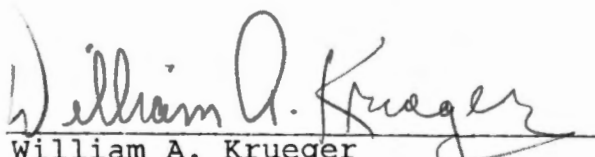
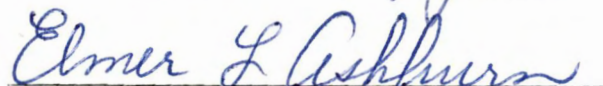


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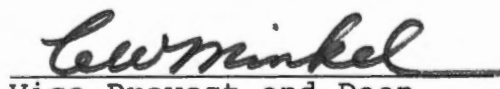
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THE BEHAVIOR AND CONTROL OF SICKLEPOD UNDER
FIELD AND GREENHOUSE CONDITIONS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Timothy Edward Adcock

December 1987

AG-VET-MED.

Thesis

87

.A239

DEDICATION

To Mom, Dad, Hollie, and the God who gave me each, I
dedicate this thesis.

ACKNOWLEDGEMENTS

The author wishes to express sincere thanks to the following persons who aided in the preparation of this thesis:

To Dr. William Krueger, whose many hours of labor and encouragement made this thesis possible and my stay enjoyable.

To Dr. Neil Rhodes, Jr., whose interest and suggestions proved to be invaluable assets to my work.

To Dr. Elmer Ashburn, whose knowledge and insight are evident throughout this thesis.

To my committee as a whole, I thank them for their help, advice, friendship, and constant devotion to this project and acknowledge that this work is not mine, but ours.

To Dr. Robert Hayes, for his help in the creation of this project.

To Dr. John Foss and the entire Department of Plant and Soil Science, for providing me the resources with which to further my education.

To Matt Thornton, whose help and friendship are greatly appreciated.

To the secretaries, Sarah, Tereasa, Jenifer, Martha, Betty, Cheryl, Jenny, Alice, and Lois, who aided me in countless ways.

To the people at the Knoxville and Spring Hill Experiment Stations, who contributed their time and effort.

To Dr. Carl Sams and his staff, who helped make the greenhouse portion of this research possible.

To Dr. Vernon Reich, for offering his assistance with the statistical analysis of this thesis.

To the graduate students and research assistants, who have made this step in my education an exceptionally enjoyable experience. Particular thanks to those with whom I have shared an office, the other members of the Weed Science program, and the members of the Plant and Soil Science Softball Team.

To my parents, for things too numerous to mention.

To my nephew and his mother, who are an endless source of joy and inspiration.

To Hollie, just for being Hollie.

"The heights by great men reached and kept
Were not attained by sudden flight,
But they, while their companions slept,
Were toiling upward in the night."

Henry Wadsworth Longfellow
The Ladder of St. Augustine

ABSTRACT

Field and greenhouse experiments to investigate the behavior and control of sicklepod (Cassia obtusifolia L.) in soybeans (Glycine max L.) were conducted from 1985 to 1987. A survey of sicklepod distribution and control in Tennessee was also conducted. Sicklepod is present in 86% of the counties in Tennessee with the heaviest infestations in the western portion of the state. Sicklepod is a threat to crop yields in 62% of Tennessee's counties and infests over 100,000 ha of cropland. Sicklepod infestations are increasing, but the problem is not as severe as some of Tennessee's most damaging agronomic weeds such as annual morningglory (Ipomoea spp.), common cocklebur (Xanthium strumarium L.), and johnsongrass [Sorghum halepense (L.) Pers.]. Atrazine and imazaquin are the most commonly used herbicides for sicklepod control in Tennessee.

Alachlor plus metribuzin applied preemergence and the following sequential (preemergence followed by postemergence) applications: metribuzin followed by chlorimuron, chlorimuron plus metribuzin followed by chlorimuron, imazaquin followed by imazaquin, and imazethapyr followed by imazethapyr, were evaluated for their effects on sicklepod. Conventional and no-tillage cropping systems were also compared. All herbicide programs reduced sicklepod number and height compared to the weedy

checks. The addition of a postemergence herbicide improved sicklepod control. Adequate sicklepod control was not obtained using any of the tested herbicides. Sicklepod numbers were greater in conventional tillage while sicklepod height was greater in no-tillage. Sicklepod control obtained relative to each cropping system varied with location. Soybean injury was noted with several herbicides in no-tillage.

Spring oats (Avena sativa L.) were evaluated for allelopathic effects on sicklepod. A spring oat mulch lowered sicklepod dry weight production. Residues left by spring oats lowered sicklepod shoot length and root dry weight. Sicklepod was evaluated for allelopathic effects on soybeans. Sicklepod residues lowered soybean leaf area. Soybeans planted into soil in which sicklepod had previously been grown had lower shoot lengths, leaf areas, and dry weights compared to the controls.

The effects of chlorimuron and imazaquin mixed with metribuzin and applied preemergence to sicklepod were evaluated under greenhouse conditions. Metribuzin mixed with chlorimuron gave up to 54% less control when measured by sicklepod number and up to 26% less control when measured by sicklepod dry weight than did metribuzin applied alone. Metribuzin mixed with imazaquin gave up to 57% less control when measured by sicklepod number and up to 33% less control

when measured by sicklepod dry weight than did metribuzin applied alone.

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CHAPTER I

INTRODUCTION

Weeds present many problems for the row crop producer. In addition to lowering crop yields, weeds can harbor insects and plant diseases, reduce crop quality, and interfere with water management (38). Weeds can interfere with crop production by competing for light, water, and nutrients or, in some cases, through allelopathy. The destructive character of weeds makes their control essential if economic returns are to be expected from agricultural field commodities.

The science of plant protection is not based solely on chemicals. Mechanical and cultural practices are valuable tools for the control of plant pests. Integrated pest management involves the combination of pest control actions based on predicted consequences (29). Consideration is given to social and economic consequences arising from techniques employed by the crop production and crop protection disciplines (29). Ecology is the study of interrelationships between living and non-living components in an ecosystem. Integrated pest management may be thought of as applied ecology in that a systematic approach is used

to insure changes made in a agricultural ecosystem are beneficial with regard to present and future needs (29).

Sicklepod (Cassia obtusifolia L.) is a non-nodulating legume reaching a height of two m under favorable moisture and fertility conditions (16). Sicklepod has an even-pinnate leaf form with entire margins and an oval to elliptical leaf shape. The leaves are rounded at the base, generally obtuse at the tip, and contain pinnate venation. Sicklepod is present in several agronomic crops, but is particularly troublesome in soybeans (Glycine max L.), corn (Zea mays L.), peanuts (Arachis hypogaea L.), and grain sorghum [Sorghum bicolor (L.) Moench.] in the southern United States (47,55). Sicklepod is the fifth most troublesome and sixth most common weed in the Southeast and the most troublesome row crop weed in Georgia, Florida, and Alabama (22,68). One reason for increased sicklepod infestations in soybeans during recent years is sicklepod's tolerance to many herbicide programs (69). Tolerance to applied herbicides can affect shifts in a weed spectrum by selection for a tolerant weed species (8). Herbicides available for use in corn and pasture are more effective against sicklepod, therefore, it is more easily controlled in these crops (32). In soybeans, preemergence herbicides establish a height differential giving soybeans a competitive advantage over sicklepod. However, preemergence

herbicides are generally insufficient for season-long control (32). The addition of a postemergence-directed herbicide application increases soybean yields over a preemergence treatment alone (32). Control using only postemergence herbicides is variable and often inadequate to protect soybean yields (32). Sicklepod's herbicide tolerance creates an additional problem. In fields where sicklepod exists in combination with other weeds, removal of other weed species intensifies sicklepod pressure due to reduced interspecific competition (32).

Other factors creating additional control problems stem from sicklepod's biological aspects. Sicklepod seed have impermeable seed coats allowing them to resist germination and remain viable in the soil for several years (20,67). Williams and Elliot (77) state that an impermeable seed coat is "considered a valuable characteristic for continuance of a plant species under conditions of climatic adversity." The seed exterior has a wax-like covering approximately 0.1 mm thick and the layer surrounding the endosperm is hard and dense (20). Germination stimulators such as ethephon, gibberellic acid, L-glutamine, hydroxylamine, hydrochloride, indole 3-acetic acid, kinetin, sodium nitrate, thiourea, and 2,4-D have not been successful in increasing sicklepod germination (24). The incubation of unscarified sicklepod

seed in moist soil for 12 months at 23 C resulted in only 15% germination (20).

Sicklepod seed germinate under a wide range of environmental conditions. Andersen (1) states:

The ability to germinate and emerge over prolonged periods, under a wide range of environmental conditions, and at a wide range of soil depths are factors which improve the competitiveness and survival of the species.

Sicklepod seed can germinate in a soil pH range from 3.2 to 7.9 (20). Germination occurs over a temperature range of 10 to 40 C with optimum germination occurring between 25 to 35 C (24). Seedling growth and rapid root elongation occur at temperatures ranging from 18 to 39 C (20).

Sicklepod seed germinate and emerge from soil depths as great as 15 cm (70). This characteristic makes sicklepod more difficult to control because it can emerge from below a treated herbicide zone (70). The emergence pressure of sicklepod, as measured by piston displacement, reaches its maximum as early as five days. Tall morningglory [Ipomoea purpurea (L.) Roth], common cocklebur (Xanthium strumarium L.), and soybeans reach maximum pressure at 7, 8, and 11 days respectively (43). Sicklepod can also germinate and emerge throughout the growing season (11). Season-long sicklepod germination can result in harvest delays and crop losses (59).

Prolific seed production enhances sicklepod's competitive ability. A sicklepod plant can produce up to 8000 seed and 363 pods (25). Sicklepod seed yields of over 900 kg/ha have been reported in heavily infested cotton (Gossypium hirsutum L.) fields (20).

The sum of sicklepod's pernicious characteristics make it a successful competitor in row crops. Soybean yield reductions of 20% have been reported at a sicklepod density of one plant per two meters of row (22). At a density of 1.09 plants per meter of row, cotton yields were reduced from 10 to 23% (17). Other studies indicate that sicklepod at a density of 7.7 plants per square meter reduced soybean yields from 19 to 35% (71). Under heavy sicklepod pressure, soybean yields have been reduced by 28% under irrigated conditions and by 31% under non-irrigated conditions (62). Sicklepod found in combination with johnsongrass [Sorghum halepense (L.) Pers.] reduced soybean yields 34% under irrigated conditions and 37% under non-irrigated conditions (62). Sicklepod is more competitive when located 15 to 30 cm from the row than directly in the row with the greatest yield reductions occurring under drier growing conditions (71). Yield reductions can occur in soybeans when sicklepod is allowed to compete for as little as four weeks (71). Sicklepod dry weight production is more highly correlated

with soybean yield than sicklepod density when the two species are grown together (71).

The objectives of this thesis were to determine 1) the present level of sicklepod infestation in Tennessee and the methods employed for its control, 2) the effects of selected herbicides and tillage on sicklepod control, 3) how sicklepod behaves in selected allelopathic interactions, and 4) how selected herbicides combinations effect sicklepod control.

CHAPTER II

LITERATURE REVIEW

A. Effects of Various Tillage Systems

Traditionally, tillage has been the major form of weed control in field crops (78). Before herbicides, economic returns from large-scale row crop production would not have been possible without the moldboard plow and disk to control weeds (60). Recently, a no-tillage cropping system has been made possible by the development of selective herbicides and advances in planter design (78). Some of the earliest reported no-tillage work was done in pasture renovation by Sprague in 1952 (64). Also in 1952, Barrons and Fitzgerald (12) reported growing corn, soybeans, and flax (Linum usitatissimum L.) in a clover (Trifolium spp.) sod killed with 2,4-D. In 1955, Porter (52) reported growing strawberries (Fragaria spp.) without soil cultivation. Studies were initiated in 1960 relating grain yields to various degrees of tillage (44).

Reduced tillage and no-tillage cropping systems have grown rapidly in popularity. In 1982, about 40 million ha of United States farmland were under a system of conservation tillage (36). While most major field crops are

adapted to a no-tillage cropping system, the majority of research has focused on corn, soybeans, wheat (Triticum aestivum L.), and grain sorghum (36). No-tillage is more difficult in vegetable and specialty crops because a narrower selection of pesticides is available and suitable planting equipment is not available (36).

There are several advantages to no-tillage that make it a desirable system of crop production. Tillage exacerbates wind and water erosion problems by deteriorating soil structure (28). No-tillage reduces water runoff and soil sedimentation and can considerably reduce erosion and prevent water contamination (31,51).

A second advantage of the no-tillage cropping system is a reduced energy requirement (50). Since fewer operations are performed in the field, the energy requirement for no-tillage production is about 7% smaller in corn and 18% smaller in soybeans (50). A no-tillage cropping system can save about 36.6 liters of diesel fuel per hectare of corn (50).

Another advantage of no-tillage is improved soil moisture due to increased water infiltration and decreased evaporation (35,50). The presence of a mulch serves to retard surface evaporation associated with conventional cropping systems (26,50). An additional benefit of the no-tillage mulch is its function as a weed control aid (21,26).

Water infiltration is increased because water channels are less disturbed in a no-tillage cropping system (50).

There are some disadvantages inherent to a no-tillage cropping system. No-tillage may intensify insect and plant disease problems (31,50). Soil temperatures have been reported 6 C lower at a depth of 2.5 cm in the spring in no-tillage when compared to conventional tillage (50). No-tillage requires the use of 30 to 50% more pesticides (31,50). Finally, to overcome these disadvantages, greater management ability is required by the producer (50).

A no-tillage cropping system influences the amount and behavior of soil nutrients. Shear and Moschler (58) reported a more rapid phosphorus uptake by corn in no-tillage. A no-tillage cropping system requires more nitrogen because higher soil moisture promotes denitrification (50). Nitrate leaching also occurs more rapidly due to decreased water evaporation in conjunction with undisturbed water channels remaining in the soil (50). Crop yields and weed responses to herbicides may differ under various cropping systems. Plant growth and corn yields have been shown to increase with decreasing amounts of tillage (34,72). Corn yields up to 39% higher have been obtained in no-tillage when compared to conventional tillage (34). Robinson et al. (54) showed a general trend toward increased weed control in no-tillage using several

herbicides on various weed species. Jimsonweed (Datura stramonium L.) control with herbicides was enhanced by a no-tillage cropping system (42).

Some work on sicklepod control in various cropping situations has been completed. Abrasion is an effective method of seed scarification for sicklepod (70). Under favorable environmental conditions, sicklepod seed present in the soil are scarified by tillage and subsequently germinate (59). Bridges and Walker (15) found that intensive cultivation could reduce the number of sicklepod seed remaining in the soil. When similar sicklepod populations were established in conventionally tilled and no-tillage soybeans, higher soybean yields were obtained under a no-tillage cropping system (9,49). Tripp and Banks (73) also measured a decrease in soil moisture in conventionally tilled soybeans due to the presence of sicklepod.

B. Herbicidal Control of Sicklepod in Soybeans

General Information

The control of sicklepod in soybeans is difficult because sicklepod is tolerant of many herbicides currently used in soybeans (22). Lack of adequate control measures enabled sicklepod to become the most troublesome weed in

soybeans in the southeastern United States (22).

Substantial research has been directed toward improved sicklepod control due to the severity of the problem.

Recently, several new herbicides have been introduced that may improve sicklepod control in soybeans. These herbicides, along with selected established herbicides, will be reviewed below. Full chemical names are given in Appendix A.

Alachlor

Alachlor is a soil-applied herbicide used to control annual grasses and some broadleaf weeds. Alachlor is a substituted amide used in soybeans, corn, peanuts, and seed-treated grain sorghum. It is absorbed by plant roots and is translocated primarily in the apoplast (7). The most notable visual symptom of alachlor activity is the inhibition of root elongation. While the mode of action of alachlor is not entirely understood, it is thought to interfere with nucleic acid and protein synthesis (7). Alachlor provides only partial control of large-seeded broadleaf weeds such as sicklepod.

Chlorimuron

Chlorimuron is a postemergence herbicide used in soybeans for broadleaf weed control. Chlorimuron may also

be soil-applied in combination with metribuzin or linuron. It belongs to the sulfonyleurea class of chemistry (18). Chlorimuron is absorbed by plant roots and foliage and is translocated in both the apoplast and symplast. Chlorimuron injures plants by inhibiting acetohydroxyacid synthase, which in turn inhibits the production of the essential amino acids valine, leucine, and isoleucine (4). Selectivity is attained by means of differential metabolism in tolerant and susceptible plant species. Chlorimuron has few recognizable plant injury symptoms. In susceptible species, growth is halted and death occurs slowly. Chlorimuron may shorten the internodes of soybean plants. Sickpod control from 83 to 91% has been observed with chlorimuron (46). Seed production can be prevented by chlorimuron applications on sickpod during early bloom (33). Soybean injury has occasionally been noted with this herbicide (46).

Imazaquin and Imazethapyr

Imazaquin and imazethapyr are herbicides used for the control of broadleaf weeds and some grasses in soybeans. They are members of the imidazolinone class of chemistry and may be applied preplant incorporated, preemergence, or postemergence. Both are absorbed by plant roots and foliage and translocated in the apoplast and symplast (3,6). Imazaquin and imazethapyr injure weeds by inhibiting an

enzyme leading to the production of the essential amino acids valine, leucine, and isoleucine (2,57). The selectivity of these herbicides is dependent upon differential metabolism in tolerant and susceptible species. While the visual symptoms associated with the imidazolinones are not pronounced, susceptible species tend to have necrotic apical meristems after emergence from treated soil. Postemergence applications can produce a purple color along the midrib of some species. Imazaquin and imazethapyr have been detected in soils of high (5.2%) organic matter content one year after application (40). In low (1.2%) organic matter soils, no herbicide residues could be detected four months after herbicide application (40). Following preemergence applications, neither herbicide moved more than 8 cm into the soil (40). Imazaquin has been shown to reduce sicklepod populations from 62 to 88% (46). Preemergence applications of imazaquin tend to hold sicklepod in the cotyledonary stage (48). Soybean injury has occasionally been found with imazaquin (46).

Metribuzin

Metribuzin is an asymmetrical triazine herbicide used in soybeans, wheat, sugarcane (Saccharum officinarum L.), and some vegetable crops. Metribuzin is soil-applied for the control of several broadleaf and grass weed species. It

is absorbed by plant roots and translocated in the apoplast. While the exact action of metribuzin is unknown, the triazines are strong inhibitors of photosynthesis (5,7). Selectivity is dependent upon differential metabolism in tolerant and susceptible species. Susceptible species exhibit foliar chlorosis followed by necrosis.

Currey et al. (22) evaluated 130 herbicide treatments for their activity on sicklepod in 1981. Metribuzin was found to be the single most effective herbicide against sicklepod. Metribuzin performance was enhanced when applied in combination with pendimethalin, trifluralin, or alachlor. Postemergence directed sprays of 2,4-DB or paraquat combined with metribuzin also gave acceptable results. Smith et al. (63) found that metribuzin alone or in combination with alachlor gave only early season sicklepod control. The addition of a postemergence-directed herbicide application to these treatments increased season-long control from 70 to 80% and reduced sicklepod seed yields.

C. Allelopathy

Until recently most plant interactions were explained in physical terms. The effect one plant species had on another was attributed to competition for such factors as light, water, and nutrients (37). However, careful

measurements tend to indicate that a plant species can gain a competitive advantage over another by means of allelopathy (37). The first recorded discussion of allelopathy was by de Candolle in 1832 (74) though the term was not coined until 1937 by Molisch (53). The word was derived from two Greek words meaning "mutual harm" but its definition has been repeatedly changed (53). Currently, a widely accepted definition is "the detrimental effects of higher plants of one species on the germination, growth, or development of plants of another species." (53).

Since the production of a secondary compound requires energy from the plant, it is logical to assume these compounds are purposeful and specialized (39). Several chemicals produced by plants have been shown to inhibit other species and influence plant populations (45). Allelopathic compounds may escape from plants through volatilization, exudation from roots, or during the decay of plant material (37). These compounds can give a plant species an adaptive advantage (76). When weed species are found to be allelopathic, more intensive management may be required to reduce their numbers in the field (53).

Several examples of allelopathy and the compounds involved have been identified in recent years. Quackgrass [Agropyron repens (L.) Beauv.] has been shown to inhibit the germination and root growth of soybeans (75). Exudates from

giant foxtail (Setaria faberi Herrm.) roots can inhibit corn growth (14). Rye (Secale cereale L.) residues reduce the emergence of lettuce (Lactuca spp.) by 58%, respectively (10). Extracts of purple nutsedge (Cyperus rotundus L.) can reduce the growth of barley (Hordeum vulgare L.) seedlings (27). Oats (Avena sativa L.) show reduced shoot growth in the presence of several chemicals thought to be allelopathic (60).

While allelopathic compounds released from weed species have the potential to reduce crop yields, not all allelopathic effects are harmful. In certain situations, allelopathy may aid in weed control. Wheat straw has been shown to have an allelopathic effect on sicklepod and could aid in its control (65).

CHAPTER III

A SURVEY OF SICKLEPOD DISTRIBUTION AND CONTROL IN TENNESSEE

A. Introduction

Sicklepod (Cassia obtusifolia L.), also referred to as coffeeweed, is a non-nodulating legume that can grow two m tall under conditions of good moisture and fertility (16). It is present in many crops but is particularly troublesome in soybeans (Glycine max L.), corn (Zea mays L.), peanuts (Arachis hypogaea L.), and grain sorghum [Sorghum bicolor (L.) Moench.] in the southern United States and is considered the most troublesome weed in row crops in Georgia, Florida, and Alabama (22,68). The spread of sicklepod into Tennessee has had a marked impact on row crop production within the state.

One reason for increased sicklepod infestations in soybeans over recent years is the tolerance of the weed to many herbicides used during this period (69). Tolerance to applied herbicides can effect shifts in a weed spectrum by selection for the tolerant weed species (8). Because the herbicides available for use in corn and pasture are more effective against sicklepod, it is more easily controlled in these crops (32). In soybeans, preemergence herbicides establish a height differential which gives soybeans a

competitive advantage over sicklepod. However, preemergence herbicides are generally insufficient to provide sicklepod control over the entire growing season (32). The addition of a postemergence-directed herbicide application has increased soybean yields over preemergence treatments applied alone (32).

Additional control problems stem from sicklepod's biological aspects. Sicklepod seed have impermeable seed coats that allow them to resist germination and remain viable in the soil for several years (20). Sicklepod seed can emerge from soil depths as great as 15 cm and in soils ranging in pH from 5.1 to 6.5 (70). Sicklepod can produce up to 8000 seeds on a single plant, thus it can become a serious problem within a relatively short period of time (25).

If sicklepod is to be adequately managed in Tennessee row crops, it is useful to ascertain its present level of infestation within the state. Other useful information includes the major crops in which sicklepod is found, and the management practices currently employed for its control. From this information we may better assess the severity of the sicklepod problem in Tennessee and the measures needed for its control.

The objectives of this survey were to measure the distribution and severity of sicklepod infestations within

the state and determine the techniques currently employed for sicklepod control.

B. Materials and Methods

A single page survey was mailed to the Extension Leader of each county in Tennessee on February 18, 1987. The responses obtained were used to ascertain the level of sicklepod infestation, the crops threatened by sicklepod, and the management practices used for sicklepod control. Responses were received from Extension Leaders in 90 of the 95 counties within the state. Statistics were performed on the survey results using Pearson product-moment correlations at the 95% probability level. A copy of the survey and cover letter are included in Appendix B.

C. Results and Discussion

Presence of Sicklepod

Sicklepod is reported in 91% of the counties responding to the survey. The majority of the counties without sicklepod infestations are located in the eastern-most portion of the state. All counties in the western half of Tennessee have sicklepod infestations.

Threat to Crops

Among the counties reporting the presence of sicklepod, 65% indicate that sicklepod currently poses a threat to crop yields (Figure 1). In counties where sicklepod is a threat to crop yields, soybeans is the most commonly threatened crop. Eighty-five percent of these counties indicate sicklepod is a threat to soybean yields. Corn (21%), grain sorghum (15%), and cotton (Gossypium hirsutum L.) (4%) are the other most frequently listed crops. Sicklepod is also reported as being a threat to alfalfa (Medicago sativa L.), tobacco (Nicotiana tabacum L.), and nursery stock in isolated cases.

Area Infested With Sicklepod

The total area infested with sicklepod is difficult to determine. Only 68% of the Extension Leaders responding felt they could accurately estimate the area infested within the county. The state total for those giving estimates is approximately 100,000 ha. The actual total for the state is probably well over 120,000 ha.

The greatest total area of sicklepod infested cropland is found in West Tennessee (Mississippi Delta, Loess, and Coastal Plain). There are 70,000 ha reported to be infested in this region. Middle Tennessee (Highland Rim and Central Basin) reports 20,000 ha to be sicklepod infested while East

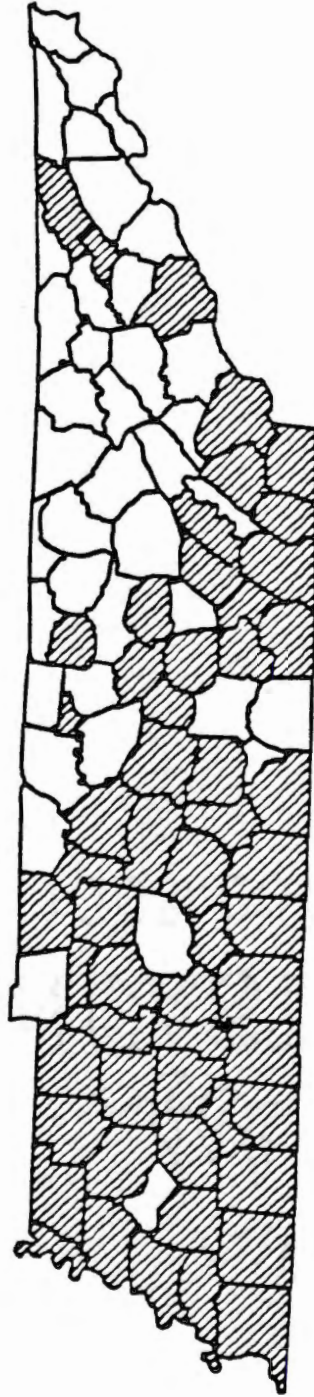


Figure 1. Counties in Tennessee reporting sicklepod as a threat to crop yields.

Tennessee reports only 8,000 infested ha (Cumberland Plateau, Appalachian Ridges and Valleys, and Smoky Mountains).

Sicklepod Trends

Each Extension Leader was asked if sicklepod infestations had increased, decreased, or remained about the same over the last five years. Of the responding counties, 68% indicate sicklepod infestations have increased. Twenty-eight percent indicate that sicklepod populations have remained constant while only 4% show a decrease in sicklepod. These statistics are an indication of sicklepod's ability to invade uninfested areas and the difficulty associated with its control.

West Tennessee has the greatest increase in sicklepod infested areas. With the exception of Lauderdale, Crockett, and Wayne counties, all the counties in this region report an increase in sicklepod infestations. The increases in Middle and East Tennessee are not as dramatic but several counties in both areas show increased sicklepod populations.

Sicklepod Relative to Other Weeds

When evaluating the severity of the sicklepod problem in Tennessee, it is useful to compare sicklepod to other

weeds within the state. Each respondent was asked to indicate whether sicklepod was more or less of a problem than several common weeds. More than half the survey respondents indicated that sicklepod is more troublesome than trumpetcreeper, velvetleaf, or foxtail (Table 1). Sicklepod also proves to be quite troublesome when compared to such weeds as prickly sida, fall panicum, common lambsquarters, and jimsonweed. Sicklepod does not yet pose the problem presented by some of Tennessee's most damaging agronomic weeds such as common ragweed, pigweed, annual morningglory, cocklebur, and johnsongrass.

Control Practices

For survey purposes, sicklepod control was partitioned into two areas. First, each Extension Leader was asked to list the herbicides most frequently used to control sicklepod in the county. Secondly, they were asked to list the other management practices that were currently being employed for sicklepod control by farmers within the county.

A total of 32 individual herbicides and herbicide combinations are reportedly used for sicklepod control. The most common of these are listed in Table 2. Imazaquin is the most frequently listed compound. Imazaquin is generally applied preplant incorporated or preemergence, followed by a postemergence application for control of sicklepod.

Table 1. Selected weeds compared to sicklepod for severity as plant pest.

Common Name	Scientific Name	Counties Reporting Sicklepod to be more Troublesome
		(%)
Trumpetcreeper	<u>Campsis radicans</u> (L.) Seem.	61
Velvetleaf	<u>Abutilon theophrasti</u> Medik.	58
Foxtail	<u>Setaria</u> spp.	53
Prickly sida	<u>Sida spinosa</u> L.	49
Fall panicum	<u>Panicum dichotomiflorum</u> Michx.	45
Common lambsquarters	<u>Chenopodium album</u> L.	45
Jimsonweed	<u>Datura stramonium</u> L.	42
Giant ragweed	<u>Ambrosia trifida</u> L.	28
Pigweed	<u>Amaranthus</u> spp.	27
Annual morningglory	<u>Ipomoea</u> spp.	18
Cocklebur	<u>Xanthium strumarium</u> L.	12
Johnsongrass	<u>Sorghum halepense</u> (L.) Pers.	4

Table 2. The most frequently used herbicides and the percentage of counties reporting the use of each.

Common Name	Trade Name(s)*	Counties Reporting Individual + Individual Appl.	Individual + Combinations
		(%)	(%)
Soybean Herbicides			
Chlorimuron	Classic	22	22
Chlorimuron + Metribuzin	Canopy	16	16
Glyphosate	Roundup	6	6
Imazaquin	Scepter	41	41
Metolachlor	Dual	2	7
Metribuzin	Sencor, Lexone	32	38
2,4-DB	Several	7	8
Corn Herbicides			
Alachlor	Lasso	7	18
Atrazine	AAtrex, Atrazine	32	45
Dicamba	Banvel	2	2
2,4-D	Several	3	3
Cotton Herbicides			
Fluometuron	Cotoran	4	4
MSMA	Several	2	2

*The use of a product tradename does not constitute an endorsement by the authors or by the University of Tennessee Agriculture Experiment Station to the exclusion of other products that may also be suitable.

Metribuzin, applied alone or in combination with alachlor or metolachlor, is another frequently listed compound for control of sicklepod in soybeans. Chlorimuron is generally used preplant incorporated or preemergence in combination with metribuzin, and postemergence alone. Glyphosate and 2,4-DB are occasionally used in soybeans as are several other less frequently mentioned herbicides.

Atrazine, applied alone or in combination with EPTC, butylate, alachlor, or simazine, is the most frequently used herbicide for sicklepod control in corn. Atrazine is applied preplant incorporated, preemergence, or early postemergence for effective sicklepod control. Dicamba and 2,4-D are also mentioned as sicklepod herbicides but are used substantially less than atrazine.

Only two herbicides, fluometuron and MSMA, are used for sicklepod control in cotton. Neither of these herbicides is used in a large number of counties which reflects the relatively small number of counties producing cotton.

Other Management Practices

Each Extension Leader was asked to list the management practices other than herbicide applications that farmers were using to control sicklepod. Crop rotation is the most frequently reported management practice. Of the counties responding, 47% indicate that they are currently employing

crop rotation to deal with sicklepod. The most frequently used system is to rotate soybeans with corn. In corn, atrazine provides control superior to the soybean herbicides that are currently available. The most popular tillage system for sicklepod control is conventional tillage. Sixteen percent of the reports received indicate conventional tillage is used as a sicklepod control method compared to 2% that use a no-tillage cropping system.

Sicklepod and Environmental Factors

An attempt was made to determine the relationship of the presence and severity of sicklepod infestations to several environmental and cultural factors. The factors considered include the number of ha of soybeans, annual rainfall, average temperature, date of last frost in spring and first frost in fall, and length of growing season. While there are no strong correlations obtained using these factors, the relative strength of the correlations may provide information on sicklepod's preferred habitat. The number of ha of sicklepod per county is best correlated with the date of the last frost in spring ($r=-.47$). This inverse correlation indicates that a later spring frost may be somewhat detrimental to sicklepod populations. The number of infested ha is correlated to a lesser extent with length of growing season ($r=.39$), soybean area ($r=.37$), and

temperature ($r=.30$). Sicklepod infested area is not correlated with the date of the first frost in the fall ($r=.25$) or annual rainfall ($r=.15$).

The relationship of sicklepod severity in comparison to other weeds and the above environmental and cultural factors was also assessed. Average temperature is found to be the most highly correlated ($r=.39$) with sicklepod severity. Sicklepod severity is also inversely correlated ($r=-.36$) with the date of the last frost in spring. Sicklepod severity is found to be correlated to a lesser extent with length of growing season ($r=.30$) and annual rainfall ($r=.28$). Soybean area ($r=.15$) and the date of the first frost in fall ($r=.15$) are not correlated with sicklepod severity.

D. Summary

Sicklepod is reported to be present in many counties across the state of Tennessee. While the distribution and severity of the weed varies from region to region, heavy infestations can be found in many counties of West Tennessee. Sicklepod is present on over 100,000 ha of cropland and these infestations threaten crop yields in such agronomically important crops as soybeans, corn, grain sorghum, and cotton. Overall, the problem appears to be

growing. Relatively few counties have been able to prevent sicklepod spread over the past five years.

On a state-wide basis, sicklepod does not yet pose a problem equal to that of some of Tennessee's more pernicious weeds. Johnsongrass, cocklebur, and morningglory still present a substantially greater problem. The rapid adoption of the newer herbicides available for sicklepod control may be reason for some optimism in Tennessee. However, a system of integrated weed management will likely be needed to reduce sicklepod populations to more acceptable levels. The selection of an appropriate tillage system, the use of crop rotation, and the application of effective herbicides are all valuable tools for controlling sicklepod infestations.

CHAPTER IV

THE CONTROL OF SICKLEPOD WITH HERBICIDES IN CONVENTIONAL AND NO-TILLAGE CROPPING SYSTEMS

A. Introduction

Sicklepod (Cassia obtusifolia L.) is one of the largest weed control problems in the southern United States. While sicklepod is present in several agronomic crops, it is particularly difficult to control in soybeans (Glycine max L.) (47,59). One reason for the increase in sicklepod infestations over recent years is sicklepod's tolerance to many of the herbicides used during that period (69). Tolerance to applied herbicides affect shifts in a weed spectrum by selection for a tolerant weed species (8). Sicklepod is generally not controlled in soybeans by a single preemergence herbicide application (32). Preemergence herbicides establish a height differential which gives soybeans a competitive advantage over sicklepod. However, preemergence herbicides are generally insufficient for control over an entire growing season (32). A combination of preemergence and postemergence herbicide applications may be required to protect soybean yields. Recently, several herbicides have been introduced that may

provide sicklepod control superior to that previously available.

Tillage is an additional factor which may influence the control of sicklepod. Plant growth and herbicide response have been shown to differ with various degrees of tillage (34,54,72). Under favorable environmental conditions, sicklepod seed present in the soil are scarified by tillage and subsequently germinate (59). Abrasion is an effective method of seed scarification for sicklepod (70). Bridges and Walker (15) found that intensive cultivation could reduce the number of sicklepod seed remaining in the soil. When similar sicklepod populations were established in conventionally tilled and no-tillage soybeans, higher soybean yields were obtained under a no-tillage cropping system (9,49).

The first objective of this study was to evaluate several herbicides for their effectiveness against sicklepod. The second objective was to evaluate the effects of conventional and no-tillage cropping systems on sicklepod growth and herbicide response.

B. Materials and Methods

Field studies were conducted in 1986 and 1987 at the Middle TN Exp. Sta. near Spring Hill, TN and on leased land

near Vonore, TN to determine the effects of several herbicide treatments and tillage on sicklepod. The soil type at the Spring Hill location is a Maury silt loam (Typic Paleudalf; fine, mixed, mesic) with an organic matter content of 1.5% and a pH of 6.5. The soil type at the Vonore location is a Leadvale silt loam (Typic Fragiudult; fine-silty, siliceous, thermic) with an organic matter content of 1.7% and a pH of 5.5. Soil samples were taken at a 0 to 8 cm depth. Plots were established on existing sicklepod infestations at both locations.

Spring oats (Avena sativa L.) were planted at each location and killed with paraquat at 0.7 kg ai/ha plus 0.25% (v/v) nonionic surfactant. Spot treatment of grass weeds was accomplished with a solution of fluazifop-P at 0.24% ai (v/v) or sethoxydim at 0.8% ai (v/v). Crop oil concentrate was included with either herbicide at 2% (v/v). Horseweed [Conyza canadensis (L.) Cronq.] was controlled by wiping with glyphosate at 8.2% ai (v/v). 'Asgrow 5474' soybeans, a determinant, medium-maturing cultivar, were planted on June 12, 1986 and June 10, 1987 at Vonore and June 18, 1986 and June 2, 1987 at the Spring Hill location. At Vonore in 1986, conventional tillage consisted of moldboard plowing and disking. Soybeans were planted in eight row plots with a row spacing of 51 cm and 9.1 m in length. Conventional tillage at all other locations and

years was accomplished with a PTO-driven tiller. The soil was tilled to a depth of 10 cm. Soybeans were planted in six row plots with a row spacing of 61 cm and 9.1 m in length.

In 1986, herbicide treatments included alachlor plus metribuzin (2.2 + 0.42 kg ai/ha) applied preemergence, and the following sequential (preemergence followed by postemergence) applications: metribuzin (0.42 kg ai/ha) followed by chlorimuron (0.14 kg ai/ha), chlorimuron plus metribuzin (1 to 6 ratio, w/w, 0.42 kg ai/ha) followed by chlorimuron (0.14 kg ai/ha), imazaquin (0.14 kg ai/ha) followed by imazaquin (0.14 kg ai/ha), and imazethapyr (0.14 kg ai/ha) followed by imazethapyr (0.14 kg ai/ha). In 1987, the postemergence rate of chlorimuron was adjusted to 0.011 kg ai/ha. Weedy and weed free checks were included. Preemergence herbicides were applied immediately after soybean planting. Postemergence herbicides were applied 30 days after planting with most sicklepod plants in the cotyledon to four leaf stage. Herbicide applications were made using a CO₂ backpack sprayer equipped with a four nozzle boom having nozzle spacings of 46 cm. A water carrier volume of 224 L/ha and a pressure of 207 kPa were used for all herbicide treatments applied in 1986. A water carrier volume of 327 L/ha and a pressure of 241 kPa were

used in 1987. A nonionic surfactant at 0.5% (v/v) was added to all postemergence applications.

Treatment effects were measured using stand counts, visual ratings, and height measurements. Stand counts were taken by sampling each plot three times on each recorded date and converting the data to sicklepod number/m². Stand counts were taken 30 days after preemergence and 12 days after postemergence herbicide applications. Percent control was determined by visually rating each plot on a 0 to 100% control basis. The weedy check in each replication was defined as 0% control and compared to each herbicide treatment within the same replication to determine the amount of control obtained. Plots were rated 30 days after preemergence and 12 and 38 days after postemergence applications were made. Sicklepod heights were taken by assigning each plot an estimated average height in cm. Sicklepod height measurements were taken 12 and 38 days after the application of postemergence herbicides. Soybean injury was determined by comparing the soybeans in each herbicide treatment to the untreated check within the same replication. The experiment utilized a split-plot arrangement of a randomized complete block design with six replications. Conventional and no-tillage cropping systems were used as main plots and herbicide treatments as subplots. Data were subjected to an analysis of variance

and means were separated by Duncan's multiple range test at the 5% level of probability. Data from different locations were not combined due to differences in sicklepod pressure.

In 1986, the Spring Hill location received 0.25 and 2.62 cm of rainfall 11 and 14 days, respectively, following application of preemergence herbicides. In 1987, 0.51 and 0.43 cm of rainfall were received 11 and 14 days, respectively, following preemergence applications. Precise rainfall data was not available at the Vonore location. However, no rainfall occurred at Vonore in 1986, and only trace amounts in 1987, within 14 days of preemergence herbicide applications. No soybean yield data could be taken in 1986 due to drought conditions.

C. Results and Discussion

Herbicide Effects

Sicklepod Number

The weedy checks consistently produced more sicklepod plants than any of the herbicide treated plots (Table 3). Only the weedy check in one location and year contained significantly more sicklepod than all preemergence herbicide treatments when counts were taken 30 days after herbicide applications. The addition of a postemergence herbicide

Table 3. Effects of selected herbicides on sicklepod number.^a

Herbicide Treatments	Vonore		Spring Hill	
	1986	1987	1986	1987
30 days after preemergence applications				
Alachlor + Metribuzin	58 a	70 b	6 b	24 a
Metribuzin	70 a	113 ab	9 b	34 a
Chlorimuron + Metribuzin	58 a	95 b	8 b	38 a
Imazaquin	71 a	113 ab	9 b	47 a
Imazethapyr	66 a	74 b	8 b	45 a
Weedy Check	106 a	140 a	19 a	69 a
12 days after postemergence applications				
Alachlor + Metribuzin, pre	57 b	63 b	6 b	38 a
Metribuzin, pre	49 b	58 b	6 b	47 a
Chlorimuron, post				
Chlorimuron + Metribuzin, pre	45 b	53 b	5 b	48 a
Chlorimuron, post				
Imazaquin, pre	45 b	29 c	5 b	38 a
Imazaquin, post				
Imazethapyr, pre	34 b	23 c	4 b	52 a
Imazethapyr, post				
Weedy Check	102 a	102 a	17 a	66 a

^aMeans within a column relative to the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

application improved sicklepod control with three of the four locations and years having fewer sicklepod plants in all treated plots when compared to the weedy checks. However, the alachlor plus metribuzin treatment also reduced sicklepod below the weedy check at the same rating date. Few differences among herbicide treatments were measured by sicklepod stand counts and no consistent pattern could be detected.

Sicklepod Height

With the exception of one location and year, the weedy checks contained the tallest sicklepod plants (Table 4). Sicklepod treated with only alachlor plus metribuzin applied preemergence were taller than those receiving both a preemergence and postemergence herbicide application. Of the remaining treatments, sicklepod plants receiving a high rate of chlorimuron postemergence in 1986 were shorter than those receiving other herbicide treatments. This difference was diminished when the chlorimuron rate was lowered in 1987. With the exception of the alachlor plus metribuzin standard, all herbicide treatments performed similarly in 1987.

Table 4. Effects of selected herbicides on sicklepod height.^a

Herbicide Treatments	Vonore		Spring Hill	
	1986	1987	1986	1987
----- (cm) -----				
12 days after postemergence applications				
Alachlor + Metribuzin, pre	18 b	17 b	15 b	24 b
Metribuzin, pre	5 cd	8 c	5 d	10 d
Chlorimuron, post				
Chlorimuron + Metribuzin, pre	4 d	6 c	4 d	9 d
Chlorimuron, post				
Imazaquin, pre	6 cd	7 c	9 c	15 cd
Imazaquin, post				
Imazethapyr, pre	7 c	7 c	12 b	17 c
Imazethapyr, post				
Weedy Check	23 a	22 a	22 a	40 a
38 days after postemergence applications				
Alachlor + Metribuzin, pre	73 a	28 b	57 b	75 b
Metribuzin, pre	8 c	17 c	20 d	62 c
Chlorimuron, post				
Chlorimuron + Metribuzin, pre	9 c	17 c	16 d	54 c
Chlorimuron, post				
Imazaquin, pre	39 b	19 c	51 c	61 c
Imazaquin, post				
Imazethapyr, pre	40 b	18 c	56 b	63 c
Imazethapyr, post				
Weedy Checks	71 a	36 a	66 a	92 a

^aMeans within a column relative to the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Visual Ratings

Preemergence sicklepod control was variable and generally unacceptable (Table 5). Greater sicklepod control was obtained in 1987 over the previous year probably due to slightly improved moisture conditions. The highest level of control with preemergence herbicide applications was obtained with imazaquin and imazethapyr in 1987 at Vonore but the results were not duplicated at any other location or year. Sicklepod control was enhanced by the addition of a postemergence herbicide application. All plots receiving a postemergence treatment showed increased sicklepod control while control in the alachlor plus metribuzin treated plots declined. The chlorimuron plus metribuzin followed by chlorimuron, imazaquin followed by imazaquin, and imazethapyr followed by imazethapyr treated plots gave 80% control or better 12 days after postemergence herbicide applications at Vonore in 1986. Again, this level of control could not be duplicated in any other location or year. A general decrease in sicklepod control was noted 38 days after postemergence herbicide applications. Plots receiving a postemergence application of chlorimuron in 1986 gave noticeably better control than the other herbicide treatments due to the high application rate. At the lower rate used in 1987, this difference was not evident. In summary, adequate sicklepod control was not obtained

Table 5. Effects of selected herbicides on sicklepod control.^a

Herbicide Treatments	Vonore		Spring Hill	
	1986	1987	1986	1987
------(%)-----				
30 days after preemergence application				
Alachlor + Metribuzin	39 bc	67 b	43 b	71 a
Metribuzin	37 c	58 c	43 b	57 ab
Chlorimuron + Metribuzin	44 abc	75 ab	51 a	57 ab
Imazaquin	49 a	83 a	39 b	43 b
Imazethapyr	48 ab	82 a	38 b	45 b
12 days after postemergence application				
Alachlor + Metribuzin, pre	14 b	54 c	35 c	52 a
Metribuzin, pre	53 a	69 b	53 ab	68 a
Chlorimuron, post				
Chlorimuron + Metribuzin, pre	58 a	80 a	56 a	71 a
Chlorimuron, post				
Imazaquin, pre	58 a	83 a	53 ab	68 a
Imazaquin, post				
Imazethapyr, pre	58 a	85 a	47 b	61 a
38 days after postemergence application				
Alachlor + Metribuzin, pre	4 c	46 c	21 c	45 a
Metribuzin, pre	80 a	60 b	58 a	58 a
Chlorimuron, post				
Chlorimuron + Metribuzin, pre	81 a	75 a	61 a	63 a
Chlorimuron, post				
Imazaquin, pre	54 b	75 a	30 b	54 a
Imazaquin, post				
Imazethapyr, pre	54 b	82 a	34 b	46 a
Imazethapyr, post				

^aMeans within a column relative to the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

consistently with any of the treatments. Inadequate control must be partially attributed to the low amounts of rainfall received during the testing period.

Tillage Effects

Sicklepod Number

At 30 days after preemergence applications, more sicklepod was found in the conventionally tilled than the no-tillage cropping systems at three of the four locations and years (Table 6). The similarity of sicklepod densities between tillage systems at Spring Hill in 1987 may be partially attributed to the relatively poor mulch achieved in the no-tillage cropping system that year. The trends expressed 30 days after preemergence herbicide applications remained intact after the addition of a postemergence herbicide application. The differences in sicklepod number between tillage systems did tend to narrow after the application of a postemergence herbicide.

Sicklepod Height

Sicklepod was found to be taller within the no-tillage cropping system in all years except at Spring Hill in 1986 (Table 7). Improved moisture conditions in the no-tillage cropping system may explain this phenomenon.

Table 6. Effects of tillage on sicklepod number.^a

Tillage System	Vonore		Spring Hill	
	1986	1987	1986	1987
----- (plants/m ²) -----				
30 days after preemergence applications				
Conventional	101 a	115 a	13 a	43 a
No-tillage	42 b	87 b	6 b	43 a
12 days after postemergence applications				
Conventional	69 a	68 a	9 a	48 a
No-tillage	42 b	41 b	5 b	49 a

^aMeans within a column relative to the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Table 7. Effects of tillage on sicklepod height.^a

Tillage System	Vonore		Spring Hill	
	1986	1987	1986	1987
----- (cm) -----				
12 days after postemergence applications				
Conventional	9 b	10 b	11 a	15 b
No-tillage	12 a	12 a	10 a	24 a
38 days after postemergence applications				
Conventional	38 b	20 b	44 a	65 b
No-tillage	42 a	25 a	45 a	70 a

^aMeans within a column relative to the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Visual Ratings

Strong location effects for sicklepod control were expressed between tillage systems (Table 8). Superior sicklepod control was obtained with a no-tillage cropping system in Vonore. The Spring Hill location generally gave better sicklepod control within the conventionally tilled cropping system. These trends were established after the application of preemergence herbicides and remained intact with the addition of postemergence herbicide applications. Location effects may be partially explained by pH differences between locations. The lower pH at Vonore (5.5) may have increased the availability of some herbicides when compared to the pH at Spring Hill (6.5). In addition, the generally low rainfall at Vonore may have magnified the soil moisture differences between cropping systems. Some combination of these location differences can partially explain the differential sicklepod control obtained between cropping systems at different locations.

Soybean Injury

Soybean injury was observed and quantified at Spring Hill in 1987 (Table 9). Soybean injury symptoms included marked reduction in soybean stand and height apparently caused by several herbicides applied preemergence. Soybeans under a conventionally tilled cropping system were largely

Table 8. Effects of tillage on sicklepod control.^a

Tillage System	Monroe Co.		Middle TN	
	1986	1987	1986	1987
------(%)-----				
30 days after preemergence applications				
Conventional	40 b	71 a	47 a	51 a
No-tillage	47 a	75 a	39 b	58 a
12 days after postemergence applications				
Conventional	43 b	72 b	59 a	68 a
No-tillage	53 a	77 a	39 b	59 a
38 days after postemergence applications				
Conventional	52 b	66 a	45 a	66 a
No-tillage	58 a	68 a	37 b	40 b

^aMeans within a column relative to the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Table 9. Soybean injury by herbicides at Spring Hill in 1987.^a

Herbicide Treatment	12 days after postemergence treatments		38 days after postemergence treatments	
	Till	No-till	Till	No-till
	------(%)-----			
Alachlor + Metribuzin, pre	0 a	0 b	0 a	0 a
Metribuzin, pre	0 a	21 ab	0 a	13 a
Chlorimuron, post				
Chlorimuron + Metribuzin, pre	0 a	25 ab	0 a	13 a
Chlorimuron, post				
Imazaquin, pre	0 a	25 ab	0 a	15 a
Imazaquin, post				
Imazethapyr, pre	8 a	31 a	5 a	5 a
Imazethapyr, post				
Weedy Check	0 a	0 b	0 a	0 a
Weed Free Check	0 a	0 b	0 a	0 a

^aMeans within a column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

unaffected. With the exception of the alachlor plus metribuzin preemergence treatments, all herbicide treatments showed crop injury 12 days after postemergence applications under a no-tillage cropping system. While average crop injury for these treatments ranged from 21 to 31%, several individual plots contained injury of 60% or above. By 38 days after postemergence herbicide applications, soybeans overcame much of the initial injury. Apparent soybean injury also occurred in 1987 at Vonore. This injury could not be quantified due to variable soybean emergence within replications.

CHAPTER V

ALLELOPATHIC INTERACTIONS INVOLVING SICKLEPOD

A. Introduction

Until recently, most plant interactions were explained in physical terms. The effect one plant species has on another was attributed to competition for such factors as light, water, and nutrients (37). However, careful measurements indicate that a plant species can gain a competitive advantage over another by means of allelopathy (37). Allelopathy may be defined as "the detrimental effects of higher plants of one species on the germination, growth, or development of plants of another species" (53).

Since the production of a secondary compound requires energy from the plant, it is logical to assume these compounds are purposeful and specialized (39). Several chemicals produced by plants inhibit other species and influence plant populations (45). Allelopathic compounds escape from plants through volatilization, exudation from roots, or during the decay of plant material (37). These compounds can give a plant species an adaptive advantage (76).

While allelopathic compounds released from weed species have the potential to reduce crop yields, not all allelopathic effects are harmful. In certain situations, allelopathy may aid in weed control. Wheat (Triticum aestivum L.) straw has been shown to have an allelopathic effect on sicklepod (Cassia obtusifolia L.) and could aid in its control in the field (65).

The objectives of these experiments were 1) to determine if spring oats (Avena sativa L.) exhibit allelopathic effects on sicklepod, 2) to determine if sicklepod exhibits allelopathic effects on soybeans (Glycine max L.), 3) and to examine different routes by which allelopathic compounds may be transmitted.

B. Materials and Methods

Studies were conducted in 1987 at the greenhouse facilities on the University of Tennessee campus in Knoxville. Experiments were conducted in soil with a pH of 5.5 and an organic matter content from 1.4 to 2.3% or on sterilized sand. 'Ogle White' spring oats, 'Asgrow 5474' soybeans, and sicklepod seed harvested in Loudon Co., TN were used in all experiments. Sicklepod seed were scarified for 18 min in 36 N sulfuric acid prior to use. Experiments were conducted in a randomized complete block design with

four or eight replications and repeated except where noted. Data were subjected to an analysis of variance and means were separated by Duncan's multiple range test at the 5% level of probability. Regression analysis for linear response was also performed. No supplemental light was used and plants were watered as needed.

Sicklepod Following Spring Oats

Spring oat seed were planted in 425 g of soil in a 0.53 L plastic pot and allowed to grow for 36 days. Spring oat densities of 0, 5, 10, 20, and 40 seed/pot were used. The above-ground portions of all spring oats were then removed and sicklepod seed were planted at a rate of 25 seed/pot. The sicklepod seed were allowed to grow for 27 days, after which the above-ground portions were harvested, dried, and weighed.

Spring Oat Mulch on Sicklepod

Spring oats were grown in flats for a period of 48 days. The above-ground portion of the spring oats were then harvested and divided into treatments of 0, 1, 2, 4, and 8 g of fresh plant material. These treatments were placed in 0.53 L pots containing 25 sicklepod seed planted in 425 g of soil. The sicklepod seed were allowed to grow for 30 days.

The above-ground portions of the sicklepod plants were then harvested, dried, and weighed.

Spring Oat Residues on Sicklepod

Spring oats were planted in 0.3 L styrofoam cups containing 345 g of sterilized sand. The cups were placed inside 0.53 L plastic pots and watered by filling the pots and allowing water to enter through holes near the bottom of the cups. Spring oats were planted at densities of 0, 5, 10, and 20 seed/pot and fertilized with 30 ml of modified Hoagland's solution (66). The spring oats were allowed to grow for 24 days. The entire spring oat plants were then removed from the sand and 10 sicklepod seed/cup were planted. An additional 30 ml of modified Hoagland's solution was added after sicklepod planting. The sicklepod plants were harvested after 28 days, then measured, dried, and weighed.

Spring Oat Foliage on Sicklepod

Spring oats were grown in flats for 50 days and then harvested at the soil surface, dried, and finely ground. The ground plant material was then mixed with water at rates of 0, 4, 8, 16, and 32 g/L. The mixtures were applied at the rate of 100 ml/pot to 25 sicklepod plants grown for 21 days in 400 g of soil in 0.53 L pots. The sicklepod plants

were allowed to grow for an additional 29 days, dried, and weighed.

Sicklepod Extracts on Soybeans

Sicklepod was grown on flats and removed intact after 48 days. A mixture composed of 170 g of fresh sicklepod and 1300 ml of water was prepared in a 'Waring' blender and strained through cheese cloth. The sicklepod extract was then added to 0.53 L plastic pots with 10 soybean seed planted in 400 g of soil at volumes of 0, 20, 40, and 80 ml/pot. The above-ground portions of the soybeans were harvested after 28 days.

Sicklepod Residues on Soybeans

Sicklepod was planted in 0.3 L styrofoam cups containing 345 g of sterilized sand. The cups were placed inside 0.53 L plastic pots and watered by filling the pots and allowing water to enter through holes near the bottom of the cups. Sicklepod was planted at densities of 0, 5, 10, and 20 seed/pot and fertilized with 30 ml of modified Hoagland's solution (65). The sicklepod plants were allowed to grow for 22 days. The entire sicklepod plants were then removed from the sand and 5 soybean seed/cup were planted. An additional 30 ml of modified Hoagland's solution was

added after soybean planting. The soybeans were harvested after 25 days.

Soybeans Following Sicklepod

Sicklepod was planted in 425 g of soil in a 0.53 L plastic pot and allowed to grow for 36 days. Sicklepod densities of 0, 5, 10, 20, and 40 seed/pot were used. The above-ground portions of all sicklepod plants were then removed and soybean seed were planted at a rate of 5 seed/pot. The soybeans were allowed to grow for 13 days, after which the above-ground portions were harvested. Only one trial of this experiment was completed.

C. Results and Discussion

Sicklepod Following Spring Oats

The presence of spring oats in the soil before the planting of sicklepod seed significantly reduced the amount of sicklepod dry matter produced in the first trial of the experiment (Table 10). All pots that had contained spring oats produced less sicklepod biomass than the controls. The second trial of the experiment contained substantial variability and trends expressed in the first trial were not readily apparent. Regression analysis for linear response

Table 10. Dry weight of sicklepod following spring oats in soil.^a

Number of Spring Oats/Pot	Sicklepod Dry Weight	
	Trial 1	Trial 2
	----- (g) -----	
0	0.90 a	0.81 a
5	0.81 b	0.72 a
10	0.67 c	0.69 a
20	0.67 c	0.78 a
40	0.70 c	0.81 a

^aMeans within a column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

produced values of $r=.64$ and $r=.39$ for the first and second trials, respectively.

Spring Oat Mulch on Sicklepod

The two trials of this experiment were combined into one data set (Table 11). The data indicates a general trend toward reduced sicklepod dry weights with increasing amounts of spring oat mulch. A significant difference was expressed between the high and low treatments. Regression analysis gave a value of $r=.91$ indicating a generally linear response to the amount of mulch applied. It is not known how much of the decrease should be attributed to allelopathy and how much should be attributed to the role of spring oats as a physical barrier to sicklepod growth.

Spring Oat Residues on Sicklepod

Sicklepod plants grown in cups once occupied by spring oats tended to have shorter shoot lengths than the controls (Figure 2). Values obtained from sicklepod plants following spring oats were up to 12% less than the controls although the differences were not statistically significant. Increasing spring oat populations did, however, produce a linear decrease in sicklepod shoot length ($r=.94$). Total dry weight of sicklepod plants was also decreased where spring oats had been grown prior to sicklepod planting

Table 11. Effects of a spring oat mulch on sicklepod.^a

Fresh Weight of Spring Oats	Dry Weight of Sicklepod Harvested
(g)	(g)
0	0.29 a
1	0.31 a
2	0.23 ab
4	0.22 ab
8	0.17 b

^aMeans within a column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

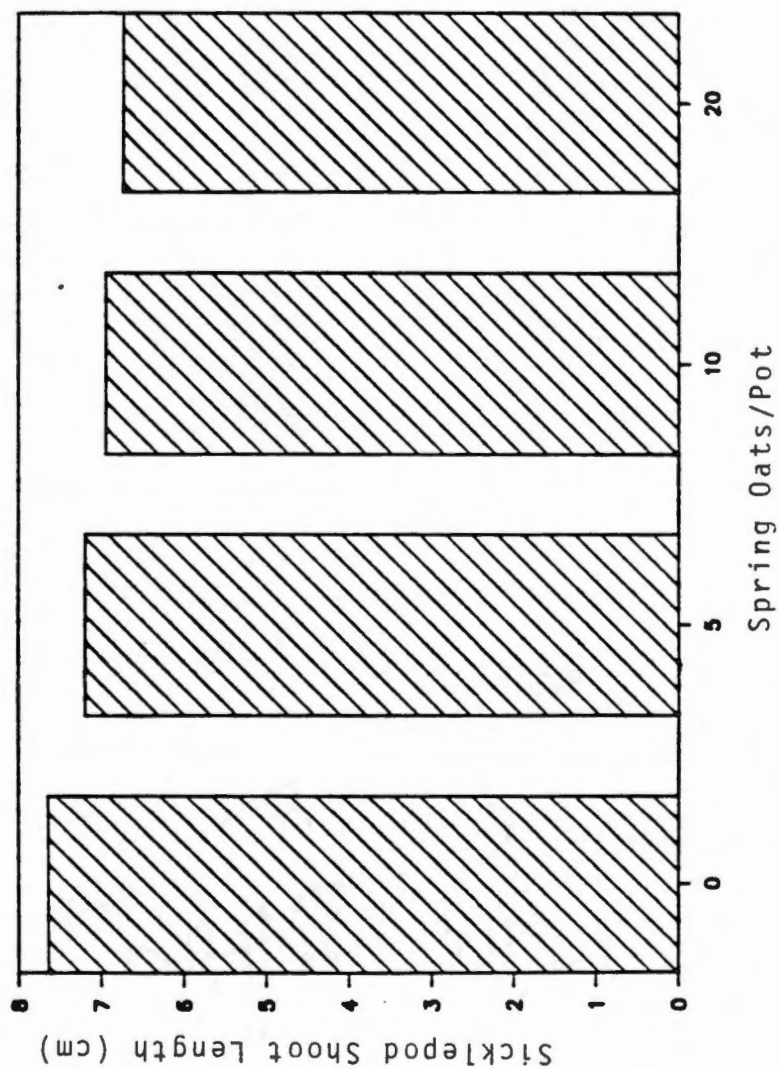


Figure 2. Effects of spring oat residues on sicklepod shoot length.

(Figure 3). Shoot dry weights were approximately equal among the four treatments, while root dry weights were up to 33% greater for the controls. The total dry weight of the controls was up to 15% greater than the other treatments. Regression analysis for linear response of total sicklepod dry weight gave a value of $r=.72$.

Spring Oat Foliage on Sicklepod

Results from both trials of the experiment indicate that the application of ground spring oats to 21-day-old sicklepod had no effect on sicklepod dry matter production.

Sicklepod Extracts on Soybeans

Soybean dry weights of the controls were greater than those treated with the sicklepod extract (Table 12). The high rate of sicklepod extract reduced soybean dry weight significantly when compared to the other treatments. Response of soybean dry weight to sicklepod extracts was linear with regression analysis showing a value of $r=.82$. Soybean shoot lengths for the control were also greater than those treated with sicklepod extract, but statistical differences were not obtained. Response of soybean shoot length was also linear with a value of $r=.81$.

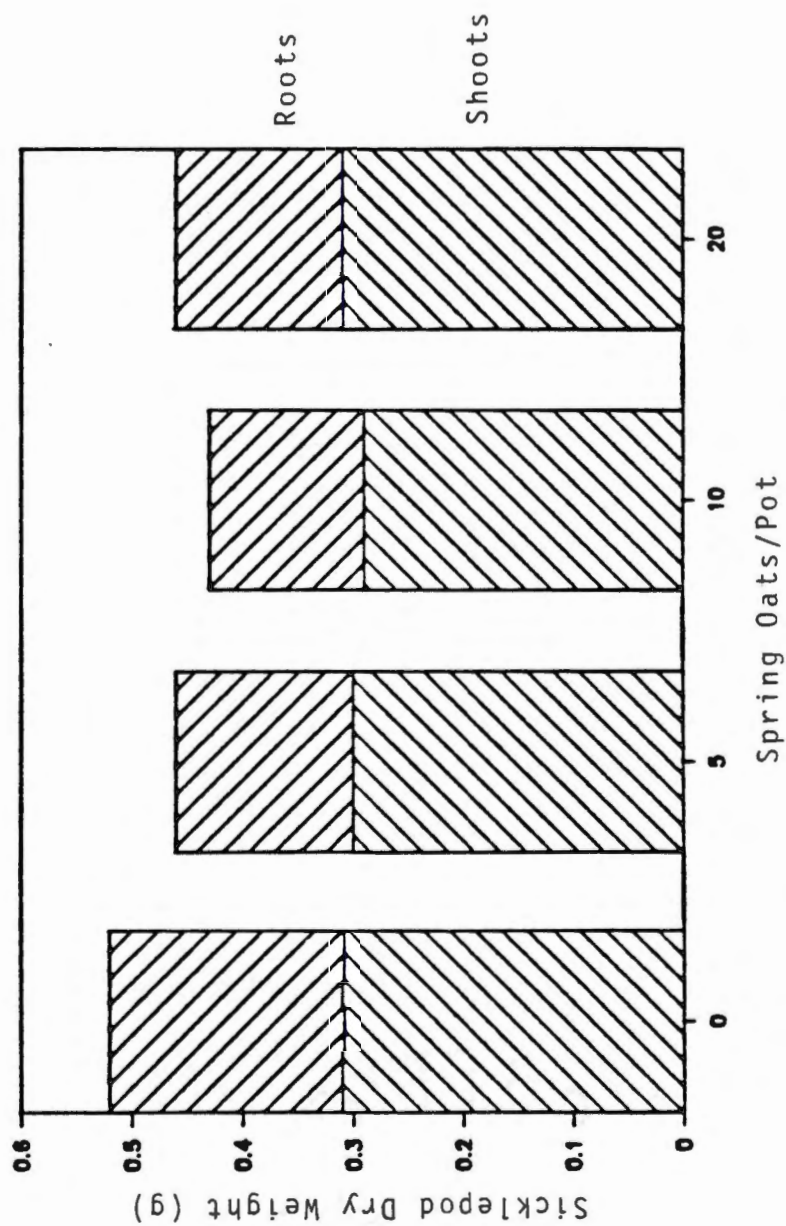


Figure 3. Effects of spring oat residues on sicklepod dry weight.

Table 12. Effects of sicklepod extracts on soybean dry weight production.^a

Sicklepod extract per pot	Soybean Dry Weight	Soybean Shoot Length
(ml)	(g)	(cm)
0	1.52 a	21.8 a
20	1.53 a	21.5 a
40	1.57 a	21.7 a
80	1.17 b	21.3 a

^aMeans within a column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Sicklepod Residues on Soybeans

The sicklepod residues remaining in the cup reduced soybean shoot growth when compared to the controls. (Table 13). The soybeans grown in the pots that previously contained sicklepod were shorter than the controls, but the reduction in shoot length did not occur in a highly linear fashion ($r=.65$). Soybean leaf area was also reduced by the same treatments, but the response was not linear ($r=.23$). Soybean shoot dry weight performed similarly to the other growth parameters measured. The controls gave the greatest shoot dry weights, but statistical significance was not obtained. Soybean shoot dry weight did not respond in a linear fashion ($r=.22$).

Soybeans Following Sicklepod

Soybean response in soil where sicklepod had previously been grown was readily detectable. The larger sicklepod densities tended to reduce soybean shoot length, leaf area, and dry weight when compared to the controls (Table 14). Soybean shoot length was lowered up to 11%. The greatest sicklepod density reduced soybean leaf area production to 36% less than the controls. Soybean dry weights for the same treatment were 19% less than the controls. Regression analysis for linear response of soybean shoot length, leaf

Table 13. Effects of sicklepod residues on soybean shoot length, leaf area, and dry weight.^a

Sicklepod per cup	Shoot Length	Leaf Area	Dry Weight
Number	(cm)	(cm ²)	(g)
0	31.3 a	390 a	2.79 a
5	28.9 b	350 b	2.42 a
10	29.1 b	362 ab	2.57 a
20	29.1 b	371 ab	2.62 a

^aMeans within a column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Table 14. Effects of soybeans following sicklepod.^a

Sicklepod per cup	Soybean shoot length	Soybean leaf area	Soybean dry weight
Number	(cm)	(cm ²)	(g)
0	14.3 a	109 a	0.70 a
5	14.0 ab	91 b	0.62 ab
10	12.7 b	72 c	0.61 b
20	13.4 ab	75 bc	0.65 ab
40	12.9 b	70 c	0.57 b

^aMeans within a column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

area, and dry weight to sicklepod densities gave values of $r=.66$, $r=.75$, and $r=.73$, respectively.

Discussion

Experiments dealing with the production of allelopathic compounds are relatively difficult to conduct and their results complicated to interpret. The release of an allelopathic compound by a plant species may occur in conjunction with other factors which may inhibit plant growth. For example, allelopathic compounds are often released during the decay of plant material. Plant decay itself has the potential to interfere with plant growth by depleting the soil of oxygen. Such was the case in experiments where one species was planted into pots containing roots of another species. Growth reductions were obtained, but it is not known what part, if any, oxygen depletion played in these reductions. Part of this problem was removed when sicklepod extracts were tested as growth inhibitors. However, the amount of inhibitory compounds that remained in the filtered plant material is unknown. In the experiment utilizing a spring oat mulch, it should be noted that the physical presence of the mulch served as a barrier to sicklepod growth. It is difficult to apportion the decrease in sicklepod growth between spring oats' role

as a producer of allelopathic compounds and its role as a physical barrier.

The easiest experiments to interpret are probably the experiments in which one species was entirely removed from the cups prior to the planting of another species. While these experiments test only for compounds exuded by sicklepod roots, they are relatively free from the complicating factors inherent in many allelopathic studies.

CHAPTER VI

INTERACTIONS OF IMAZAQUIN AND CHLORIMURON WITH METRIBUZIN

A. Introduction

Sicklepod (Cassia obtusifolia L.) is an annual, herbaceous weed shown to be present in many crops in the southern United States (41,47). It is of particular concern in soybeans (Glycine max L.) (29), having shown yield reductions from 19 to 35% (70). Soybean yield reductions of 5% have been observed with as few as 16 plants per 10 m of row (60). In some instances, soybean yields were reduced when sicklepod was allowed to compete for as little as four weeks (70).

Several herbicides have been developed that may aid in the control of sicklepod in soybeans. Chlorimuron and imazaquin are currently being evaluated for their ability to control sicklepod. Metribuzin has already been shown to be useful for controlling sicklepod in soybeans (22). It has been suggested that herbicide combinations may be particularly useful in improving the current level of sicklepod control (22).

Applying herbicides in combination is a common practice among row crop producers. Tank-mixing herbicides is

economical in that it allows the applicator to reduce the number of herbicide applications necessary for adequate weed control. Occasionally, however, reduced herbicide efficiency has been noted when herbicides are tank-mixed (14,23,56). Herbicide antagonism can result in reduced weed control and increased crop risk. The objective of this study was to determine the effects of chlorimuron and imazaquin when tank-mixed with metribuzin and applied preemergence to sicklepod under greenhouse conditions.

B. Materials and Methods

Research was conducted in the greenhouse facilities at the University of Tennessee in Knoxville, TN between Nov 6 and Dec 1, 1986. Thirty-one grams of a high (56%) organic matter potting soil were added to each 0.53 L container. Hand-harvested sicklepod seed scarified for 18 min in 36 N sulfuric acid were divided into lots of 25 and placed in the pots. An additional 31 g of potting soil were placed in each pot to cover the seed.

The pots were treated with a CO₂ backpack sprayer equipped with a one-nozzle boom. Preliminary studies indicated that the interaction was more pronounced when herbicide rates were low. Chlorimuron and imazaquin were applied alone at rates of 0.0, 0.02, 0.04, 0.07, and 0.14 kg

ai/ha. Metribuzin was applied alone at a rate of 0.07 kg ai/ha. Metribuzin at 0.07 kg ai/ha was mixed with each rate of chlorimuron and imazaquin and applied to the pots. The pots were then placed on beds in the greenhouse and grown with no supplemental light. All pots were watered as needed throughout the study.

The number of emerged sicklepod plants in each pot was determined 15 days after herbicide application. The total for each treatment was used to measure percent control later in the experiment. Stand counts were taken 20 days after herbicide application. The number of living sicklepod plants in each treatment was compared to the number of emerged plants for that treatment to obtain a percent inhibition value. The above-ground portions of all living sicklepod plants were harvested 25 days after herbicide application. The plants were dried and weighed and the mean of each treatment was compared to that of the control to obtain a percent inhibition value.

The experimental design was a randomized complete block with eight replications. The experimental unit was defined as one pot. Calculations were made according to Colby's method for calculating synergistic and antagonistic responses (19). The results of an additional study involving these compounds is found in Appendix C.

C. Results and Discussion

Stand Counts

Percent inhibition for chlorimuron applied alone ranged from 6 to 16%. Percent inhibition for imazaquin applied alone ranged from 5 to 12% while metribuzin alone gave a percent inhibition value of 87%. Chlorimuron plus metribuzin gave percent inhibition values ranging from 35 to 45% and imazaquin plus metribuzin gave percent inhibition values ranging from 31 to 61%. In every case the control obtained with a mixture was less than the control obtained when metribuzin was applied alone. To quantify the loss in the effectiveness of metribuzin, percent inhibition values were converted to percent-of-control values and the calculations made are presented in Table 15. The numbers suggest an antagonistic response between the herbicides in both mixtures with losses in inhibition of up to 54% in the chlorimuron mixture and up to 57% in the imazaquin mixture.

Dry Weights

Percent inhibition for chlorimuron applied alone ranged from 38 to 66%. Percent inhibition for imazaquin applied alone ranged from 6 to 58% while metribuzin alone gave a percent inhibition value of 100%. Chlorimuron plus metribuzin gave from 74 to 88% control and imazaquin plus

Table 15. Response of sicklepod to preemergence herbicides 20 days after application as measured by stand counts.

Herbicide Treatment	Rate	Percent-of-control	Expected response	Difference
	(kg/ha)			
Chlorimuron	0.02	86		
	0.04	84		
	0.07	88		
	0.14	94		
Imazaquin	0.02	92		
	0.04	95		
	0.07	88		
	0.14	93		
Metribuzin	0.07	13		
Chlorimuron + Metribuzin	0.02 + 0.07	55	11	-44
	0.04 + 0.07	65	11	-54
	0.07 + 0.07	57	11	-46
	0.14 + 0.07	65	12	-53
Imazaquin	0.02 + 0.07	39	12	-27
	0.04 + 0.07	63	12	-51
	0.07 + 0.07	52	11	-41
	0.14 + 0.07	69	12	-57

metribuzin gave from 66 to 89% control. In each case the amount of control obtained with a mixture was less than the control obtained when metribuzin was applied alone. To quantify the loss in effectiveness of metribuzin, percent inhibition values were converted to percent-of-control values and the calculations made are presented in Table 16. The numbers suggest an antagonistic response between the herbicides in both mixtures with losses in inhibition up to 26% in the chlorimuron mixture and up to 33% in the imazaquin mixture.

Table 16. Response of sicklepod to preemergence herbicides 25 days after application as measured by dry weights.

Herbicide Treatment	Rate	Percent-of-control	Expected response	Difference
	(kg/ha)			
Chlorimuron	0.02	62		
	0.04	52		
	0.07	46		
	0.14	34		
Imazaquin	0.02	94		
	0.04	75		
	0.07	62		
	0.14	42		
Metribuzin	0.07	0		
Chlorimuron + Metribuzin	0.02 + 0.07	16	0	-16
	0.04 + 0.07	26	0	-26
	0.07 + 0.07	15	0	-15
	0.14 + 0.07	12	0	-12
Imazaquin + Metribuzin	0.02 + 0.07	11	0	-11
	0.04 + 0.07	26	0	-26
	0.07 + 0.07	17	0	-17
	0.14 + 0.07	33	0	-33

CHAPTER VII

GENERAL SUMMARY

The objectives of this thesis were to determine 1) the present level of sicklepod infestations in Tennessee and the methods employed for its control, 2) the effects of selected herbicides and tillage on sicklepod control, 3) how sicklepod behaves in selected allelopathic interactions, and 4) how selected herbicide combinations affect sicklepod control.

Sicklepod is present in many counties across Tennessee and the number of infestations appears to be growing. Relatively few counties have been able to control the spread of sicklepod in recent years. Sicklepod is a threat to yields in such agronomically important crops as corn, grain sorghum, and cotton. It is of particular concern in soybeans where adequate control measures are often lacking. The advent of several new herbicides suitable for use in soybeans may improve sicklepod control in this crop. However, crop rotation and the selection of an appropriate tillage system are also valuable tools for controlling sicklepod infestations.

Several herbicides were evaluated for their ability to control sicklepod in conventional and no-tillage cropping

systems. Adequate sicklepod control was not obtained with any of the tested herbicides. The addition of a postemergence herbicide application increased the level of control obtained. Fewer sicklepod plants emerged in the no-tillage cropping system, but these plants tended to be taller than the sicklepod plants in the conventionally tilled cropping system. The relative amount of herbicidal control obtained with each cropping system varied with location. Soybean injury was noted with several herbicides in the no-tillage cropping system.

Several allelopathic interactions involving sicklepod were evaluated. Sicklepod dry weight showed a linear decrease with increasing amounts of spring oat mulch. Sicklepod shoot length also showed a linear decrease in the presence of residues left by increasing spring oat densities. Sicklepod extracts decreased soybean dry weight production. Sicklepod residues decreased soybean shoot length and leaf area.

When metribuzin was mixed with chlorimuron or imazaquin and applied preemergence to sicklepod, the amount of control obtained was less than when metribuzin was applied alone. These experiments were conducted at low rates on a high organic matter medium in the greenhouse. Further study will be needed to test the significance of these findings under normal use conditions.

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APPENDIXES

APPENDIX A

COMMON AND CHEMICAL NAMES OF HERBICIDES

<u>Common Name</u>	<u>Chemical Name</u>
Alachlor	2-chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl)acetamide
Chlorimuron	Ethyl 2-[[[(4-chloro-6-methoxypyrimidin-2-yl)amino]-carbonyl]amino]sulfonyl]-benzoate
Imazaquin	2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-quinoline-carboxylic acid
Imazethapyr	2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid
Metribuzin	4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one

APPENDIX B

COVER LETTER AND SURVEY



The University of Tennessee
INSTITUTE OF AGRICULTURE

Department of Plant
and Soil Science
P O Box 1071
Knoxville, Tennessee 37901-1071

Feb. 18, 1987

Dear Extension Leader:

The enclosed survey dealing with sicklepod spread and control is being conducted in conjunction with my thesis project on sicklepod control in soybeans. I need your help in assessing the sicklepod infestation in your area. Please complete the survey and return it to me as soon as possible. Your help and cooperation are greatly appreciated.

Sincerely,

Timothy Adcock
Dept. of Plant and Soil Science

Sicklepod Spread and Control Survey

1. Is sicklepod currently present in your county?

Yes _____ No _____

2. Please estimate the number of acres infested with sicklepod in your county.

3. Does sicklepod currently pose a threat to crop yields in your county?

Yes _____ No _____

If yes, please indicate which crops.

4. Over the past 5 years, have sicklepod infestations in your county increased _____, decreased _____, or remained about the same _____?

5. Please list the herbicides used most frequently to control sicklepod in your area.

6. Are you aware of any other management practices currently being used to control sicklepod (examples: the use of a conventional or no-tillage cropping system, crop rotation)? If so, please list them.

7. For each of the following weeds, indicate whether you would consider it to be more or less of a problem than sicklepod.

	Less of a problem than sicklepod -----	More of a problem than sicklepod -----
Cocklebur	_____	_____
Fall panicum	_____	_____
Foxtail	_____	_____
Jimsonweed	_____	_____
Johnsongrass	_____	_____
Lambsquarter	_____	_____
Morningglory	_____	_____
Pigweed	_____	_____
Prickly sida	_____	_____
Ragweed	_____	_____
Trumpet creeper	_____	_____
Velvetleaf	_____	_____

County: _____

Completed by: _____

Any additional comments:

APPENDIX C

A COMPARISON OF SELECTED HERBICIDES ON SICKLEPOD IN A HIGH ORGANIC MATTER MEDIUM

Research was conducted in the greenhouse facilities at the University of Tennessee in Knoxville, TN, between June 27 and Nov 6, 1986. Forty-three g of potting soil with an organic matter content of 56% were added to each of 136, 0.53 L containers. Hand-harvested sicklepod seed scarified for 18 min in 36 N sulfuric acid were divided into lots of 25 and placed in the pots. An additional 22 g of potting soil were placed in each pot to cover the seeds.

The pots were then placed on the ground and treated with a CO₂ backpack sprayer equipped with a one-nozzle boom. Imazaquin, chlorimuron, imazethapyr, and a mixture of chlorimuron and metribuzin (1 to 6, w/w ratio) were applied at rates of 0.0, 0.07, 0.14, 0.28, and 0.56 kg/ha. The pots were then placed in the greenhouse with no supplemental light. Four additional pots containing no sicklepod were placed in the test so that an estimate of evaporation could be obtained.

All pots were watered as needed throughout the study. Six days after treatment the number of emerged sicklepod plants in each pot was determined. The total for each treatment was used to measure senescence later in the

experiment. Nine days after treatment all pots were watered to a total weight of 250 g and brought back to this weight each time watered. Forty-one days after treatment the above-ground portions of all living sicklepod plants were harvested, dried, and weighed.

Experimental design was a randomized complete block with eight replications. The experiment was ran twice and is presented here in combined form. Data were analyzed by analysis of variance and means were separated using Duncan's multiple range test at the 5% level of probability.

Table 17. Water used on selected dates given as a percentage of the control pots.^a

Herbicide	Days after treatemnt				
	12	18	24	31	38
	------(%)-----				
0.07 Rate					
Imazaquin	14 a	19 ab	37 a	46 a	63 a
Chlorimuron	13 a	28 a	45 a	52 a	64 a
Imazethapyr	6 a	25 a	33 a	49 a	58 a
Chlorimuron + Metribuzin	7 a	14 b	3 b	0 b	0 b
0.14 Rate					
Imazaquin	4 a	12 a	23 a	38 a	50 a
Chlorimuron	7 a	10 a	9 ab	9 b	20 b
Imazethapyr	5 a	12 a	12 ab	16 b	31 b
Chlorimuron + Metribuzin	0 a	10 a	5 b	0 b	0 c

^aStatistics were performed using original data and are presented as a percentage of the control pots. Letters following a percentage represent differences in the original means. Means followed by the same letter referring to the same rate are not significantly different at the 5% level according to Duncan's multiple range test.

Table 18. Mean dry weight of sicklepod plants surviving 41 days after treatment.^a

Treatment	Herbicide rate in kg ai/ha				
	0.0	0.07	0.14	0.28	0.56
	----- (g) -----				
Control	2.07	---	---	---	---
Imazethapyr	---	1.24 a	0.78 a	0.38 a	0.26 a
Imazaquin	---	1.01 a	0.78 a	0.33 a	0.15 ab
Chlorimuron	---	1.10 a	0.43 b	0.19 b	0.06 ab
Chlorimuron + Metribuzin	---	0.03 b	0.0 c	0.0 b	0.0 b

^aMeans within a column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

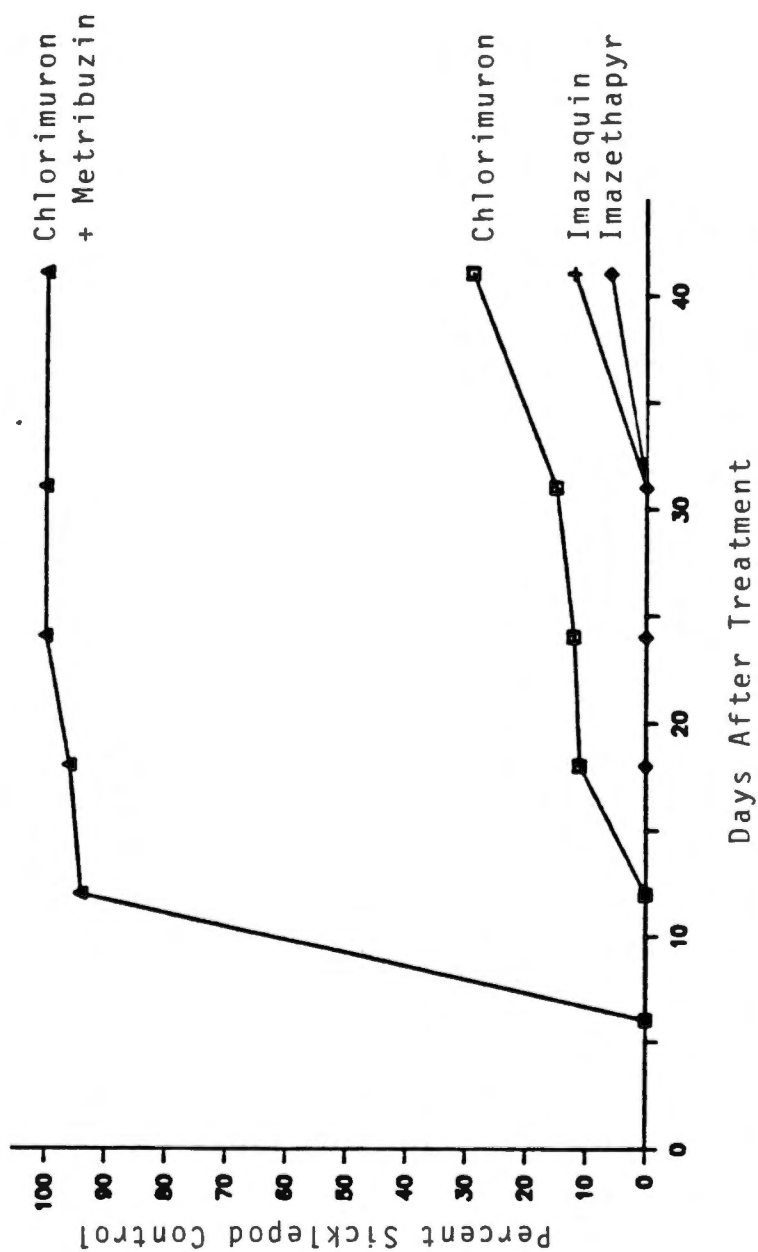


Figure 4. Sicklepod control at the 0.07 kg/ha herbicide rate.

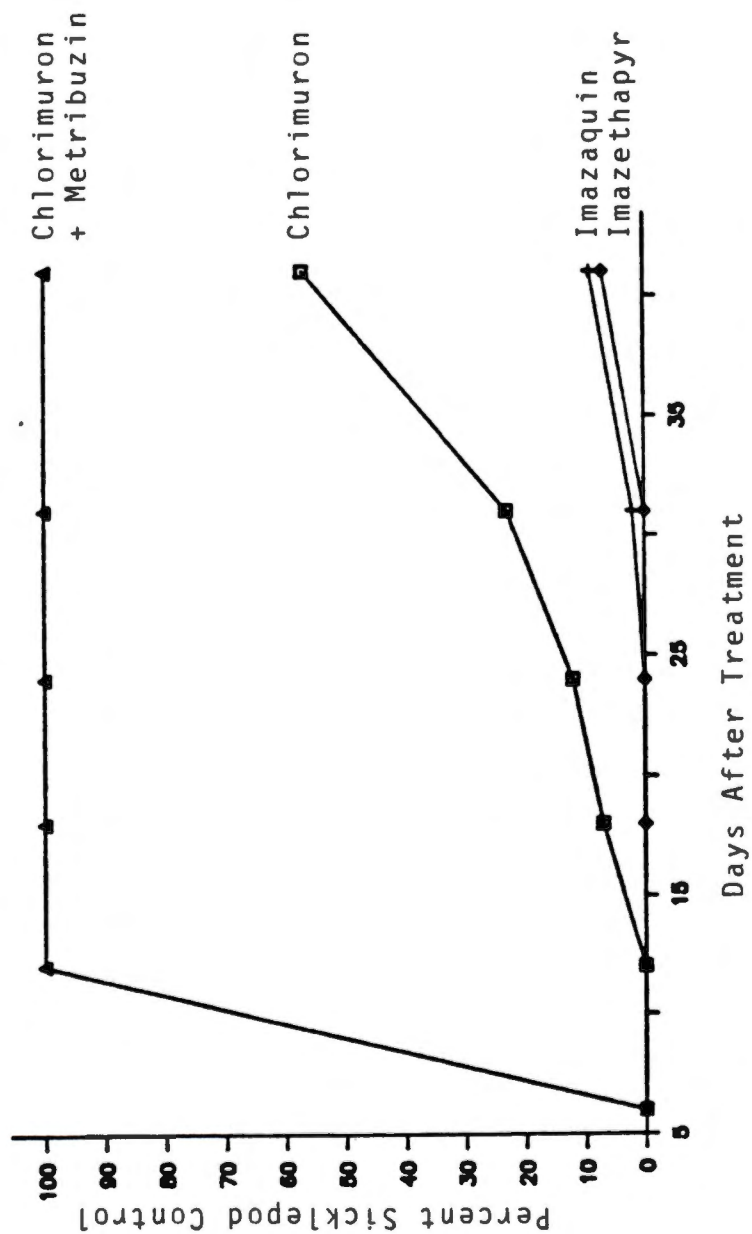


Figure 5. Sicklepod control at the 0.14 kg/ha herbicide rate.

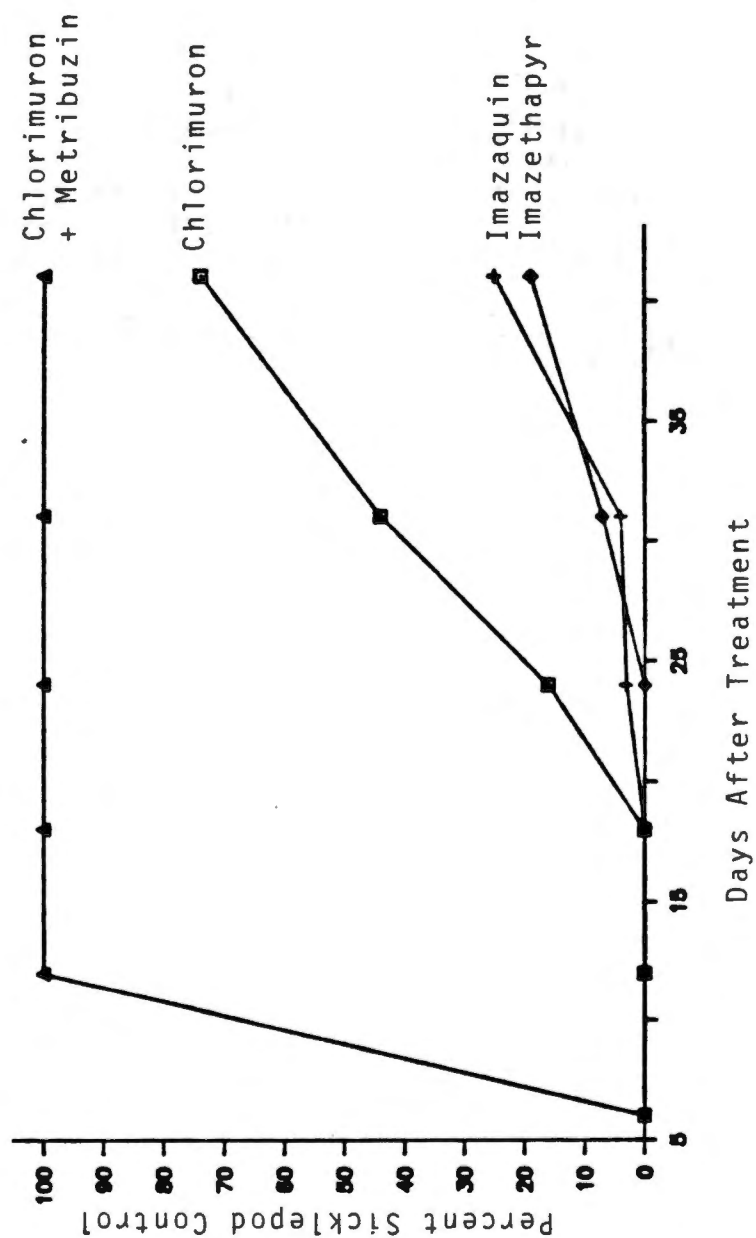


Figure 6. Sicklepod control at the 0.28 kg/ha herbicide rate.

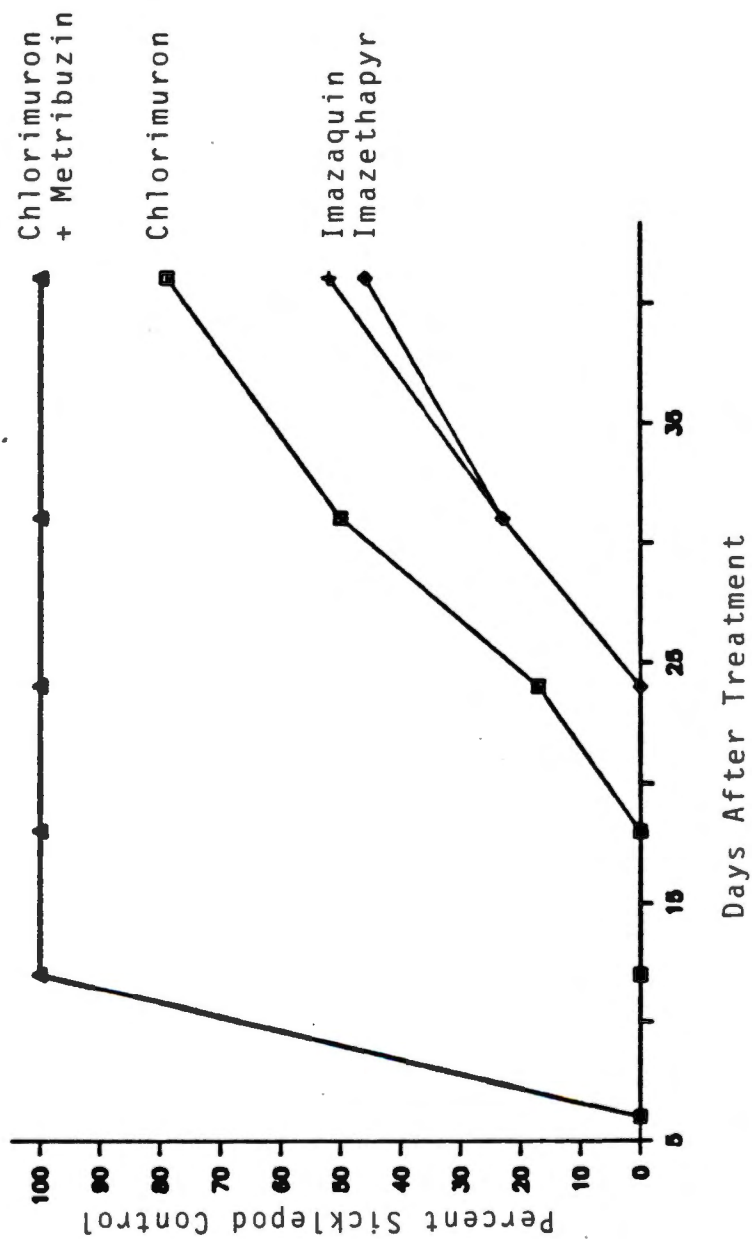


Figure 7. Sicklepod control at the 0.56 kg/ha herbicide rate.

VITA

Timothy Edward Adcock was born in Smithville, Tennessee on April 26, 1963. He attended elementary schools in that city and graduated with honors from DeKalb County High School in May 1981. He entered Middle Tennessee State University in August 1981 and graduated with honors from that institution with a Bachelor of Science degree in May 1985. He entered the University of Tennessee, Knoxville, in September 1985 as a Graduate Research Assistant in the Department of Plant and Soil Science. He received his Master of Science degree in December 1987.

The author is a member of Gamma Sigma Delta and the Weed Science Society of America. He is married to the former Hollie Ladel McElroy of Murfreesboro, Tennessee. Beginning in January 1988, he will pursue a Doctor of Philosophy degree at the University of Georgia.