooth pigweed control 28 DAT revealed chlorimuron-ethyl + metribuzin + clomazone + chloransulam-methyl + carfentrazone provided less control at 95% than pendimethalin + imazethapyr and sulfentrazone + clomazone + chlorimuron-ethyl + carfentrazone. Prickly sida control 28 DAT revealed s-metolachlor + metribuzin + acifluorfen + fenoxaprop-ethyl provided the least control. Treatment did not influence 28 DAT control of common lambsquarters. Common cocklebur 40 DAT control ranged from 35 to 92%. No differences in control occurred among the other weeds 40 DAT (Table 28).

Table 27. Weed Control 28 DAT as Influenced by Preemergence and Postemergence Treatments (Exp. D).

Treatment	**Application Rate (g ai/ha)**	**Control (%)** XANST**	AMACH**	SIDSP**	CHEAL**
pendimethalin + imazethapyr + NIS*** + 28 % UAN^	1111 71	77ab*	98a	93ab	98a
sulfentrazone + clomazone + chlorimuron-ethyl + carfentrazone + NIS	211 627 9 18	89a	98a	96a	97a
sulfentrazone + chlorimuron-ethyl + clomazone + clethodim + COC$	104 21 627 101	76ab	97ab	89ab	94a
dimethenamid-P + acifluorfen + NIS	740 420	59b	97ab	90ab	91a
flumetsulam + chloransulam-methyl clethodim + NIS + 28 % UAN	56 18 101	91a	97ab	91ab	97a
s-metolachlor + metribuzin + acifluorfen + fenoxaprop-ethyl + COC + 28 % UAN	1100 258 560 1673	61ab	96ab	85b	92a
chlorimuron-ethyl + metribuzin + clomazone + chloransulam-methyl carfentrazone + NIS	134 23 627 18 18	91a	95b	97a	96a
untreated		0c	0c	0c	0b

*Means sharing the same letter are not different (DMRT p <= 0.05)

**CHEAL = *Chenopodium album* (common lambsquarters)

**SIDSP = *Sida spinosa* (prickly sida)

**AMACH = *Amaranthus hybridus* (smooth pigweed)

**XANST = *Xanthium strumarium* (common cocklebur)

^Urea ammonium nitrate at 2.5 % v/v

***nonionic surfactant at 0.25 % v/v

$crop oil concentrate 1.0 % v/v

Table 28. Weed Control 40 DAT as Influenced by Preemergence and Postemergence Treatments (Exp. D).

Treatment	Application Rate (g ai/ha)	Control (%) XANST**	AMACH*	SIDSP**	CHEAL**
pendimethalin + imazethapyr + NIS*** + 28 % UAN^	1111 71	92a*	99a	91a	98a
sulfentrazone + clomazone + chlorimuron-ethyl + carfentrazone + NIS	211 627 9 18	88a	99a	98a	99a
sulfentrazone + chlorimuron-ethyl + clomazone + clethodim + COC$	104 21 627 101	47b	98a	88a	98a
dimethenamid-P + acifluorfen + NIS	740 420	35b	98a	88a	91a
flumetsulam + chloransulam-methyl + clethodim + NIS + 28 % UAN	56 18 101	92a	99a	92a	96a
s-metolachlor + metribuzin + acifluorfen + fenoxaprop-ethyl + COC + 28 % UAN	1100 258 560 1673	52b	99a	85a	99a
chlorimuron-ethyl + metribuzin + clomazone + chloransulam-methyl + carfentrazone + NIS	134 23 627 18 18	92a	99a	97a	99a
untreated		0c	0b	0b	0b

*Means sharing the same letter are not different (DMRT p <= 0.05)

**CHEAL = *Chenopodium album* (common lambsquarters)

**SIDSP = *Sida spinosa* (prickly sida)

**AMACH = *Amaranthus hybridus* (smooth pigweed)

**XANST = *Xanthium strumarium* (common cocklebur)

^Urea ammonium nitrate at 2.5 % v/v

***nonionic surfactant at 0.25 % v/v

$crop oil concentrate 1.0 % v/v

CHAPTER V

SUMMARY

The objectives of this research were (i) to determine the influence of tankmix herbicides on the efficacy of glyphosate and sulfosate on annual morningglory and (ii) to determine the efficacy of various soybean herbicides on annual morningglory.

The development of glyphosate-tolerant soybeans has provided growers with new options for weed control. Glyphosate provides several options for growers that include (i) controlling weeds in conventional and reduced tillage, (ii) allowing a wide window for effective application timing, and (iii) providing economical control of a broad spectrum of weeds (26).

Field studies with glyphosate and sulfosate indicated that morningglory was not effectively controlled (< 90%) with these herbicides. The addition of chlorimuron-ethyl to glyphosate or sulfosate did not improve morningglory control. Glyphosate and sulfosate alone or with the addition of imazethapyr, chloransulam-methyl, or fomesafen provided ≤ 88% morningglory control 14 DAT. The addition of these tankmixes did not improve late season control.

Field studies in conventional (non-glyphosate-tolerant) soybeans revealed that preemergence followed by postemergence herbicide programs controlled morningglory from 30 to 99%. Chloransulam + sulfentrazone + sethoxydim provided ≥ 91% control throughout the growing season, and imazaquin + pendimethalin + bentazon + acifluorfen provided ≥ 88% control throughout the season. Pendimethalin applied preemergence controlled morningglory ≤ 52% 20 DAP; however, the addition of imazaquin to pendimethalin applied preemergence, improved morningglory control to ≥ 88% 20 DAP. S-metolachlor + metribuzin applied preemergence provided 35% morningglory control 20 DAP and the application of acifluorfen + fenoxaprop-ethyl + fluazifop-P following s-metolachlor + metribuzin controlled morningglory ≤ 62%. This level of control would not be acceptable to a producer who wants a herbicide program to control weeds ≥ 90%. Pendimethalin applied preemergence controlled morningglory 52%; however, when imazethapyr + carfentrazone was applied postemergence control was improved to ≥ 85%. Dimethenamid-p applied preemergence followed by acifluorfen applied postemergence controlled morningglory successfully (≥ 90%) throughout the growing season.

Although these data revealed little advantage to the addition of a tankmix product, a producer could benefit from adding a tankmix to glyphosate or sulfosate by reducing potential problems such as weed resistance, weed shifts, and improving control of certain weed species that are difficult to control such as morningglory. By rotating active ingredients via a tankmix a producer can reduce selection pressures imposed on particular weed species when herbicides with identical modes of action are used repeatedly. Rotation of herbicides may also decrease weed shifts since weed species tolerant to a particular active ingredient are often controlled more effectively by other products. Application of preemergence herbicides may also be beneficial to a producer because preemergence herbicides provide early-season control of morningglory and other troublesome weed species. Results from this study have shown that pendimethalin +

imazaquin adequately controlled morningglory ($\geq$ 88%) and chloransulam + sulfentrazone provided excellent season-long control of morningglory. A preemergence followed by a postemergence herbicide program may allow the producer more flexibility when spraying postemergence herbicides and may reduce postemergence herbicide use. Holloway and Shaw reported that ivyleaf morningglory reduced soybean yield if it was not controlled within two weeks of soybean emergence (13). Total postemergence programs are typically targeted toward successful control of weed species that have co-existed with the soybean crop for the first 3 to 5 weeks following its emergence. Therefore, applications of preemergence herbicides that provide morningglory control or suppression may benefit soybean producers by reducing early-season morningglory competition to a level that will not cause reduction in grain yield.

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