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EFFECTS OF TILLAGE SYSTEMS ON EFFICACY OF SELECTED PREEEMERGENCE HERBICIDES IN SOYBEANS

A Thesis

Presented for the

Master of Science

Degree

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Michael Allen Fuqua

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DEDICATION

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

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ABSTRACT

Field and greenhouse studies were conducted in 1987 and 1988 to determine the influence of tillage systems on the efficacy of selected preemergence herbicides in soybeans [Glycine max (L.) Merr.]. The effects were measured using visual ratings, height measurements and soybean yields.

Field studies were conducted at four locations in Tennessee. At Knoxville and Milan the cover crop was wheat (Triticum aestivum L.), while at Crossville and Spring Hill the cover crop was spring oats (Avena sativa L.). Tillage treatments at Knoxville included conventional tillage (15 cm) following wheat harvest, stubble planting following wheat harvest and planting into standing wheat which was killed at stage 9 with glyphosate. At Crossville and Spring Hill, spring oats were killed with paraquat prior to the initiation of the three tillage treatments. These treatments consisted of no-tillage (planting into the standing spring oats), shallow tillage (8 cm); and conventional tillage (15 cm). A power-driven tiller was used for all tillage operations.

Within each tillage treatment at all locations, the following preemergence treatments were included: metribuzin (0.43 kg ai/ha), chlorimuron + metribuzin (0.06 + 0.37 kg ai/ha), chlorimuron + linuron (0.04 + 0.53 kg ai/ha), imazaquin (0.14 kg ai/ha) and imazethapyr (0.11 kg ai/ha). Hand-weeded and weedy checks were also included. The experimental design used at all locations was a split-plot factorial

arrangement in a randomized complete block with four replications of each treatment. The tillage treatments were assigned to the main plots and herbicide treatments were assigned to the sub-plots.

Results indicated that tillage systems may affect the activity of preemergence herbicides. All herbicide treatments with the exception of metribuzin provided good to excellent control of common cocklebur (Xanthium strumarium L.), annual morningglory (Ipomoea spp.), jimsonweed (Datura stramonium L.), yellow nutsedge (Cyperus esculentus L.) and large crabgrass (Digitaria sanguinalus L. Roth). No herbicide treatment gave satisfactory control of sicklepod (Cassia obtusifolia L.). At Knoxville and Milan, there was a trend for greater weed control with no-tillage treatments. This was not observed at Crossville or Spring Hill. There was also a trend for greater soybean injury with chlorimuron plus metribuzin, chlorimuron plus linuron, and imazaquin. Tillage systems and herbicides interacted significantly. Greater soybean injury was observed in no-tillage treatments. Soybean yields were higher in no-tillage treatments at Knoxville and Milan and equivalent to other tillage treatments at Crossville and Spring Hill. Heavy cover crop residue at Knoxville and Milan provided more favorable soil moisture levels in no-tillage treatments which compensated for greater initial soybean injury. However, this was not observed at Crossville or Spring Hill where less crop residue was present. In conclusion, weed control, soybean injury and yield increased with increasing amounts of cover crop residue.

Greenhouse studies were conducted to determine the interactions of straw mulch and selected preemergence herbicides on soybean injury.

'Asgrow 5474' soybeans were planted in 0.53 L plastic pots containing sandy loam soil. Three straw mulch treatments were established: (1) 4.5 g of straw mulch placed on the soil surface; (2) 4.5 g of straw mulch incorporated thoroughly into the soil; and (3) a no straw treatment. The straw level used was equivalent to 4480 kg/ha. Preemergence herbicide applications included: metribuzin (0.22 or 0.43 kg ai/ha), chlorimuron + metribuzin (0.03 + 0.19 or 0.06 + 0.37 kg ai/ha), chlorimuron + linuron (0.02 + 0.26 or 0.04 + 0.52 kg ai/ha), imazaquin (0.07 or 0.14 kg ai/ha) and imazethapyr (0.055 or 0.11 kg ai/ha). Control treatments with no preemergence herbicide were also included. The experimental design was a randomized complete block in the greenhouse; however it was analyzed as a split-plot factorial arrangement of treatments in a randomized complete block. This allowed for the determination of treatment interactions.

Results indicated that soybean height, injury and weight were affected by all herbicide treatments, and varied with straw treatments. Soybean injury tended to increase with increasing herbicide rates. Chlorimuron plus metribuzin and chlorimuron plus linuron affected soybean height and weight to a greater extent than did other herbicides. This was visible through internode shortening and reduced canopy formation. Root weights indicated decreased root growth with herbicide applications. Greater heights and injury was observed in the surface straw treatment compared to the other straw treatments. Significant interactions were observed between herbicide and straw treatments for all data with the exception of root dry weight.

Interactions for all data may be partly explained by greater moisture in the surface straw treatment compared to the incorporated or no straw treatments.

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CHAPTER I

INTRODUCTION

Implementation of conservation practices has increased over the past several years. Soil erosion has recently become a major concern especially in the Southeast. The Soil Conservation Service (SCS) reported in 1978 that Tennessee leads the nation in soil loss due to sheet and rill erosion (8). In 1982, cropland in West Tennessee had an average erosion rate of 15.8 t/ha while some areas averaged over 102 t/ha/yr (7). This is primarily a result tillage practices used in the production of soybeans [Glycine max (L.) Merr.], on highly erodible loess and coastal plain soils (52).

Farmers are adopting no-tillage as a conservation practice to decrease erosion. The 1985 Farm Bill set strategic requirements for farm program beneficiaries (48,53). By 1990, all farms participating in federal farm programs must possess a farm plan and erosion must be reduced to tolerable levels. One method to achieve this is conservation tillage cropping systems (40,48,52). This practice requires no capital investments in the land by the landowner. With the implementation of no-tillage practices, erosion rates have declined substantially. No-tillage is a complex technology which requires better management skills than conventional-type systems. Although no-till saves time, fuel and labor, more use of herbicides for weed control is necessary (23,25,26,30,31,40,41). Conservation production systems utilizing total weed control methods averaged higher yields and

greater net returns after weed control costs than did conventional systems (22). Furthermore, the reduced-tillage systems involved in conservation programs often lead to better moisture management and soil physical properties (22).

Weeds present many problems in crop production systems. By competing for available light, water and nutrients, weeds reduce crop yield, quality and harvest efficiency (24). In conservation or reduced-tillage systems, superior weed control is required for success. Rapid development of the soybean canopy is vital to the overall weed management approach used in no-till, doubled-cropped soybeans (32). Soybean planting is usually delayed in these systems until small grains are harvested. Some soybean cultivars do not form an adequate canopy until late in the season (37). Thus, greater reliance is placed on preemergence herbicides for early weed control.

New soybean herbicides have recently been developed for improved weed control in no-tillage or reduced-tillage systems (21,34,49). Two new herbicide families, the imidazolinones and sulfonylureas, have recently been introduced into the agrichemical market. These families have demonstrated improved activity on many important weed species. The objectives of this research were 1) to determine the influence of tillage systems on the efficacy of selected herbicides; and 2) to determine if tillage systems and surface residue levels influence phytotoxicity of various herbicides to soybeans. The primary herbicides studied were the imidazolinones, imazaquin (AC 252,214) and imazethapyr (AC 263,499); and chlorimuron (DPX-F6025), a sulfonylurea. Two preformulated mixtures of chlorimuron were evaluated; Canopy™, a

combination of chlorimuron (10.7% w/w) plus metribuzin (64.3% w/w) and Gemini™, a combination of chlorimuron (4.6% w/w) plus linuron (55.4% w/w).

CHAPTER II

LITERATURE REVIEW

A. Weed Control in Soybeans

Competition from weeds causes an estimated 21% soybean yield loss in the Southeast (48,57,58,60). The three most competitive weeds across the Southeast are common cocklebur (Xanthium strumarium L.), johnsongrass (Sorghum halepense (L.) Pers.) and morningglories (Ipomoea spp.). These weeds compete for essential light, water and nutrients (17,66). Barrentine et al. reported that season-long competition from common cocklebur can reduce yields up to 80% (16). Mathis and Oliver observed 40 to 66% yield reduction from the competition of various morningglory species (35). Williams and Hayes reported 59 to 88% yield decreases from full season johnsongrass competition (63). These studies and others determined that soybeans require a weed free period of 3 to 4 weeks after emergence to prevent significant yield reductions. Rapid development of the soybean canopy is vital to the overall weed management approach in no-till, double-cropped soybeans (4,16,63). These studies have demonstrated also the need for early season weed control through the use of preemergence herbicides. Preemergence herbicides help alleviate early competition from several annual weed species and allow soybeans to become more competitive through canopy formation.

B. Tillage Systems

Use of conservation tillage systems has increased over the past few years. Reduced-tillage and no-tillage cropping systems have grown rapidly in popularity. In 1982 approximately 40 million hectares of farmland were managed under conservation tillage systems (30). In 1986, 32.9% of all cropland was under some conservation tillage system. This figure was up from 24% in 1982. However, many farmers are still hesitant to implement this technology. Some of the questions often asked concern residues, equipment and weed control (48,60). A study conducted by the United States Department of Agriculture (USDA) and SCS found that 89% of producers who are not using conservation tillage ranked residue management and weed control as their major obstacle or objection to adopting reduced-tillage practices (40).

There are significant advantages to conservation tillage systems. Tillage in crop production enhances wind and water erosion by destroying soil structure (41). Soil loss with row crop production can be cut to less than 10% of the amount occurring with conventional tillage provided that residues are maintained (51). No-tillage reduces water runoff and sedimentation which in essence reduces soil erosion and water contamination (26,42). A study conducted by Shelton and Bradley (51) from 1980 to 1987 evaluated factors affecting soil erosion. They concluded that average soil losses for single-crop and double-crop, no-till soybean systems were 98% less than soil losses for conventional, single-crop and drilled soybeans.

Another advantage of no-tillage is improved soil moisture due to increased water infiltration and decreased evaporation (28,41). Mulch or crop residue serves to retard evaporation of valuable moisture (22,41). Mulch in no-tillage may also contribute to weed control (19,22). In most soils, water infiltration is increased in a no-tillage cropping system due to undisturbed water channels (41). More efficient use of time and labor is also an advantage. Reducing or eliminating field operations reduces wear on equipment and fuel costs (41).

There are some disadvantages of conservation tillage systems. More herbicides are often necessary where cultivation is minimized. Weed control is a major factor in making reduced-tillage systems work successfully (57). In reduced-tillage systems, preemergence herbicides are applied to a soil surface which is covered by residues of a previous crop. This may affect the amount of herbicide reaching the soil surface (14,57). Residues also may harbor other plant pests, thereby increasing insect and plant disease problems (26,41). In reduced-tillage systems, 30 to 50% more pesticides are required for adequate control. Soil temperatures have been reported to be 5 to 10 ^{o}C lower at 2.5 cm beneath the soil surface in the spring in no-tillage compared to conventional tillage. This may cause delayed planting due to low soil temperature and excess soil moisture (41). A no-tillage cropping system may influence requirements and behavior of soil nutrients. Shear and Moschler reported that phosphorus uptake by corn was more rapid under no-till conditions (50). More nitrogen is required in no-tillage systems because higher moisture levels promote

denitrification (41,56). Leaching of nitrate also occurs more rapidly in no-tillage due to decreased water evaporation in conjunction with undisturbed water channels in the soil (56).

Crop yields and weed response may differ under various cropping systems. Plant growth and corn yields have been shown to increase with decreasing amounts of tillage (29,56). Corn yields were reported up to 39% higher in no-tillage when compared to conventional tillage (29). Robinson et al. (46) reported a trend of increased weed control in no-tillage using various herbicides.

The use of conservation tillage will continue to increase due to new farm legislation. An estimated 65% of the seven major annual crops [corn (Zea mays L.), soybeans, sorghum (Sorghum bicolor L.), wheat (Triticum aestivum L.), oats (Avena sativa L.), barley (Hordeum vulgare L.)and rye (Secale cereale L.)] will be grown in a no-tillage system by 2010 (53).

Several studies focusing on the effects of straw mulch have revealed some interesting results. Studies by Banks and Robinson (13,14) showed less than 1% of metribuzin applied to wheat straw reached the soil surface without rainfall or irrigation. When rainfall occurred within 10 days after application, the amount of metribuzin reaching the surface increased to 15%. This application was directed to heavy straw accumulations of 8900 kg/ha. It was revealed that 50% of metribuzin could degrade or volatilize when exposed to warm temperatures or intense sunlight. Banks and Robinson found 56% of the metribuzin applied reached the surface when irrigated on the day of application. These data were obtained from straw accumulations of 5600

kg/ha. This research showed that the level of straw mulch in a minimum or no-tillage system may tremendously affect the efficacy of preemergence herbicides.

Farmers in the Southeast who practice a wheat and soybean double-cropping system might experience similar effects of straw mulch on herbicide placement and activity. Consequently, decreasing the amount of herbicide reaching the soil will decrease the availability for uptake (14). Some researchers have observed differences in weed density with different tillage systems. Adcock (1) reported decreased sicklepod (Cassia obtusifolia L.) density in a no-tillage system compared to conventional tillage. Reports are conflicting regarding the affect of mulch on herbicide activity (12,13,55). Control of certain species was not affected by straw retention of herbicides (33), while reduced weed control has been observed when herbicides were applied to straw-mulched soils in other studies (55).

C. Review of Selected Herbicides

Common and chemical names of herbicides are given in Appendix A.

Chlorimuron

Chlorimuron is a preemergence, preplant incorporated or postemergence herbicide for control of broadleaved weeds in soybeans. The mode of action is the inhibition of the biosynthesis of the essential amino acids, valine, leucine and isoleucine. Chlorimuron was developed by E. I. du Pont de Nemours and Company and is marketed under

the trade name CLassic™ as well as in combinations with metribuzin (Canopy™, Preview™) and linuron (Gemini™) (4,6,9,11,18,43).

A study conducted by Gamble et al. (23) revealed excellent results for preemergence combinations of chlorimuron and imazaquin. Imazaquin at the rate of 0.28 kg ai/ha and chlorimuron at 0.07 kg ai/ha provided excellent control of sicklepod in conservation tillage plots.

Allen and Banks (3) evaluated the preemergence and postemergence activity of chlorimuron. Chlorimuron was applied preemergence at 9, 18, 35, 70 105 or 140 g ai/ha. Postemergence applications included 9, 18, 35 or 70 g ai/ha. The preemergence treatments of 105 or 140 g ai/ha significantly reduced sicklepod stand counts and fresh weights. However, both preemergence treatments and postemergence treatments caused crop injury and significantly reduced soybean yields. Early postemergence application of 70 g ai/ha with or without surfactant significantly reduced sicklepod stand and fresh weights, but again caused crop injury and reduced soybean yields. The authors concluded that no preemergence or late postemergence application adequately controlled sicklepod without significantly injuring the crop. The only effective application was 70 g ai/ha applied early postemergence.

Gemini™, which consists of a 12:1 ratio of linuron to chlorimuron was evaluated by Rodrique et al. (47). In tests across the eastern and southern states, preemergence rates of 0.55 to 1.0 kg ai/ha gave excellent (>95%) broadleaved weed control in soybeans. Control of common cocklebur, morningglory species, ragweed (Ambrosia spp.) and

velvetleaf [Abutilon theophrasti (L.) Medic.] was observed. Good crop tolerance was also observed at the above rates.

Norris and Walker (38) reported broad spectrum weed control with chlorimuron. However, greater crop injury was observed from chlorimuron than from imazaquin.

Allen and Banks (3) studied chlorimuron for broadleaved weed control and crop tolerance. Chlorimuron provided excellent (>95%) control of tall morningglory [Ipomoea purpurea (L.) Roth.], smooth pigweed (Amaranthus hybridus L.) and prickly sida (Sida spinosa L.) at rates of 0.07 or 0.035 kg ai/ha. Preplant applications caused crop injury at both rates but did not reduce yields significantly.

Edmund and York (20) evaluated chlorimuron for sicklepod control. Postemergence applications of 18 g ai/ha provided excellent control and yields equivalent to toxaphene. However, preemergence applications of 23 and 53 g ai/ha and postemergence applications of 9 g ai/ha did not control sicklepod adequately.

Common cocklebur, hemp sesbania [Sesbania exaltata (Raf.) Rydb.], prickly sida, pitted morningglory (Ipomoea lacunosa L.)and sicklepod control with chlorimuron was determined by Barrentine and Kurtz (15). Preemergence applications of 0.11 kg ai/ha provided 90% or better control of all weeds except sicklepod. When chlorimuron was combined with 0.28 kg ai/ha of metribuzin, adequate control of sicklepod was observed.

Imazaquin

Imazaquin is a selective, broad spectrum herbicide which may be applied preplant incorporated, preemergence or postemergence in soybeans. The mode of action involves inhibition of the biosynthesis of valine, leucine and isoleucine, three essential amino acids. Imazaquin was developed by American Cyanamid and is marketed as Scepter^{TM} (4,10,49).

Preplant incorporated (PPI), preemergence (Pre) or postemergence (Post) applications of 0.14 kg ai/ha in combination with a grass herbicide provided excellent control of common cocklebur, prickly sida (PPI and Pre, only), common ragweed and pigweed (Amaranthus spp.) (45). In small plots imazaquin demonstrated effectiveness against certain grass species, but for maximum grass control, a grass herbicide was required.

Bozsa et al. (17) conducted studies also to evaluate the weed spectrum of imazaquin. Results from their studies indicated excellent broad spectrum control with only legumes as a weakness when applied preemergence at 0.125 kg ai/ha. When applied postemergence at the same rate, adequate control of barnyardgrass [Echinochloa crus-galli(L.) Beauv.], common cocklebur and pigweed species was observed .

Norris and Walker (38) also observed a weakness of imazaquin for control of legume species when applied at 112, 224, 336 or 448 g ai/ha in a growth chamber study.

Hirrel and Tripp (27) focused on the effects of high soil moisture and imazaquin on root rot of soybeans. Applications of imazaquin were made preemergence and preplant incorporated. Reduced

vigor, stand, and plant weight were found when imazaquin was applied in high moisture regimes. Evidence showed that using imazaquin or imazaquin plus pendimethalin can lead to increased infection by a complex of soil-rotting pathogens.

Mills et al. (36) evaluated the effects of tillage on imazaquin. Under two tillage systems, conventional and no-tillage, imazaquin was applied preemergence at 0.14, 0.21 or 0.28 kg ai/ha. Excellent control (>95%) of common cocklebur was observed in both tillage systems. Giant foxtail (Setaria faberii Herrm.) control was higher in no-tillage than in conventional tillage (99% vs 90%).

Aison and Harger (2) observed good (86%) sicklepod control from imazaquin when applied postemergence at rates of 0.30 and 0.45 kg ai/ha. When applied preemergence, 89% control of mexicanweed [Caperonia castaniifolia (L.) St. Hil.] was obtained.

Umeda et al. (59) studied optimum timing of imazaquin for sicklepod and hemp sesbania control in the greenhouse. Optimal control of sicklepod occurred when imazaquin was applied preemergence at 0.125 kg ai/ha. However, 0.5 kg ai/ha was required for optimum control at the cotyledon to two-leaf stage.

In another study, Retzinger et al. (44) evaluated imazaquin applied preplant incorporated, preemergence and postemergence at 0.14 kg ai/ha. Good to excellent control (87 to 99%) of pigweed, prickly sida, ivyleaf morningglory (Ipomoea hederacea (L.) Jacq.) and common cocklebur was observed with preplant and preemergence applications. Postemergence control was sightly lower (63 to 94%). They also conducted tests to examine imazaquin activity on johnsongrass in a

wheat and soybean double-cropping system. Applied at 0.42 kg ai/ha, imazaquin gave 95% control of johnsongrass which was equivalent to a tank mixture of glyphosate, metolachlor and metribuzin.

Imazethapyr

Imazethapyr is a new broad spectrum imidazolinone herbicide developed by American Cyanamid. It carries the trade name Pursuit™ and can be applied preplant incorporated, preemergence, at cracking (between the cracking of the soil surface and the emergence of the crop cotyledons) and early postemergence. Imazethapyr acts by inhibiting the biosynthesis of aliphatic amino acids, valine, leucine and isoleucine. The selectivity of imazethapyr in soybeans is the result of rapid metabolism by the soybean plant (4,5,49).

Imazethapyr was evaluated in several southern states by American Cyanamid Company (39,62). This imidazolinone provided excellent (>95%) control of several grasses and broadleaved weeds when applied preplant incorporated, preemergence and postemergence. Preplant incorporated treatments of 0.07 kg ai/ha gave good to excellent (85 to 99%) control of barnyardgrass and large crabgrass (Digitaria sanguinalus L. Roth). At 0.1 kg ai/ha or higher it provided good to excellent control of common cocklebur, ivyleaf morningglory and prickly sida. At the rate of 0.14 kg ai/ha imazethapyr provided excellent control of giant foxtail. Preemergence applications of 0.04 kg ai/ha provided excellent control of redroot (Amaranthus retroflexus L.) and smooth pigweed; at 0.1 kg ai/ha or higher good to excellent control of crabgrass and prickly sida was achieved; 0.14 kg ai/ha gave good to excellent control

of barnyardgrass, giant foxtail, and ivyleaf morningglory.

In a study by Bozsa et al., (17) the weed spectrum of imazethapyr was determined. From 1984 to 1986, preemergence application of 0.053 kg ai/ha provided adequate control of all species except Leguminosae species and balloonvine (Cardiospermum halicacabum L.) Balloonvine and sicklepod were controlled at 0.14 kg ai/ha. When applied postemergence at 0.14 kg ai/ha, imazethapyr gave good to excellent control of common cocklebur, jimsonweed (Datura stramonium L.) , Convolvulaceae species, Malvaceae species except prickly sida, Gramineae species except goosegrass [Eleusine indica (L.) Gaertn.] and Amaranthaceae species.

Mills et al. (36) studied the effects of tillage on imazethapyr. Greater common cocklebur control was observed in no-tillage than in conventional tillage (98 vs 83%). Soybean yields from imazethapyr were lower than the weed free check in conventional tillage, but were equal to the check in no-tillage.

CHAPTER III

EFFECTS OF TILLAGE SYSTEMS ON EFFICACY OF SELECTED PREEMERGENCE HERBICIDES IN SOYBEANS

A. Introduction

Conservation tillage has become extremely popular in the southeastern United States. Soil erosion and water quality concerns have promoted the use of reduced and no-tillage systems. These systems aid in decreasing erosion and runoff which in essence improves water quality. It has also been reported that reduced and no-tillage systems improve soil moisture and properties in field crop situations. However, concerns about weed control and residue management make farmers reluctant to adopt these programs. Studies have indicated that weed control is affected by various tillage systems. However, research is needed for new low dosage herbicides which have been developed in recent years. New imidazolinones and sulfonylureas have been introduced into the soybean market since the early 1980's. Some of the latest developments have been chlorimuron, imazaquin and imazethapyr. These herbicides are much more active at lower dosages than compounds developed earlier. The objectives of this research were 1) to determine the influence of tillage on efficacy of selected herbicides and 2) to determine the effects of crop residue on soybean injury and yield under various tillage systems.

B. Materials and Methods

Field studies were conducted in 1987 and 1988 at four locations across Tennessee: Plant Sciences Field Laboratory, Knoxville; Plateau Experiment Station, Crossville; Middle Tennessee Experiment Station, Spring Hill; and Milan Experiment Station, Milan. These studies were conducted to determine the effects of tillage on the efficacy of selected preemergence herbicides in soybeans.

The soil at Knoxville was a Sequatchie fine sandy loam (Humic Hapludult: fine-loam, siliceous, thermic) with 1.5% O.M. and a pH of 6.5. The soil at Crossville was a Tilsit loam (Typic Hapludult: fine-loamy, siliceous, mesic) with 1.5% O.M. and a pH of 6.5. At Spring Hill, the soil was a Maury silt loam (Typic Paleudalf: fine, mixed, mesic) with 1.5% O.M. and a pH of 6.5. The soil at Milan was a Grenada silt loam (Glossic Fragiudalf: fine silty, mixed, thermic) with 1.0% O.M. and a pH of 6.6. In 1987 at Knoxville and Milan, wheat was planted in the fall of 1986 as a cover crop. Spring oats (Avena sativa L.) were planted as a cover crop at Crossville and Spring Hill. Tillage treatments at Knoxville included conventional tillage (15 cm) following wheat harvest, stubble planting following wheat harvest and planting into standing wheat which was killed with glyphosate at growth stage 9. At Milan, the standing wheat treatment was omitted. At Spring Hill and Crossville, spring oats were killed with paraquat one week prior to the initiation of the following tillage treatments: no-tillage (planting into standing spring oats); shallow tillage (8 cm); and conventional tillage (15 cm). A power-driven tiller was used for

all tillage treatments with the exception of Milan, where a tandem disk was used.

In 1988 at Knoxville and Milan, the cover crop was wheat and the tillage treatments were identical to those used in 1987 at Knoxville. At Crossville, the same tillage treatments which were used in 1987 were again evaluated following spring oats.

'Asgrow 5474' soybeans (determinate, maturity group V) were planted: June 18, 1987 and June 15, 1988 at Knoxville; June 9, 1987 and June 29, 1988 at Crossville; May 21, 1987 at Spring Hill; and June 10, 1987 and July 10, 1988 at Milan. Soybeans were planted in 3 m by 9.1 m plots with 51-cm row spacing at all locations except Crossville where the row spacing was 46 cm.

The herbicide treatments were the same both years at all locations. A treatment of glyphosate at 1.68 kg ai/ha + 0.25% v/v surfactant was applied to no-tillage treatments prior to preemergence applications to control existing vegetation in all experiments except at Knoxville in 1987 where paraquat at 0.48 kg ai/ha + 0.25% v/v surfactant was used.

Preemergence treatments included: metribuzin (0.43 kg ai/ha), chlorimuron + metribuzin (0.06 + 0.37 kg ai/ha), chlorimuron + linuron (0.04 + 0.52 kg ai/ha), imazaquin (0.14 kg ai/ha), and imazethapyr (0.11 kg ai/ ha). Preemergence herbicides were applied immediately after soybean planting. Herbicide applications were made using a CO_2 backpack sprayer equipped with a 6 nozzle boom having a nozzle spacing of 51 cm. A water carrier volume of 187 L/ha and pressure of 262 kPa was used in 1987. A water carrier volume of 187 L/ha and a pressure

of 366 kPa was used in 1988. Hand-weeded and weedy checks were also included. Hand-weeded checks were maintained in 1987 by hand weeding. Fomesafen at 0.43 kg ai/ha was used as a early postemergence application on hand-weeded checks in 1988.

Treatment effects were measured using visual ratings, plant heights and soybean yields. Visual ratings included weed control by species and soybean injury. Percent control or injury was determined by visually rating each plot on a 0 to 100% scale, with 100% representing complete control or crop death and 0% representing no control or soybean injury. Soybean injury was determined by comparing the soybeans in each treated plot to the hand-weeded check within the same main treatment and replication.

Soybeans yields were obtained at all locations in 1987 and at Knoxville and Milan in 1988. Yield and soybean injury data were not available in 1988 at Crossville due to unsatisfactory soybean stand.

Experimental design used at all locations was a split-plot factorial arrangement of treatments in a randomized complete block with four replications of each treatment. Tillage treatments were assigned to the main plots and herbicides were assigned to sub-plots. Data were subjected to an analysis of variance and means were separated by Duncan's multiple range test at the 5% level of probability.

Rainfall data were collected and are available in Appendix C. In 1987 all locations received adequate activation rainfall within 10 days for preemergence herbicide applications: Knoxville, 6.9 cm: Crossville, 3.0 cm; Spring Hill, 4.9 cm; and Milan, 9.2 cm. In 1988,

activation rainfall within 10 days was as follows: Knoxville, 0.59 cm; Crossville, 2.07 cm; and Milan, 13.37 cm.

C. Results and Discussion

Herbicide Comparisons

Weed Control

At Knoxville, weed pressure was extremely heavy both in 1987 and 1988. In 1987 all herbicide treatments with the exception of metribuzin provided 76 to 98% control of common cocklebur (XANST), tall morningglory (PHBPU) and entireleaf morningglory (IPOHG), three weeks after planting (WAP)(Table 1). In 1988, all herbicide treatments provided slightly lower weed control (69 to 95%) for all species (Table 2). Metribuzin did not provide satisfactory control during either year. Seven weeks after planting in both years, similar results were observed. Good control with all treatments with the exception of metribuzin alone was observed for common cocklebur, tall and entireleaf morningglory. Greater control of all species was observed in 1987 compared to 1988. This difference might be partially explained by lower moisture levels in 1988.

At Milan, common cocklebur, ivyleaf morningglory (IPOHE) and large crabgrass (DIGSA) control was evaluated in 1987 (Table 3). In 1988, sicklepod (CASOB) was rated rather than large crabgrass (Table 4). At 3 WAP in both years, 91 to 99% control of common cocklebur, ivyleaf morningglory and large crabgrass (1987 only) was observed with

Table 1. Weed Control Under Different Tillage Systems at Knoxville in 1987.[a]

Herbicide Treatments	Tillage Systems: CT[b] XANST	CT[b] PHBPU	CT[b] IPOHG	NT-BD[b] XANST	NT-BD[b] PHBPU	NT-BD[b] IPOHG	NT-DC[b] XANST	NT-DC[b] PHBPU	NT-DC[b] IPOHG
	(% Control)								
3 Weeks after application									
Metribuzin	46b	73b	65b	49b	53b	39b	43b	63b	50b
Chlorimuron + Metribuzin	83a	89ab	80a	97a	97a	96a	98a	98a	96a
Chlorimuron + Linuron	80a	92a	88a	97a	96a	95a	96a	96a	92ab
Imazaquin	78a	95a	91a	96a	96a	93a	96a	99a	96a
Imazethapyr	76a	95a	90a	96a	97a	95a	97a	98a	97a
7 Weeks after application									
Metribuzin	43b	74b	60b	50b	44c	35b	48b	56b	45b
Chlorimuron + Metribuzin	70a	80a	74ab	90a	91a	85a	90a	90a	89a
Chlorimuron + Linuron	69a	85a	78a	90a	86b	81a	88a	89a	84a
Imazaquin	65a	86a	80a	89a	88a	85a	89a	90a	90a
Imazethapyr	70a	86a	81a	91a	89a	86a	91a	90a	88a

[a]Means in a column within the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, NT-BD = no-tillage following burndown, NT-DC = no-tillage, double-cropped.

Table 2. Weed Control Under Different Tillage Systems at Knoxville in 1988.[a]

Herbicide Treatments	Tillage Systems: CT[b] XANST	CT[b] PHBPU	CT[b] IPOHG	NT-BD[b] XANST	NT-BD[b] PHBPU	NT-BD[b] IPOHG	NT-DC[b] XANST	NT-DC[b] PHBPU	NT-DC[b] IPOHG
	(% Control)								
3 Weeks after application									
Metribuzin	23b	30b	20c	25b	35b	28b	28b	33b	24b
Chlorimuron + Metribuzin	83a	74a	74a	91a	95a	89a	94a	94a	90a
Chlorimuron + Linuron	80a	69a	69b	88a	91a	85a	91a	91a	88a
Imazaquin	78a	70a	70ab	85a	91a	84a	90a	93a	86a
Imazethapyr	79a	70a	70ab	85a	93a	87a	90a	93a	89a
7 Weeks after application									
Metribuzin	24b	29b	23c	23b	26b	23b	23b	29b	20c
Chlorimuron + Metribuzin	84a	80a	73ab	88a	84a	80a	90a	89a	83ab
Chlorimuron + Linuron	83a	81a	74ab	86a	81a	79a	88a	86a	79b
Imazaquin	81a	80a	70b	85a	83a	73a	88a	86a	80b
Imazethapyr	86a	86a	81a	85a	84a	79a	90a	90a	88a

[a]Means in a column within the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, NT-BD = no-tillage following burndown, NT-DC = no-tillage, double-cropped.

Table 3. Weed Control Under Different Tillage Systems at Milan in 1987.[a]

Herbicide Treatments	Tillage Systems					
	CT[b]			NT-DC[b]		
	XANST	IPOHE	DIGSA	XANST	IPOHE	DIGSA
	(% Control)					
3 Weeks after application						
Metribuzin	49 b	55 b	65 b	35 b	43 b	55 b
Chlorimuron + Metribuzin	98 a	98 a	98 a	98 a	99 a	92 a
Chlorimuron + Linuron	93 a	91 a	97 a	96 a	98 a	92 a
Imazaquin	99 a	98 a	97 a	96 a	98 a	97 a
Imazethapyr	97 a	98 a	99 a	98 a	99 a	97 a
7 Weeks after application						
Metribuzin	49 b	55 b	58 b	35 b	40 b	56 b
Chlorimuron + Metribuzin	94 a	95 a	93 ab	96 a	98 a	91 ab
Chlorimuron + Linuron	88 a	90 a	92 ab	96 a	97 a	91 ab
Imazaquin	98 a	97 a	82 b	93 a	96 a	83 b
Imazethapyr	97 a	98 a	99 a	97 a	98 a	94 a

[a]Means in a column within the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage system designated as follows: CT = conventional tillage, NT-DC = no-tillage, double-cropped.

Table 4. Weed Control Under Different Tillage Systems at Milan in 1988.[a]

Herbicide Treatments	Tillage Systems: CT[b] XANST	CT[b] IPOHE	CT[b] CASOB	NT-BD[b] XANST	NT-BD[b] IPOHE	NT-BD[b] CASOB	NT-DC[b] XANST	NT-DC[b] IPOHE	NT-DC[b] CASOB
	(% Control)								
3 Weeks after application									
Metribuzin	30b	30b	44a	29b	30b	49a	30b	30b	45a
Chlorimuron + Metribuzin	98a	99a	36b	95a	99a	39b	97a	99a	39b
Chlorimuron + Linuron	98a	97a	33b	99a	99a	43b	95a	99a	38b
Imazaquin	98a	96a	36b	95a	99a	39b	96a	99a	40b
Imazethapyr	99a	99a	33b	97a	99a	34c	96a	99a	34c
7 Weeks after application									
Metribuzin	51b	49b	54a	35b	34b	60a	32b	31b	55b
Chlorimuron + Metribuzin	93a	95a	53a	90a	94a	67a	95a	94a	69a
Chlorimuron + Linuron	95a	91a	54a	94a	95a	68a	93a	94a	63ab
Imazaquin	64ab	60ab	44a	93a	94a	63a	93a	91a	60ab
Imazethapyr	93a	94a	45a	95a	94a	63a	91a	91a	58ab

[a]Means in a column within the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, NT-BD = no-tillage following burndown, NT-DC = no-tillage, double-cropped.

all treatments except metribuzin. Sicklepod control at 3 WAP in 1988 was unsatisfactory. Metribuzin gave the best sicklepod control at this rating. At 7 WAP, all herbicide treatments except metribuzin provided adequate control of all species excluding sicklepod. There was a trend for greater sicklepod control with chlorimuron plus metribuzin or chlorimuron plus linuron at this rating.

At Crossville, all herbicide treatments with the exception of metribuzin provided 73 to 99% control of pitted morningglory, ivyleaf morningglory, common cocklebur (1988 only) and yellow nutsedge at 3 WAP (Table 5 and 6). In 1987 slightly better yellow nutsedge control was observed with chlorimuron plus metribuzin. Control was maintained through the seven week rating.

At Spring Hill in 1987, with the exception of metribuzin there were no statistical differences at 3 WAP among herbicides for control of tall morningglory (PHBPU), ivyleaf morningglory or jimsonweed (DATST)(Table 7). All herbicides provided better control of these species than did metribuzin. At 7 WAP, the same trend was observed with slightly better ivyleaf morningglory control with imazethapyr.

Significant interactions between herbicide treatments and tillage treatments occurred at Knoxville and Milan. At Knoxville, interactions were observed for the control of entireleaf and tall morningglory in 1987 and 1988. At Milan, interactions were observed for the control of ivyleaf morningglory in 1987 and 1988, plus common cocklebur in 1988. These interactions may possibly be associated with the increased cover crop residue present at these locations.

Table 5. Weed Control Under Different Tillage Systems at Crossville in 1987.[a]

Herbicide Treatments	Tillage Systems								
	CT[b]			ST[b]			NT[b]		
	IPOLA	IPOHE	CYPES	IPOLA	IPOHE	CYPES	IPOLA	IPOHE	CYPES
	(% Control)								
3 Weeks after application									
Metribuzin	80b	75b	74b	86b	85b	60c	87b	88b	64b
Chlorimuron + Metribuzin	97a	95a	97a	99a	99a	98a	97a	98a	94a
Chlorimuron + Linuron	97a	94a	97a	98a	98a	88ab	97a	88a	94a
Imazaquin	93a	92a	91a	99a	98a	73b	95a	98a	88a
Imazethapyr	92a	96a	96a	99a	97a	93a	95a	97a	94a
7 Weeks after application									
Metribuzin	58b	53b	55c	66b	65b	55b	66c	74b	53b
Chlorimuron + Metribuzin	92a	89a	94a	91a	90a	89a	92a	95a	91a
Chlorimuron + Linuron	89a	91a	88a	86a	89a	84a	89a	90a	88a
Imazaquin	85a	89a	80b	88a	90a	63a	86ab	90a	76a
Imazethapyr	88a	90a	88a	91a	94a	83a	85b	91a	88a

[a]Means in a column within the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, ST = shallow tillage, NT = no-tillage.

Table 6. Weed Control Under Different Tillage Systems at Crossville in 1988.[a]

Herbicide Treatments	Tillage Systems								
	CT[b]			ST[b]			NT[b]		
	IPOLA	IPOHE	XANST	IPOLA	IPOHE	XANST	IPOLA	IPOHE	XANST
	(% Control)								
3 Weeks after application									
Metribuzin	34b	35b	35b	33b	38b	38c	30b	35b	33b
Chlorimuron + Metribuzin	93a	94a	95a	95a	99a	98a	95a	97a	96a
Chlorimuron + Linuron	95a	95a	94a	97a	99a	97a	90a	92a	90a
Imazaquin	91a	96a	95a	95a	97a	97a	95a	96a	96a
Imazethapyr	95a	96a	95a	95a	97a	93b	94a	97a	96a
7 Weeks after application									
Metribuzin	28c	28b	64b	29b	30b	66b	30b	25b	68b
Chlorimuron + Metribuzin	90ab	88a	99a	93a	91a	99a	91a	93a	99a
Chlorimuron + Linuron	89ab	89a	98a	90a	88a	97a	90a	91a	99a
Imazaquin	85b	86a	99a	89a	90a	97a	91a	91a	98a
Imazethapyr	94a	91a	99a	90a	91a	99a	91a	91a	99a

[a]Means in a column within the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, ST = shallow tillage, NT = no-tillage.

Table 7. Weed Control Under Different Tillage Systems at Spring Hill in 1987.[a]

Herbicide Treatments	Tillage Systems: CT[b]			ST[b]			NT[b]		
	PHBPU	IPOHE	DATST	PHBPU	IPOHE	DATST	PHBPU	IPOHE	DATST
	(% Control)								
3 Weeks after application									
Metribuzin	55c	33c	51b	58b	49b	79b	53b	49b	63b
Chlorimuron + Metribuzin	97a	90b	99a	98a	95a	99a	93a	89a	96a
Chlorimuron + Linuron	95b	88b	99a	97a	94a	99a	90a	88a	99a
Imazaquin	98a	95ab	99a	90a	86a	99a	96a	91a	99a
Imazethapyr	99a	98a	99a	93a	90a	99a	99a	98a	99a
7 Weeks after application									
Metribuzin	49b	41c	51b	43c	39b	73b	59b	53b	66b
Chlorimuron + Metribuzin	93a	90ab	99a	94a	88a	99a	88ab	80ab	98a
Chlorimuron + Linuron	88a	83b	99a	94a	90a	97a	85ab	80ab	99a
Imazaquin	96a	93a	99a	79b	79a	99a	89ab	85a	99a
Imazethapyr	95a	92a	99a	90a	86a	99a	96a	96a	99a

[a]Means in a column within the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, ST = shallow tillage, NT = no-tillage.

Soybean Response

Soybean response to herbicide applications was measured and quantified using visual ratings and heights at each location during both years with the exception of Crossville in 1988 (Table 8). Due to unsatisfactory stand, response data could not be collected. Chlorimuron plus metribuzin, chlorimuron plus linuron, and imazaquin produced the greatest soybean injury at both rating dates at Knoxville both years. Imazethapyr caused less visual injury than the herbicides mentioned above. In 1987 and 1988, significant tillage by herbicide interactions were recorded for soybean injury data. Soybean height data correlate well with visual soybean injury data (Table 9). Chlorimuron plus metribuzin and chlorimuron plus linuron had 10 and 14% height reductions, respectively (7 WAP, 1987). Imazaquin and imazethapyr had 7% reductions at this rating. At harvest, chlorimuron plus metribuzin, chlorimuron plus linuron and imazaquin had 7% height reductions while imazethapyr exhibited no reduction. In 1988, chlorimuron plus metribuzin was the only treatment exhibiting a height reduction (14%) at 7 WAP. At harvest, no treatment with the exception of the weedy check showed any significant height reduction.

At Milan, chlorimuron plus metribuzin produced the greatest soybean injury 3 WAP both years (Table 10). However, at 7 WAP in 1987, there were no significant differences among herbicide treatments with the exception of the metribuzin alone treatment. In 1988, the seven week rating indicated greater injury with chlorimuron plus metribuzin. Tillage systems and herbicides interacted significantly in 1988, but not in 1987. Herbicides did not affect soybean height at

Table 8. Soybean Injury Under Different Tillage Systems at Knoxville in 1987 and 1988.[a]

Herbicide Treatments	3 Weeks After Planting			7 Weeks After Planting		
	CT[b]	NT-BD[b]	NT-DC[b]	CT[b]	NT-BD[b]	NT-DC[b]
	--------(%)----------			----------(%)----------		
1987						
Metribuzin	0 a	0 c	0 b	5 a	3 c	8 a
Chlorimuron + Metribuzin	3 a	9 ab	10 a	4 a	11 ab	13 a
Chlorimuron + Linuron	4 a	11 a	10 a	5 a	14 a	13 a
Imazaquin	3 a	6 b	11 a	4 a	6 bc	9 a
Imazethapyr	4 a	6 b	9 a	1 a	6 bc	9 a
1988						
Metribuzin	0 b	0 c	3 c	0 c	0 c	0 c
Chlorimuron + Metribuzin	8 a	14 a	14 a	6 ab	10 ab	11 a
Chlorimuron + Linuron	6 a	13 a	13 ab	7 a	10 ab	11 a
Imazaquin	5 a	14 a	11 ab	7 a	8 ab	7 b
Imazethapyr	5 a	8 b	9 b	5 b	7 b	7 b

[a]Means in a column within the same year with the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, NT-BD = no-tillage following wheat burndown, NT-DC = no-tillage, double-cropped.

Table 9. Effects of selected herbicides on soybean height.[a]

Herbicide Treatments	Knoxville 1987	Knoxville 1988	Milan 1987	Milan 1988	Crossville 1987	Spring Hill 1987
	(cm)					
7 weeks after planting						
Metribuzin	61 bc	64 a	84 a	93 a	84 a	102 ab
Chlorimuron + Metribuzin	58 cd	56 b	79 ab	78 c	79 b	94 c
Chlorimuron + Linuron	58 cd	58 ab	79 ab	81 c	76 b	97 bc
Imazaquin	64 ab	60 ab	79 ab	87 b	76 b	94 c
Imazethapyr	64 ab	63 a	81 ab	89 b	74 b	102 ab
Weed free	69 a	65 a	79 ab	93 a	86 a	107 a
Weedy	57 d	59 ab	76 b	94 a	88 a	104 a
At harvest						
Metribuzin	64 bc	60 a	81 a	90 a	98 b	94 a
Chlorimuron + Metribuzin	66 bc	56 ab	79 a	77 b	94 b	89 bc
Chlorimuron + Linuron	64 bc	56 ab	76 a	78 b	94 b	89 bc
Imazaquin	66 ab	57 ab	79 a	82 ab	94 b	86 c
Imazethapyr	71 a	60 a	79 a	88 a	94 b	89 bc
Weed free	69 ab	60 a	79 a	90 a	100 a	91 ab
Weedy	61 c	53 b	76 a	89 a	94 b	91 ab

[a]Means in a column within the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Table 10. Soybean Injury Under Different Tillage Systems at Milan in 1987 and 1988.[a]

Herbicide Treatments	3 Weeks After Planting CT[b]	NT-BD[b]	NT-DC[b]	7 Weeks After Planting CT[b]	NT-BD[b]	NT-DC[b]
	--------(%)----------			----------(%)----------		
1987						
Metribuzin	1 b	--	1 c	5 a	--	5 c
Chlorimuron + Metribuzin	6 a	--	14 a	8 a	--	15 a
Chlorimuron + Linuron	6 a	--	10 a	6 a	--	14 a
Imazaquin	6 a	--	11 a	9 a	--	13 a
Imazethapyr	6 a	--	4 b	6 a	--	11 a
1988						
Metribuzin	0 c	0 d	0 d	1 b	0 c	1 d
Chlorimuron + Metribuzin	9 a	15 a	15 a	13 a	21 a	25 a
Chlorimuron + Linuron	5 b	15 a	11 b	12 a	10 b	19 b
Imazaquin	5 b	11 b	10 b	4 b	10 b	12 c
Imazethapyr	0 c	5 c	5 c	5 b	13 b	8 c

[a]Means in a column within the same year with the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, NT-BD = no-tillage following wheat burndown, NT-DC = no-tillage following wheat harvest.

Milan in 1987 (Table 9). In 1988, all treatments with the exception of metribuzin caused significant reductions in height when compared to the hand-weeded check. Chlorimuron plus metribuzin and chlorimuron plus linuron produced the shortest soybeans. At harvest, the same trend was observed.

At Crossville in 1987, no differences were recorded among herbicide treatments at 3 WAP (Table 11). At the seven week rating imazethapyr showed the greatest injury. Soybean height data showed reductions of 3 to 12% compared to the untreated check (3 WAP). Heights for all herbicide treatments with the exception of metribuzin were statistically equivalent to the hand-weeded check at 7 WAP (Table 9).

At Spring Hill in 1987, chlorimuron plus metribuzin and imazaquin caused the greatest soybean injury at both rating dates (Table 12). Soybean heights were reduced with chlorimuron plus metribuzin, chlorimuron plus linuron, and imazaquin at both ratings (Table 9).

In summary, greater soybean injury occurred with chlorimuron plus either metribuzin or linuron and imazaquin. This injury was primarily in the form of delayed canopy closure and reduced height due to internode shortening.

Soybean Yields

Soybean yields at all locations in 1987 were low due to unusually dry conditions (Table 13). At Knoxville, imazethapyr produced significantly greater yields compared to other herbicide treatments.

Table 11. Soybean Injury Under Different Tillage Systems at Crossville in 1987.[a]

Herbicide Treatments	3 Weeks After Planting			7 Weeks After Planting		
	CT[b]	ST[b]	NT[b]	CT[b]	ST[b]	NT[b]
	--------(%)----------			----------(%)----------		
Metribuzin	1 b	1 a	3 a	3 b	4 c	2 b
Chlorimuron + Metribuzin	4 ab	4 a	1 a	8 ab	11 ab	5 ab
Chlorimuron + Linuron	4 ab	5 a	3 a	8 ab	12 ab	4 b
Imazaquin	6 a	1 a	4 a	9 a	9 bc	5 ab
Imazethapyr	4 ab	5 a	5 a	9 a	17 a	8 a

[a]Means in a column with the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, ST = shallow tillage, NT = no-tillage.

Table 12. Soybean Injury Under Different Tillage Systems at Spring Hill in 1987.[a]

Herbicide Treatments	3 Weeks After Planting			7 Weeks After Planting		
	CT[b]	ST[b]	NT[b]	CT[b]	ST[b]	NT[b]
	--------(%)----------			----------(%)----------		
Metribuzin	1 b	1 c	0 d	0 c	0 c	0 c
Chlorimuron + Metribuzin	10 a	19 a	7 bc	11 b	21 a	9 b
Chlorimuron + Linuron	4 b	16 ab	8 ab	6 b	16 ab	8 b
Imazaquin	11 a	12 ab	11 a	18 a	10 b	16 a
Imazethapyr	6 ab	9 bc	4 c	9 b	9 bc	11 ab

[a]Means in a column with the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, ST = shallow tillage, NT = no-tillage.

Table 13. Effects of selected herbicides on soybean yields.[a]

Herbicide Treatment	Knoxville	Milan	Crossville	Spring Hill
1987	----------(kg/ha)----------			
Metribuzin	672 bcd	1478 a	1747 bc	806 b
Chlorimuron + Metribuzin	874 b	1747 a	1949 a	1008 a
Chlorimuron + Linuron	605 cd	1680 a	1882 abc	1075 a
Imazaquin	739 bcd	1680 a	1814 abc	1008 a
Imazethapyr	1210 a	1747 a	1949 a	980 a
Weed free	783 bc	1478 a	1814 abc	1008 a
Weedy	538 d	739 b	1680 c	980 a
1988				
Metribuzin	790 c	1346 b	--	--
Chlorimuron + Metribuzin	1080 b	1989 a	--	--
Chlorimuron + Linuron	832 c	1956 a	--	--
Imazaquin	1057 b	1982 a	--	--
Imazethapyr	1218 b	2021 a	--	--
Weed free	1625 a	2047 a	--	--
Weedy	677 c	1478 b	--	--

[a]Means within the same column and same year followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

All other herbicide treatments produced yields greater or statistically equivalent to the hand-weeded check.

At Milan, there were no significant differences among herbicide treatments; however, all were significantly greater than the weedy check and equal to or greater than the hand-weeded check.

At Crossville, soybeans in chlorimuron plus metribuzin and imazethapyr treatments produced the greatest yields but were only statistically different from the metribuzin treatment and the weedy check. Soybeans in all herbicide treatments produced yields equivalent to or greater than the hand-weeded check.

At Spring Hill, yields from the metribuzin treatment were significantly lower than the remaining herbicide treatments. No differences were observed among other treatments; consequently all were equivalent to the hand-weeded check.

In 1988, yield data were collected only at Knoxville and Milan. At Knoxville, soybeans within chlorimuron plus metribuzin, imazaquin and imazethapyr treatments produced greater yields compared to the chlorimuron plus linuron and metribuzin treatments. Yields of soybeans in all herbicide treatments were greater than the weedy check; however, none were equivalent to the hand-weeded check.

At Milan in 1988, all herbicide treatments with the exception of metribuzin provided yields equivalent to the hand-weeded check. Yield from the metribuzin treatment was not different from the weedy check.

Tillage Comparisons

Weed control

Tillage effects varied with location and year. At Knoxville and Milan, greater effects were measured both years and possibly relate closely to the greater levels of cover crop residue.

At Knoxville in 1987 residue levels were 10,922 kg/ha in the no-till following burndown and 8792 kg/ha in the other two tillage treatments. Tillage effect differences at the 3 and 7 WAP were primarily a reflection of the control of common cocklebur (Table 14). Common cocklebur control was higher in no-till following burndown and no-till following harvest compared to conventional tillage treatment. Cocklebur control was the same in the two no-tillage treatments. Residue levels in 1988 were 8950 kg/ha for the no-till following burndown treatment and 8815 kg/ha for the no-till following wheat harvest treatment. In 1988, differences were recorded for all weed species at 3 weeks after planting (Table 14). Both no-tillage treatments again provided greater weed control. At 7 WAP, tillage effects decreased for morningglory species and did not exist for common cocklebur.

At Milan in 1987, the residue level was 12,463 kg/ha. Tillage did not influence weed control (Table 15). In 1988, differences in control of ivyleaf morningglory and sicklepod were observed between tillage treatments. Residue levels in 1988 were 11,240 kg/ha for no-till

Table 14. Effects of tillage systems on weed control at Knoxville.[a]

Tillage Systems	1987 XANST	1987 PHBPU	1987 IPOHG	1988 XANST	1988 PHBPU	1988 IPOHG
	----------(%)----------			----------(%)----------		
3 weeks after planting						
Conventional	73 b	88	83	68 c	68 b	61 b
No-till/BD	87 a	88	84	75 b	81 a	74 a
No-till/DC	86 a	91	86	79 a	81 a	75 a
		NS	NS			
7 weeks after planting						
Conventional	63 b	82	75	72	71 b	64 b
No-till/BD	82 a	80	75	73	72 b	67 ab
No-till/DC	81 a	83	79	76	76 a	70 a
		NS	NS	NS		

[a]Means in the same column within the same rating date followed by the same letter or NS are not significantly different at the 5% level using Duncan's multiple range test.

Table 15. Effects of tillage systems on weed control at Milan.[a]

Tillage Systems	1987 XANST	1987 IPOHE	1987 DIGSA	1988 XANST	1988 IPOHE	1988 CASOB
	----------(%)----------			----------(%)----------		
3 weeks after planting						
Conventional	87	88	91	84	84	36
No-till/BD	--	--	--	83	85	41
No-till/DC	85	87	86	83	85	40
	NS	NS	NS	NS	NS	NS
7 weeks after planting						
Conventional	85	87	85	79	78	50 b
No-till/BD	--	--	--	81	82	64 a
No-till/DC	83	86	83	81	80	61 a
	NS	NS	NS	NS	NS	

[a]Means within the same column within the same rating date followed by the same letter or NS are not significantly different at the 5% level using Duncan's multiple range test.

following burndown and 11,801 kg/ha for no-till following wheat harvest.

Tillage did not influence weed control at Spring Hill in 1987 (Table 16). The level of cover crop residue was extremely light at 1861 kg/ha and probably did not contribute significantly to moisture conservation.

There were no differences among tillage systems at Crossville in 1987 under light cover crop residue (1091 kg/ha)(Table 17). A slight trend was observed in 1988 for greater weed control with no-tillage treatments compared to conventional or shallow tillage under a residue level of 5815 kg/ha.

Across locations heavy cover crop residue levels seemed to contribute to weed control. This may be explained, in part, by more favorable soil moisture and soil properties.

Soybean Response

Tillage effects on soybean injury varied with location and cover crop residue. Soybean injury tended to increase with increasing amounts of cover crop residue. At Knoxville, differences in soybean injury were observed among tillage treatments (Table 18). The same trend was observed both years at the 3 WAP. Greater soybean injury was observed in the two no-tillage treatments compared to conventional tillage. At the seven week rating, differences among tillage systems decreased in 1987 and 1988. Tillage systems contributed to soybean height differences (Table 19). In 1987 and 1988, no-tillage treatments

Table 16. Effects of tillage systems on weed control at Spring Hill.[a]

Tillage Systems	1987 PHBPU	IPOHE	DATST
	----------(%)----------		
3 weeks after planting			
Conventional tillage	89	81	90
Shallow tillage	87	83	91
No-tillage	86	83	95
	NS	NS	NS
7 weeks after planting			
Conventional tillage	84	80	91
Shallow tillage	83	79	92
No-tillage	80	76	93
	NS	NS	NS

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

Table 17. Effects of tillage systems on weed control at Crossville.[a]

Tillage Systems	1987 IPOLA	1987 IPOHE	1987 CYPES	1988 IPOLA	1988 IPOHE	1988 XANST
	----------(%)----------			----------(%)----------		
3 weeks after planting						
Conventional	92 b	90	91 a	81	83	83
Shallow tillage	94 ab	95	87 ab	81	83	82
No-tillage	96 a	96	82 b	83	86	85
		NS		NS	NS	NS
7 weeks after planting						
Conventional	85	84	84	77	76	79
Shallow tillage	89	90	82	79	78	80
No-tillage	88	88	75	77	78	80
	NS	NS	NS	NS	NS	NS

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

Table 18. Effects of tillage systems on soybean injury at Knoxville and Milan.[a]

Tillage Systems	Knoxville		Milan	
	1987	1988	1987	1988
	(%)			
3 weeks after planting				
Conventional	3 b	5 b	5 b	4 c
No-till/BD	8 a	10 a	-	8 b
No-till/DC	7 a	10 a	8 a	9 a
7 weeks after planting				
Conventional	4 b	5	7 b	7 b
No-till/BD	10 a	7	-	13 a
No-till/DC	8 ab	7	12 a	11 a
		NS		

[a]Means in a column within the same rating date followed by the same letter or NS are not significantly different at the 5% level using Duncan's multiple range test.

Table 19. Effects of tillage systems on soybean height at Knoxville and Milan.[a]

Tillage Systems	Knoxville		Milan	
	1987	1988	1987	1988
	----------(cm)----------			
7 weeks after planting				
Conventional	52 b	46 b	74 b	79 b
No-till/BD	66 a	64 a	--	91 a
No-till/DC	67 a	62 a	85 a	93 a
At harvest				
Conventional	62 c	48 b	73 b	78 b
No-till/BD	65 b	65 a	--	89 a
No-till/DC	71 a	62 a	84 a	90 a

[a]Means in a column within the same rating date followed by the same letter are not significantly different at 5% level using Duncan's multiple range test.

produced taller soybean plants compared to the conventional tillage treatment. These results were observed at both dates.

At Milan in 1987, the no-tillage treatment showed greater injury than did the conventional tillage treatment (Table 18). This was observed at both rating dates. In 1988 when a third tillage treatment was added, similar results were obtained. Under the heavy crop residue (8950 and 8815 kg/ha), increased soybean injury occurred in the two no-tillage treatments. The two no-tillage treatments differed also. After planting, soybeans in the no-till following burndown treatment emerged 1 to 2 days early than other tillage treatments, perhaps due to the additional moisture. Soybean plants grew taller within no-tillage systems (Table 19).

At Spring Hill in 1987, there were no differences recorded among tillage systems (Table 20), yet there was a trend of greater soybean injury with the no-tillage treatment. Soybean heights were not affected by tillage (Table 21).

Results at Crossville were similar to those from Spring Hill. In 1987, no differences were observed among tillage systems at 3 WAP; however, there were differences at 7 WAP (Table 20). The no-tillage treatment exhibited greater injury than did conventional or shallow tillage. No differences were observed among tillage systems for soybean height (Table 21).

Differences among tillage systems could be related to several factors. Decreased furrow coverage by the planter in no-till plots may allow for herbicide movement into the rooting zone during rainfall. A study by Worsham (61) concluded differences in furrow coverage may

Table 20. Effects of tillage systems on soybean injury at Crossville and Spring Hill.[a]

Tillage Systems	Crossville 1987	Spring Hill 1987
	----------(%)----------	
3 weeks after planting		
Conventional	4	6
Shallow tillage	3	6
No-tillage	3	11
	NS	NS
7 weeks after planting		
Conventional	7 b	9
Shallow tillage	5 b	9
No-tillage	11 a	11
		NS

[a]Means in a column within the same rating date followed by the same letter or NS are not significantly different at the 5% level using Duncan's multiple range test.

Table 21. Effects of tillage systems on soybean heights at Crossville and Spring Hill.[a]

Tillage Systems	Crossville 1987	Spring Hill 1987
	----------(cm)----------	
7 weeks after planting		
Conventional	78 b	98
Shallow tillage	81 a	98
No-tillage	80 ab	101
		NS
At harvest		
Conventional	96	90
Shallow tillage	95	90
No-tillage	96	88
	NS	NS

[a]Means in a column within the same rating dating followed by the same letter or NS are not significantly different at the 5% level using Duncan's multiple range test.

contribute to soybean injury. Some soybean response may also be associated with emerging soybeans contacting herbicide on surface straw residue. Improved soil moisture and properties may, perhaps, be factors affecting soybean injury. These may aid or allow for more rapid herbicide movement. The trend for greater soybean heights with no-tillage might be related to moisture conservation during the growing season.

Soybean Yields

Soybean yields were quantified at all locations in 1987 and at Knoxville and Milan in 1988 (Table 22). Differences among tillage systems were observed at locations where heavy cover crop residue was present. At Knoxville in 1987 and 1988, statistical differences were observed among tillage treatments. The two no-tillage treatments produced greater soybean yields compared to the conventional tillage treatment. At Milan in 1987, a trend for greater soybeans yields in no-tillage was observed, but was not significant. However, in 1988 differences among tillage treatments were significant and again showed greater yields with no-tillage treatments. There were no differences among tillage treatments at Crossville and Spring Hill in 1987. Soybean yields tended to increase with increasing amounts of cover crop residue. Again, this might be partially explained by moisture conservation.

Table 22. Effects of tillage systems on soybean yields.[a]

Tillage Systems	Knoxville 1987	Knoxville 1988	Milan 1987	Milan 1988
	(kg/ha)			
Conventional	585 b	718 b	1329	1566 b
No-till/BD	943 a	1195 a	----	1982 a
No-till/DC	852 a	1206 a	1698	1948 a
			NS	

Tillage Systems	Crossville 1987	Spring Hill 1987
	(kg/ha)	
Conventional	1927	939
Shallow tillage	1738	943
No-tillage	1839	1007
	NS	NS

[a]Means within a column with the same letter or NS are not significantly different at the 5% level using Duncan's multiple range test.

CHAPTER IV

INTERACTIONS OF STRAW MULCH AND PREEMERGENCE HERBICIDES IN THE GREENHOUSE

A. Introduction

The use of conservation tillage systems has increased over the past several years. With the introduction of these tillage systems have come concerns about residue management. Researchers investigating no-tillage usage report reluctance of adoption by farmers are due to concerns about weed control and residue management. Studies have shown that surface residue from a previous crop may alter herbicide application and activity. In the Southeast, the primary residue concerns are associated with a wheat and soybean double-cropping program.

Controlling erosion in the Southeast is the primary reason for the use of conservation tillage systems. There have also been reports of improved soil moisture and soil physical properties with the use of these systems. Eliminating major tillage operations allows for reduced soil compaction and structure destruction. Conservation tillage therefore reduces runoff and sedimentation which in essence decreases water contamination as well as soil erosion.

In conservation tillage, greater amounts of herbicides are used for weed control. Applying herbicides to surfaces covered with residue may alter weed control and crop response. The objective of this study

was to determine the effects of straw mulch on the soybean injury associated with selected preemergence herbicides.

B. Materials and Methods

Research was conducted in the greenhouse facilities at the University of Tennessee in Knoxville between March 23 and May 30, 1988. Five hundred and eighty grams (g) of a sandy loam soil with 1% organic matter and a pH of 7.8 were added to 0.53 L plastic containers. Three straw mulch treatments were established: (1) 4.5 g of straw placed on the soil surface; (2) 4.5 g of straw incorporated thoroughly into the soil; and (3) a no straw treatment. The 4.5 g of straw was equivalent to 4480 kg/ha of residue. The straw mulch was chopped in 1- to 3-cm lengths. Ten ('Asgrow 5474') soybean seed were planted 3.7 cm deep in each container. Upon germination the plants were thinned to five plants per pot.

The pots were treated with a preemergence herbicide with a CO_2 backpack sprayer with a three nozzle boom. Applications were made in a water carrier at 187 liters per acre. The preemergence herbicide applications included: metribuzin (0.22 or 0.43 kg ai/ha), chlorimuron + metribuzin (0.03 + 0.19 or 0.06 + 0.37 kg ai/ha), chlorimuron + linuron (0.02 + 0.26 or 0.04 + 0.52 kg ai/ha), imazaquin (0.07 or 0.14 kg ai/ha), and imazethapyr (0.055 or 0.11 kg ai/ha). Control treatments with no preemergence herbicide were also included.

Plant heights and visual soybean injury ratings were taken at weekly intervals. The plants were harvested at 4 WAP and fresh and dry

weights determined. The data were subjected to an analysis of variance and means separated by Duncan's multiple range test at the 5% level of probability.

The experimental design was a randomized complete block in the greenhouse; however was analyzed as a split-plot factorial arrangement of treatments in a randomized complete block. This allowed for the determination of treatment interactions. The straw mulch treatment were assigned to the main plots and the herbicide treatments were assigned to the sub-plots. The study was conducted twice and data were combined for a total of 8 replications of each treatment.

C. Results and Discussion

Herbicide Comparisons

Crop Response

Soybean heights were affected by all herbicide treatments; however, significance varied with straw treatments. No differences among herbicides were observed with no straw treatments, 2 WAP (Table 23). At 4 WAP, the high rate of chlorimuron plus linuron caused a 15% decrease in soybean height compared to the untreated check. In the surface straw treatment, both rates of chlorimuron plus metribuzin, chlorimuron plus linuron and the low rate of imazethapyr reduced plant heights at 2 WAP. Reductions of 10 to 24% were observed with these treatments. At 4 WAP, the high rate of chlorimuron plus linuron was the only herbicide treatment which showed a significant reduction of

Table 23. Effects of straw and selected herbicide treatments on soybean injury and soybean height under greenhouse conditions.[a]

Herbicide Treatments	No Straw		Surface		Incorporated	
	Injury	Height	Injury	Height	Injury	Height
--(kg/ha)-------(%)----(cm)---------(%)----(cm)---------(%)----(cm)--						
2 weeks after application						
Metribuzin						
0.22	6 a	7.9 ab	15 a	10.1 ab	2 ab	6.6 ab
0.43	6 a	7.7 abc	16 a	11.4 a	4 a	6.8 ab
Chlorimuron + Metribuzin						
0.03 + 0.19	5 a	7.6 abc	6 bc	8.8 bc	2 ab	6.5 b
0.06 + 0.37	8 a	7.5 abc	14 a	7.8 c	3 ab	6.2 b
Chlorimuron + Linuron						
0.02 + 0.26	3 a	6.7 c	6 bc	8.8 bc	2 ab	6.5 b
0.04 + 0.52	4 a	7.6 abc	14 a	9.1 bc	3 ab	6.2 b
Imazaquin						
0.07	9 a	6.7 c	5 bc	9.9 ab	2 ab	6.5 b
0.14	2 a	7.1 bc	8 b	13.3 a	2 ab	6.5 b
Imazethapyr						
0.06	0 b	8.2 a	5 bc	9.2 bc	3 ab	6.6 ab
0.11	3 a	7.3 abc	6 bc	9.9 ab	2 ab	5.6 b
Check	0 b	6.8 bc	0 c	10.2 a	0 c	7.8 a
4 weeks after application						
Metribuzin						
0.22	9 a	16.5 a	16 a	18.4 a	5 ab	16.6 a
0.43	13 a	16.3 a	16 a	18.5 a	4 abc	14.2 b
Chlorimuron + Metribuzin						
0.03 + 0.19	2 b	16.2 a	6 bc	14.8 a	2 de	14.5 b
0.06 + 0.37	5 b	14.6 b	16 a	15.1 cde	6 a	13.4 b
Chlorimuron + Linuron						
0.02 + 0.26	3 b	14.4 b	8 b	16.0 bcd	3 bcd	14.6 b
0.04 + 0.52	1 b	13.1 c	9 b	13.8 e	3 bcd	13.4 b
Imazaquin						
0.07	0 b	14.3 bc	6 b	18.2 ab	3 bcd	14.5 b
0.14	1 b	16.6 a	8 b	17.9 ab	0 c	14.3 b
Imazethapyr						
0.06	2 b	16.8 a	5 bc	17.8 abc	3 bcd	13.7 b
0.11	2 b	14.4 b	4 bc	17.4 ab	3 bcd	13.2 b
Check	0 b	15.4 ab	0 c	16.2 cd	0 c	15.0 ab

[a]Means within a column relative to the same rating date with the same letter are not significantly different using Duncan's multiple range test at the 5% level of probability.

15%. All other herbicide treatments were equivalent or greater than the untreated check. With the incorporated treatment, both rates of chlorimuron plus metribuzin, chlorimuron plus linuron, imazaquin and the high rate of imazethapyr caused soybean height reductions (17 to 28%), 2 WAP. At 4 WAP, no differences were observed among herbicide treatments.

Visual rating data for soybean injury were also collected. In the no straw treatment, all herbicides with the exception of the low rate of imazethapyr caused significant soybean injury, 2 WAP. At 4 WAP, only soybeans treated with metribuzin showed significant injury. In the surface straw treatment, both rates of metribuzin, the high rate of chlorimuron plus metribuzin, chlorimuron plus linuron, and imazaquin caused significant injury at 2 WAP. At 4 WAP, the same trend was observed. With the incorporated straw treatment, all herbicides caused significant soybean injury at 2 WAP. Two weeks later, only the low rate of metribuzin continued to cause significant injury. The increased injury with metribuzin can be associated with the sandy textured soil and high pH. This was visible through yellowing and interveinal chlorosis. Chlorimuron plus metribuzin and chlorimuron plus linuron treatments exhibited internode shortening and reduced canopy formation.

Fresh and Dry Weights

Plant fresh weights indicated reductions in plant biomass with all herbicide treatments (Table 24). Imazaquin and imazethapyr affected plant fresh weight less than did other herbicide treatments.

Table 24. Effects of straw and selected herbicide treatments on plant fresh and dry weights under greenhouse conditions.[a]

Herbicide Treatments	No Straw		Surface		Incorporated	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
--(kg/ha)--	----------	----------	(g/plant)	----------	----------	----------
Metribuzin						
0.22	1.04 cde	0.21 ab	1.18 def	0.22 d	1.09 bcd	0.23 abc
0.43	1.06 cde	0.30 a	1.04 ef	0.15 e	0.99 cd	0.18 c
Chlorimuron + Metribuzin						
0.03 + 0.19	1.23 abc	0.25 ab	1.29 cde	0.30 bc	1.15 abc	0.23 abc
0.06 + 0.37	0.93 e	0.18 b	0.93 f	0.14 e	1.10 bcd	0.18 c
Chlorimuron + Linuron						
0.02 + 0.26	1.14 bcd	0.23 ab	1.35 cd	0.31 b	1.35 ab	0.29 a
0.04 + 0.52	1.01 de	0.22 ab	1.10 ef	0.24 cd	0.87 d	0.17 c
Imazaquin						
0.07	1.39 a	0.28 ab	1.58 bc	0.42 a	1.37 ab	0.25 ab
0.14	1.33 ab	0.27 ab	1.51 c	0.38 a	1.18 abc	0.26 ab
Imazethapyr						
0.06	1.18 a-d	0.25 ab	1.83 ab	0.41 a	1.40 a	0.29 ab
0.11	1.22 abc	0.25 ab	1.36 cd	0.31 b	1.08 cd	0.22 bc
Check	1.28 ab	0.26 ab	1.90 a	0.41 a	1.25 abc	0.27 ab

[a]Means within a column with the same letter are not significantly different using Duncan's multiple range test at the 5% level of probability.

Chlorimuron plus metribuzin and chlorimuron plus linuron treatments caused greater reduction than did imazaquin or imazethapyr (5 to 51% vs. 0 to 28%). Reductions seemed to increased with increasing rates of each herbicide. Metribuzin treatments also caused significant reductions (12 to 45%). Plant dry weights showed similar trends with chlorimuron plus metribuzin, chlorimuron plus linuron and metribuzin treatments exhibiting the lowest plant dry weights.

Fresh root weights indicated that all herbicide treatments affected root development (Table 25). Three to 64% reductions in fresh weights were recorded. Chlorimuron plus metribuzin treatments provided the lowest root weights followed by chlorimuron plus linuron, imazaquin, metribuzin and imazethapyr treatments. Lack of differences in dry root weights might be attributed to lack of sensitivity in measurements. A decrease in the number of fibrous roots was observed in all herbicide treatments.

Straw Treatment Comparisons

Soybean Response

Soybean heights were significantly affected by straw treatments. At all rating dates, surface straw produced the tallest soybeans (Table 26). Differences between the no straw and the incorporated straw treatments were observed at 2 and 3 WAP. Increased plant height with the surface straw treatment can be explained by moisture retention. Surface straw pots retained mositure considerably longer than did the other pots. Soybean injury rated visually also showed increased

injury with the surface straw treatment. There were no differences between no straw and incorporated straw treatments.

Fresh and Dry Weights

Plant fresh weights for straw treatments followed the trend seen with plant height data (Table 27). Surface straw treatment provided significantly greater soybean fresh and dry weights compared to the other straw treatments. There were no differences between no straw and incorporated straw treatments for soybean fresh and dry plant weights. Fresh and dry root weights did not indicate differences among straw treatments.

Significant interactions between herbicide and straw treatments were observed for all data with the exception of dry root weights. Interactions for all data may be explained by moisture differences in the surface straw treatment compared to the incorporated and no straw treatments.

Table 25. Effects of straw and selected herbicide treatments on root fresh and dry weights under greenhouse conditions.[a]

Herbicide Treatments	No Straw		Surface		Incorporated	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
--(kg/ha)----------	----------	----------	(g/plant)----------	----------	----------	----------
Metribuzin						
0.22	0.86 c	0.10 b	0.91 b	0.10 ab	0.90 b	0.09 ab
0.43	0.83 c	0.12 b	0.74 c	0.10 ab	0.69 d	0.09 ab
Chlorimuron + Metribuzin						
0.03 + 0.19	0.50 f	0.07 b	0.51 fg	0.07 b	0.51 ef	0.06 b
0.06 + 0.37	0.52 ef	0.08 b	0.44 g	0.07 b	0.45 f	0.07 b
Chlorimuron + Linuron						
0.02 + 0.26	0.64 de	0.10 b	0.56 ef	0.07 b	0.51 ef	0.08 b
0.04 + 0.52	0.58 def	0.08 b	0.64 de	0.80 b	0.55 e	0.07 b
Imazaquin						
0.07	0.85 c	0.10 b	0.85 b	0.10 ab	0.83 c	0.10 ab
0.14	0.56 def	0.08 b	0.56 ef	0.08 ab	0.55 e	0.08 b
Imazethapyr						
0.06	1.08 b	0.12 b	1.13 a	0.11 ab	1.20 a	0.13 a
0.11	0.67 d	0.08 b	0.67 c	0.09 ab	0.71 d	0.09 ab
Check	1.33 a	0.31 a	1.22 a	0.12 ab	1.23 a	0.14 a

[a]Means within a column with the same letter are not significantly different using Duncan's multiple range test at the 5% level of probability.

Table 26. Effects of straw treatments on soybean injury and heights under greenhouse conditions.[a]

Straw Treatments	Soybean Injury			Soybean Height		
	2 wks	3 wks	4 wks	2 wks	3 wks	4 wks
----------	----------	(%)----------	----------	----------	(cm)----------	----------
No straw	4 b	3 b	3 b	7 b	11 b	15 b
Surface	8 a	9 a	9 a	10 a	13 a	17 a
Incorporated	2 b	2 b	3 b	6 c	10 c	14 b

[a]Means with in a column with the same letter are not significantly different using Duncan's multiple range test at the 5% level of probability.

Table 27. Effects of straw treatments on plant fresh and dry weights under greenhouse conditions.[a]

Straw Treatments	Plant Fresh Weights	Plant Dry Weights	Root Fresh Weights	Root Dry Weights
	----------(g/plant)----------			
No straw	1.16 b	0.24 b	0.77	0.12
Surface	1.37 a	0.30 a	0.75	0.10
Incorporated	1.17 b	0.24 b	0.74	0.11
			NS	NS

[a]Means within a column with the same letter or NS are not significantly different using Duncan's multiple range test at the 5% level of probability.

CHAPTER V

GENERAL SUMMARY

The objectives of this research were 1) to determine the influence of tillage systems on the efficacy of selected herbicides, and 2) to determine if tillage systems and surface residue levels influence phytotoxicity of various herbicides to soybeans. The primary herbicides studied were the imidazolinones, imazaquin and imazethaypr; and chlorimuron, a sulfonylurea.

With the implementation of new farm bill legislation, the use of conservation tillage has become necessary to control erosion on vulnerable Tennessee soils. In conservation tillage systems, more herbicides are needed to control undesirable vegetation and thus, may be affected by increased levels of cover crop residue.

Results from field and greenhouse studies indicate that tillage systems affect the activity of preemergence herbicides. In field studies all herbicides, with the exception of metribuzin, provided satisfactory control of common cocklebur, annual morningglory, jimsonweed, yellow nutsedge and large crabgrass. However, due to significant tillage by herbicide interactions, trends of greater weed control were observed where heavy surface residues were present. Soybean injury was more pronounced with herbicide treatments containing chlorimuron and imazaquin. Soybean injury, height and yield also tended to be greater where heavy surface residues were present.

Greenhouse studies focusing on soybean injury as affected by straw mulch also supported the trends associated with surface residue. Soybean injury and height tended to be greater when surface straw mulch was present compared to no surface straw.

In conclusion, weed control, soybean injury, height and yield tend to increase with increasing amounts of cover crop residue. Factors contributing to these findings may be associated with increased soil moisture and more favorable soil physical properties. Future research should examine soil and herbicide interactions and the effects these may have on herbicide activity and degradation. There should also be research focusing on the effects of tillage systems on water quality in the agricultural sector.

LITERATURE CITED

LITERATURE CITED

1. Adcock, T. E. 1987. The behavior and control of sicklepod under field and greenhouse conditions. M.S. Thesis. Univ. Tennessee, Knoxville, TN. Pages 73-76.

2. Aison,S. and T. R. Harger. 1984. Evidence of experimental compounds for sicklepod and mexicanweed control in soybeans. Proc. South. Weed Sci. Soc. 37:66.

3. Allen, D. R. and P. A. Banks. 1985. Sicklepod control in soybean with DPX-F6025, (Classic). Proc. South. Weed. Sci. Soc. 38:58.

4. Anderson, P. C. and K. A. Hibberd. 1985. Evidence for the interaction of an imidazolinone herbicide with leucine, valine and isoleucine metabolism. Weed Sci. 33:470-483.

5. Anonymous. 1986. AC-263,499 technical bulletin. American Cyanamid Co. Princeton, NJ 08540.

6. Anonymous. 1985. Agrichemical Product Manual. E. I. du Pont de Nemours and Co. Wilmington DE 19898.

7. Anonymous. 1982. Census for Agriculture. Preliminary Report. United States Dept. of Agri. AC 82-A-47-001-189(P) Pages 49-50.

8. Anonymous. 1978. Census of Agriculture. United States Dept. of Agri. Bureau of the Census. Page 5.

9. Anonymous. 1986. Classic™ technical bulletin. E. I. du Pont de Nemours and Co. Wilmington, DE 19898.

10. Anonymous. 1986. Scepter™ specimen label. American Cyanamid Co. Princeton, NJ 08540.

11. Ashton, F. M. and A. S. Crafts. Mode of action of herbicides. 2nd ed. John Wiley and Sons. New York, NY. Pages 462-463.

12. Banks, P. A. and E. L. Robinson. 1980. Effects of straw mulch on preemergence herbicides. Proc. South. Weed Sci. Soc. 33:286.

13. Banks, P. A. and E. L. Robinson. 1982. The influence of straw mulch on the soil reception and persistence of metribuzin. Weed Sci. 30:164-168.

14. Banks, P. A. and E. L. Robinson. 1986. Soil reception and activity of acetochlor, alachlor and metolachlor as affected by wheat straw and irrigation. Weed Sci. 34:607-611.

15. Barrentine, W. L. and M. E. Kurtz. 1985. Broadleaf weed control in soybeans with DPX-F6025. Proc. South. Weed Sci. Soc. 38:62.

16. Barrentine, W. L. and L. R. Oliver. 1977. Competition threshold levels and control of cocklebur in soybeans. Univ. of Ark. Tech. Bulletin 83.

17. Bozsa, R. C., L. R. Oliver and M. A. Risley. 1986. A weed spectrum comparison of AC-263,499 (Pursuit) and Imazaquin (Scepter). Ark. Agri. Pest. Assoc., Abstract. 25:16.

18. Claus, J. S. 1987. Chlorimuron-ethyl (Classic): A new broadleaf postemergence herbicide in soybeans. Weed Tech. 1:114-115.

19. Crutchfield, D. A., G. A. Wicks and O. C. Burnside. 1985. Effects of winter wheat straw mulch on weed control. Weed Sci. 34:110-114.

20. Edmund, R. M., Jr., A. C. York. 1984. Sicklepod management in soybeans with AC-252,214 and DPX-F6025. Proc. South Weed Sci. Soc. 37:61.

21. Finley, C. R., B. Viar and E. E. Ellison. 1985. Conservation till soybean production - answers to weed control. Proc. South. Weed. Sci. Soc. 38:56-57.

22. Flinchum, W. T. 1983. Guide to no-till soybean production in Tennessee. Publication 1086. Agri. Ext. Service, Univ. of Tennessee, Knoxville, TN. 37901.

23. Gamble, B. E., R. H. Walker, and J. R. Harris. 1985. Evaluation of weed management systems in conservation tillage systems. Proc. South. Weed Sci. Soc. 38:60.

24. Geddes, R. D, H. D. Scott and L. R. Oliver. 1979. Growth and water use by common cocklebur and soybeans under fields conditions. Weed Sci. 27:206-217.

25. Hart, C. and F. Leuthold. 1986. Land tenure and no-tillage use by West Tennessee farmers. Tennessee Farm and Home Sci. 139:10-13.

26. Hinkle, M. L. 1983. Problems with conservation tillage. J. of Soil and Water Conservation 38(3):201-206.

27. Hirrel, M. C. and T. N. Tripp. 1986. Imazaquin (Scepter™) as a predesposing factor associated with root rot complexes of soybean. Ark. Agri. Pest. Assoc., Abstract. 25:16.

28. Jones, J. N., Jr., J. E. Moody and J. H. Lillard. 1969. Effects of tillage, no-tillage and mulch on soil water and plant growth. Agron. J. 61:719-721.

29. Jones, J. N., J. E. Moody, G. M. Shear, W. W. Moschler, and J. H. Lillard. 1968. The no-tillage system for corn. Agron. J. 60:17-20.

30. King, A. D. 1983. Progress in no-till. J. of Soil and Water Conservation. 39(3):160-161.

31. Leuthold, F. O., C. Hart. 1986. Land tenure and no-tillage use by West Tennessee farmers. Dept. of Ag. Econ. and Rural Soc., Institute of Agri., Univ. of TN. 37901. Pages 1-15. (Unpublished)

32. Lewis, W. W. 1978. Weed control in no-till soybeans. In J. T Touchton and D. G. Cummins, eds. Proc. Southeastern No-till Soybean Conf., Univ. Georgia Expt. Sta. Spec. Pub. #5.

33. Lowder, S. W. and J. B. Weber. 1979. Atrazine retention by crop residues in reduced-tillage systems. Proc. South. Weed Sci. Soc. 32:303-307.

34. Malefyt T., P. A. Marc, M. Los, R. S. Orwick and K. Umeda. 1984. AC-263,499 - A new broad spectrum herbicide for soybeans and other leguminous crops. Weed Sci. Soc. Am. Abstracts. Page 18.

35. Mathis, W. D. and L. R. Oliver. 1980. Control of six morningglory species in soybeans (Glycine max). Weed Sci. 28:409-415.

36. Mills, J. A., W. W. Witt, and C. H. Slack. 1987. Effects of tillage on imazaquin, AC-263,499 and FMC-57020 efficacy and phytotoxicity to rotational corn. Weed Sci. Soc. Am. Abstracts. 27:1.

37. Newcomer, D. T., L. J. Girando, and P. A. Banks. 1986. Soybean (Glycine max) cultivar as a factor of weed control in no-till, double-cropped production following wheat (Triticum aestivum). Georgia Agri. Expt. Sta., Univ. of GA. Page 1.

38. Norris, B. E., Jr., and R. H. Walker. 1984. Response of weed species (Fabaceae) to DPX-6025 and AC-252,214 applied postemergence. Proc. South. Weed Sci. Soc. 37:71.

39. O'Neil, J. B., W. F. Congleton, J. C. Dunn, H. M. Hackworth, F. R Huffman, R. S. Mathews, K. R. Muzyk, F. R. Walls, R. M. Watkins, and E. H. Lignowsi. 1985. Weed control in soybeans in the southern region. Proc. South Weed Sci. Soc. 38:62.

40. Paul, J. 1987. Resisting residues. Agrichemical Age. 31(10):6-8.

41. Phillips, R. E., R. L. Blevins, G. W. Thomas, W. W. Frye and S. H. Phillips. 1980. No-tillage agriculture. Science 208:1108-1113.

42. Phillips. S. H. 1982. No-tillage Research: Research Reports and Reviews. R. E. Phillips, G. W. Thomas and R. L. Blevins, eds. Univ. of Kentucky, Lexington, Ky. Pages 1-5.

43. Ray, T. B. 1984. Site of action of chlorsulfuron. Agricultural Chemical Dept. E. I. du Pont de Nemours and Co. Wilmington, DE. 19898. Page 43.

44. Retzinger, E. J., R. L. Rogers and P. A. Richard. 1984. Weed control in soybeans with AC-252,214. Proc. South. Weed Sci. Soc. 37:71.

45. Risley, M. A. and L. R. Oliver. 1984. Influence of application methods of AC-252,214 on a spectrum of weed species. Proc. South. Weed Sci. Soc. 37:72.

46. Robinson. E. L., G. W. Langdale and J. H. Stuedermann. 1984. Effect of three weed control regimes on no-tillage and tilled soybeans. Weed Sci. 32:17-19.

47. Rodrique, L. G. III, B. A. Hadley, C. R. Davis. 1986. Gemini herbicide for weed control in soybeans. Proc. South. Weed. Sci. Soc. 39:29.

48. Senuta, A. 1987. Refining the future of conservation tillage. Agrichemical Age 31(10):12-13.

49. Shaner, D. L., P. C. Anderson and M. A. Stidham. 1984. Imidazolinones - potent inhibitors of acetohydroxyacid synthase. Plant Phys. 76:545-546.

50. Shear, G. M. and W. W. Moschler. 1969. Continuous corn by the no-tillage and conventional tillage methods: a six year comparison. Agron. J. 61:524-526.

51. Shelton C. H. and J. F. Bradley. 1987. Controlling erosion and sustaining production with no-till systems. Tennessee Farm and Home Sci. 141:18.

52. Shelton C. H., F. D. Tompkins and D. D. Tyler. 1983. Soil erosion from five soybean tillage systems in West Tennessee. Tennessee Farm and Home Sci. 122:14.

53. Smith, D. 1987. Countdown to compliance. Farm J. 11(14):18-19.

54. Sprague, M. A. 1952. The substitution of chemical for tillage in pasture renovation. Agron. J. 44:405-409.

55. Steinsiek, J. W. and L. R. Oliver. 1979. Effects of wheat straw and ash on field activity of preemergence herbicides. Proc. South. Weed Sci. Soc. 32:312.

56. Triplett, G. B., Jr. and D. M. Van Dorn, Jr. 1969. Nitrogen, phosphorus and postemergence fertilization of no-tilled maize. Agron. J. 61:637-639.

57. Triplett, G. B., Jr. 1978. Weed control for double crop soybeans planted with the no-tillage method following small grain harvest. Agron. J. 70:577-581.

58. Triplett, G. B., Jr., J. R. Abernathy, C. R. Fensler, W. Flinchum, D. L. Linscottt, E. L. Robinson, L. Standiferand and J. D. Walker. 1983. Weed control reduced-tillage systems. USDA Pages 1-8.

59. Umeda, K., T. Malefyt, R. A. Marc and P. L. Orwick. 1984. Optimum timing of application of Scepter™ soybean herbicide for sicklepod (Cassia obtusifolia) and hemp sesbania (Sesbania exaltata) control: greenhouse studies. Proc. South. Weed Sci. Soc. 37:67.

60. Worsham, A. D. and W. M. Lewis. 1985. Weed management: key to no-tillage crop production. Proc. South Region No-till Conf. Pages 177-186.

61. Worsham, A. D. 1974. Influence of no-tillage planters on tolerance of soybeans to linuron. Weed Sci. 22:340-344.

62. Watkins, R. M. 1985 field evaluation of AC-263,499 for weed control in soybeans. Proc. South. Weed Sci. Soc. 38:49-50.

63. Williams, C. S. and R. M. Hayes. 1984. Johnsongrass (Sorghum halepense) competition in soybeans (Gylcine max). Weed Sci. 32:498-501.

APPENDIXES

LANCASTER BIBLE
100% CHRIST

APPENDIX A

COMMON AND CHEMICAL NAME OF HERBICIDES

APPENDIX A

COMMON AND CHEMICAL NAMES OF HERBICIDES

Common Name	Chemical Name
Chlorimuron	2-[[[[(4-chloro-6-methoxy-2-pyrimidinyl) amino] carbonyl] amino] sulfonyl] benzoic acid
Glyphosate	N-(phosphonomethyl)glycine
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-methyl ethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid
Linuron	N'-(3,4-dichlorophenyl)-N-methoxy-N-methylurea
Metribuzin	4-amino-6-(1,1-dimethylethyl)-3-(methyl-thio)-1,2,4-triazin-5(4H)-one
Paraquat	1,1'-dimethyl-4,4'-bipyridinium ion

APPENDIX B

ADDITIONAL FIELD DATA

APPENDIX B

Table B-1. Weed control under different tillage systems at Knoxville 5 weeks after planting in 1987 and 1988.[a]

Herbicide Treatments	Tillage Systems: CT[b] XANST	CT[b] PHBPU	CT[b] IPOHG	NT-BD[b] XANST	NT-BD[b] PHBPU	NT-BD[b] IPOHG	NT-DC[b] XANST	NT-DC[b] PHBPU	NT-DC[b] IPOHG
	(% Control)								
5 Weeks after application 1987									
Metribuzin	46b	76b	68b	51b	50b	38b	46b	47b	38b
Chlorimuron + Metribuzin	78a	84ab	78a	95a	95a	93a	94a	95a	94a
Chlorimuron + Linuron	75a	90a	81a	94a	91a	89a	91a	95a	87a
Imazaquin	69ab	91a	85a	94a	93a	90a	94a	95a	95a
Imazethapyr	76a	90a	85a	96a	94a	93a	96a	96a	95a
5 Weeks after application 1988									
Metribuzin	25b	38b	26b	25b	33b	24b	30b	35b	28b
Chlorimuron + Metribuzin	85a	81a	76a	89a	88a	83a	94a	91a	90a
Chlorimuron + Linuron	84a	84a	76a	87a	84b	80a	91a	89a	84a
Imazaquin	81a	81a	70a	85a	85a	78a	90a	90a	85a
Imazethapyr	86a	84a	76a	85a	86a	81a	93a	93a	90a

[a]Means in a column within the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, NT-BD = no-tillage following burndown, NT-DC = no-tillage, double-cropped.

Table B-2. Weed control under different tillage systems at Milan 5 weeks after planting in 1987 and 1988.[a]

Herbicide Treatments	Tillage Systems: CT[b]			NT-BD[b]			NT-DC[b]		
	XANST	IPOHE	DIGSA	XANST	IPOHE	DIGSA	XANST	IPOHE	DIGSA
	(% Control)								
5 Weeks after application 1987									
Metribuzin	46b	55b	58c	--	--	--	36b	43b	55b
Chlorimuron + Metribuzin	91a	91a	89ab	--	--	--	95a	95a	89a
Chlorimuron + Linuron	85a	88a	91a	--	--	--	92a	94a	87a
Imazaquin	96a	93a	78bc	--	--	--	91a	93a	81a
Imazethapyr	95a	97a	98a	--	--	--	94a	97a	92a
5 weeks after application 1988									
	XANST	IPOHE	CASOB	XANST	IPOHE	CASOB	XANST	IPOHE	CASOB
Metribuzin	53b	50b	58c	35b	34b	59b	36b	35b	61b
Chlorimuron + Metribuzin	96a	97a	58a	97a	97a	91a	93a	97a	76a
Chlorimuron + Linuron	95a	95a	56a	94a	96a	59a	95a	97a	70ab
Imazaquin	65ab	64ab	44a	93a	95a	65a	95a	97a	69ab
Imazethapyr	93a	93a	45a	93a	95a	65a	94a	94a	69ab

[a]Means in a column within the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, NT-BD = no-tillage following burndown, NT-DC = no-tillage, double-cropped.

Table B-3. Weed control under different tillage systems at Crossville 5 weeks after planting in 1987 and 1988.[a]

Herbicide Treatments	Tillage Systems: CT[b]			ST[b]			NT[b]		
	IPOLA	IPOHE	CYPES	IPOLA	IPOHE	CYPES	IPOLA	IPOHE	CYPES
	(% Control)								
5 Weeks after application 1987									
Metribuzin	65b	59b	64b	79b	80b	59c	70b	71b	61c
Chlorimuron + Metribuzin	95a	95a	97a	97a	98a	95ab	95a	97a	95a
Chlorimuron + Linuron	92a	92a	95a	95a	96a	93ab	92a	93a	88a
Imazaquin	90a	91a	89a	90a	95a	82b	95a	93a	65b
Imazethapyr	91a	94a	94a	93a	96a	95a	98a	96a	88a
5 weeks after application 1988									
	IPOLA	IPOHE	XANST	IPOLA	IPOHE	XANST	IPOLA	IPOHE	XANST
Metribuzin	30b	26b	30c	30b	28b	30b	31b	30b	30b
Chlorimuron + Metribuzin	94a	92a	95a	92a	96a	98a	97a	97a	96a
Chlorimuron + Linuron	95a	92a	93a	93a	94a	95a	97a	96a	97a
Imazaquin	95a	90a	95a	95a	93a	96a	96a	95a	97a
Imazethapyr	96a	96a	96a	96a	96a	97a	96a	95a	97a

[a]Means in a column within the same rating date followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, ST = shallow tillage, NT = no-tillage.

Table B-4. Weed control under different tillage systems at Spring Hill 5 weeks after planting in 1987.[a]

Herbicide Treatments	Tillage Systems								
	CT[b]			ST[b]			NT[b]		
	PHBPU	IPOHE	DATST	PHBPU	IPOHE	DATST	PHBPU	IPOHE	DATST
	----------(% Control)----------								
5 Weeks after applications 1987									
Metribuzin	55b	41c	72b	55b	48b	68b	56b	49b	81b
Chlorimuron + Metribuzin	96a	96a	98a	95a	90a	99a	97a	97a	99a
Chlorimuron + Linuron	94a	90a	99a	91a	90a	99a	97a	95a	99a
Imazaquin	98a	98a	99a	96a	95a	99b	88a	86a	99a
Imazethapyr	98a	97a	99a	98a	98a	99a	97a	96a	99a

[a]Means in a column with the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, ST = shallow tillage, NT = no-tillage.

Table B-5. Soybean injury under different tillage systems at Knoxville 5 weeks after planting in 1987 and 1988.[a]

Herbicide Treatments	1987 CT	1987 NT-BD	1987 NT-DC	1988 CT	1988 NT-BD	1988 NT-DC
	--------(%)----------			----------(%)----------		
Metribuzin	4 a	6 b	8 c	0 b	0 c	0 c
Chlorimuron + Metribuzin	4 a	13 a	13 ab	7 a	14 a	12 a
Chlorimuron + Linuron	6 a	16 a	15 a	6 a	13 a	11 a
Imazaquin	4 a	10 b	6 bc	5 a	9 b	11 a
Imazethapyr	3 a	8 b	6 bc	5 a	9 b	7 b

[a]Means in a column within the same year with the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, NT-BD = no-tillage following wheat burndown, NT-DC = no-tillage, double-cropped.

Table B-6. Soybean injury under different tillage systems at Milan 5 weeks after planting in 1987 and 1988.[a]

Herbicide Treatments	1987 CT	1987 NT-BD	1987 NT-DC	1988 CT	1988 NT-BD	1988 NT-DC
	--------(%)----------			----------(%)----------		
Metribuzin	5 a	--	6 b	1 b	0 c	1 d
Chlorimuron + Metribuzin	8 a	--	13 a	15 a	28 a	28 a
Chlorimuron + Linuron	6 a	--	11 a	16 a	13 b	26 a
Imazaquin	8 a	--	9 ab	5 b	10 b	15 a
Imazethapyr	6 a	--	11 a	5 b	15 b	9 c

[a]Means in a column within the same year with the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, NT-BD = no-tillage following wheat burndown, NT-DC = no-tillage, double-cropped.

Table B-7. Soybean injury under different tillage systems at Crossville 5 weeks after planting in 1987.[a]

Herbicide Treatments	1987 CT[b]	ST[b]	NT[b]
	----------(%)----------		
Metribuzin	0 b	0 c	0 c
Chlorimuron + Metribuzin	6 a	8 a	10 b
Chlorimuron + Linuron	5 a	6 b	13 a
Imazaquin	8 a	5 b	9 b
Imazethapyr	6 a	8 a	16 a

[a]Means in a column within the same year with the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, ST = shallow tillage, NT = no-tillage.

Table B-8. Soybean injury under different tillage systems at Spring Hill 5 weeks after planting in 1987.[a]

Herbicide Treatments	1987 CT[b]	ST[b]	NT[b]
	----------(%)----------		
Metribuzin	0 d	0 c	0 c
Chlorimuron + Metribuzin	8 ab	7 ab	16 a
Chlorimuron + Linuron	3 cd	8 ab	14 a
Imazaquin	11 a	12 a	10 ab
Imazethapyr	5 bc	4 b	7 b

[a]Means in a column within the same year with the same letter are not significantly different at the 5% level using Duncan's multiple range test.
[b]Tillage systems designated as follows: CT = conventional tillage, ST = shallow tillage, NT = no-tillage.

APPENDIX C

RAINFALL DATA

APPENDIX C

Table C-1. Rainfall data at Knoxville in 1987.

DATE	APRIL	MAY	JUNE	JULY	AUG	SEPT
			(cm)			
1	0.05					
2					1.68	0.15
3	1.73					
4	0.89	0.81	2.21	1.04	0.08	
5				0.38		
6				2.92	0.08	
7				1.68	3.40	
8						0.15
9						0.03
10				0.20	0.23	
11	0.51		0.05			
12	0.36			0.43		3.81
13	0.10		1.60		0.03	3.43
14	0.69	0.20		1.02		
15	0.86					
16	0.03		0.03			
17	0.56	0.05	1.85			
18	0.05		0.08		3.68	
19		0.05	1.93			0.10
20			0.25			1.22
21						
22		2.34	1.63			
23		0.03	0.03			
24	0.89	0.03	2.84			
25	0.64					
26						
27			0.20			
28		0.10				
29						
30		0.23				1.27
31		0.41				
TOTAL	7.34	4.24	12.70	9.35	7.65	10.01

Table C-2. Rainfall data at Crossville in 1987.

DATE	APRIL	MAY	JUNE	JULY	AUG	SEPT
			(cm)			
1	0.03			0.91		
2		0.05				
3		0.89	0.56	0.66	2.03	
4	0.15	0.61	1.60	2.41		
5		0.08			0.03	
6				0.94	0.13	0.43
7				0.13	0.28	0.13
8						0.03
9						0.38
10				1.42	0.20	
11						0.46
12				0.05		0.23
13			0.30	1.78	1.17	
14	1.07			0.58		0.28
15	3.86					
16	0.86					
17	0.56		0.81			
18	0.03				0.99	0.38
19		0.20	0.15			1.02
20			1.63			1.14
21		0.33	0.13			
22		1.93	1.27			
23					0.13	
24	0.43	0.13	0.76			
25		1.35	0.05			
26		0.05	0.18			
27		1.14				
28					3.07	
29		0.61				7.75
30		0.18				
31		2.39				
TOTAL	6.99	9.94	7.44	8.88	8.03	12.23

Table C-3. Rainfall data at Spring Hill in 1987.

DATE	APRIL	MAY	JUNE	JULY	AUG	SEPT
	----------	----------	(cm)	----------	----------	----------
1			0.05	1.73		
2			0.18	0.71	0.81	
3	0.43	0.10		1.32	0.23	
4	0.05			1.93	0.20	
5				0.30		
6						0.03
7	0.05					
8						0.13
9				0.74		0.05
10				1.02		
11	0.69			0.36	0.05	2.34
12				0.03		1.70
13			0.51			0.03
14	2.84	0.13		1.12		0.05
15	0.56	0.71	0.43			
16	0.66		0.05			
17	0.46	0.69	0.20			0.03
18	0.05	0.08	0.20		0.86	0.13
19		0.10	0.64			1.85
20			0.13			0.05
21			0.89			
22		0.15	1.04			
23			0.15			
24		3.81	0.08	1.55		
25		0.08	0.48			
26		0.25				
27		0.03				
28	0.38			0.08	0.36	
29						
30		0.20				4.70
31		0.36				
TOTAL	6.17	6.68	5.03	10.87	2.51	11.07

Table C-4. Rainfall data at Milan in 1987.

DATE	APRIL	MAY	JUNE	JULY	AUG	SEPT
	----------(cm)----------					
1				3.81		
2	0.30					
3						
4						
5						
6						
7						2.64
8						
9						
10	0.79				4.83	
11						
12			0.66			
13						0.86
14						
15		1.55				
16						2.95
17						
18						
19						
20						
21	3.25		8.51			
22						
23						
24				1.14		
25		0.76	0.76			
26						
27					0.38	
28						2.18
29						
30			3.81			
31		3.53				
TOTAL	4.34	5.84	13.74	4.95	5.21	8.64

Table C-5. Rainfall data at Knoxville in 1988.

DATE	APRIL	MAY	JUNE	JULY	AUG	SEPT
	(cm)					
1	0.10					
2	0.74					
3	0.08			0.05		
4	0.33	0.89		0.64		0.31
5		3.25			2.74	
6	0.33					
7	0.13				0.38	
8	0.25					
9		0.45				
10		0.41	1.60			
11		0.94				0.03
12	0.13			1.96	0.31	
13	0.13			0.05		0.18
14				5.21		
15						
16	0.79	0.03				
17		1.04				2.01
18	0.99			0.28		0.51
19	2.03					
20					1.14	
21			0.03	0.13	0.10	
22				3.43		
23		0.10		0.20		
24	0.28	0.46		0.18	0.25	
25		1.65	0.56			0.87
26			0.61			
27				0.10		
28				0.36		
29						
30			0.23			
TOTAL	6.31	9.23	3.04	12.63	4.92	3.91

Table C-6. Rainfall data at Crossville in 1988.

DATE	APRIL	MAY	JUNE	JULY	AUG	SEPT
			(cm)			
1	0.43			0.51		
2	2.41					
3				1.02		
4	0.25	1.04		0.03	1.40	4.27
5		0.81				0.15
6					0.51	0.03
7					0.51	
8						
9		0.66				
10		1.30	1.52			
11						
12	0.61			4.45	0.79	0.25
13	0.71			0.79		
14				5.38		
15						
16	0.31					
17		0.13		0.84		3.99
18	2.03					0.48
19	1.17			0.36		
20					4.88	
21				5.59	3.35	
22				0.66		
23		0.25		0.03		
24	0.38	0.94			3.12	
25		1.02				4.62
26			2.24	0.51		2.82
27				0.18		
28				0.13		
29						
30			0.51	0.69	0.10	
31						
TOTAL	10.52	6.15	2.44	19.30	13.70	16.61

Table C-7. Rainfall data at Milan in 1988.

DATE	APRIL	MAY	JUNE	JULY	AUG	SEPT
	----------(cm)----------					
1						
2				2.69	0.08	
3						2.41
4						
5	0.25					
6						
7						
8		3.50				
9						
10				0.28		
11						0.05
12						
13				8.97		
14						
15						
16						
17	1.75					
18						
19						
20						
21					2.03	
22		3.96				
23						
24		1.25		7.24		
25						
26						
27						
28						
29						
30				5.46		
31						
TOTAL	2.00	8.71	0.00	24.64	2.11	2.46

APPENDIX D

LIST OF ABBREVIATIONS

APPENDIX D

LIST OF ABBREVIATIONS

ABBREVIATION	EXPLANATION
CASOB[a]	Cassia obtusifolia L.
CYPES[a]	Cyperus esculentus L.
CT	conventional tillage
DATST[a]	Datura stramonium L.
DIGSA[a]	Digitaria sanquinalis (L.) Roth.
IPOHE[a]	Ipomoea hederacea (L.) Jacq.
IPOHG[a]	Ipomoea hederacea var. integriuscula L.
NS	not significant
NT	no-tillage
NT-BD	no-tillage following burndown
NT-DC	no-tillage, double-cropped
PHBPU[a]	Ipomoea purpurea (L.) Roth.
ST	shallow tillage
WAP	weeks after planting
XANST[a]	Xanthium strumarium L.

[a]Letters are a Weed Science Society of America - approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl. 2.

VITA

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