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I am submitting herewith this thesis written by Jason L. Alford entitled "Interference and Management of Broadleaf Signalgrass (*Brachiaria platyphylla*) in Corn (*Zea mays* L.)." I have examined the final paper copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant and Soil Sciences.

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Interference and Management of Broadleaf Signalgrass (*Brachiaria platyphylla*) in Corn (*Zea mays* L.)

A Thesis

Presented for the

Master of Science

Degree

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Jason L. Alford

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DEDICATION

To my wife, family, and friends who have encouraged me throughout my life and shared their time and knowledge to help me succeed, I dedicate this thesis.

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ABSTRACT

Broadleaf signalgrass is a troublesome weed in the southern United States. However, with the development of glyphosate-resistant corn, glyphosate, a highly effective graminicide, can be used to manage broadleaf signalgrass.

Field experiments were conducted in the summers of 2000 to 2002 at University of Tennessee experiment stations in Jackson and Knoxville, TN. The focuses of the experiments were to determine the effect of broadleaf signalgrass competition on corn and the optimum time to apply glyphosate to prevent broadleaf signalgrass interference.

Glyphosate isopropylamine salt at 0.84 kg ae ha^{-1} was applied as single applications at 2, 3, 4, 5, 6, 7, and 8 weeks after corn emergence (WAE) and as sequential applications at 2 and 4 WAE; 2, 4, and 6 WAE; 2, 4, 6, and 8 WAE at both locations. The test also included a weed-free and untreated check. Broadleaf signalgrass densities were ~30 plants m^{-2} at Jackson and 150 to 300 plants m^{-2} at Knoxville. Corn injury was evaluated at each subsequent treatment and prior to harvest. Broadleaf signalgrass control and biomass were determined prior to harvest.

While there were decreasing yield trends at Jackson, broadleaf signalgrass did not significantly reduce corn yields at (P=0.05), likely due to low densities and adequate soil moisture and nutrients. In 2001, corn yields increased by 248 kg ha^{-1} wk^{-1}, when single applications of glyphosate were delayed from 2 to 5 WAE, due possibly to resurgence of broadleaf signalgrass following the early glyphosate applications. Corn yields with glyphosate treatments applied 6 to 8 WAE steadily decreased, apparently due to broadleaf signalgrass interference. Glyphosate treatments applied later than 5 WAE had an average yield decrease of 500 kg ha^{-1} wk^{-1} the treatment was delayed. In 2002, corn

yields from single applications of glyphosate between 2 to 5 WAE did not differ, while treatments applied 6 to 8 WAE had an average decrease of 300 kg ha^{-1} wk^{-1} delay in treatment.

Corn yields at Knoxville in 2000 to 2002 were reduced by broadleaf signalgrass interference, compared with the weed-free check. In 2000, the 7 and 8 WAE treatments and untreated check had lower corn yields than the weed-free check. Corn yields with single applications of glyphosate between 2 to 5 WAE did not differ, while yields from treatments applied 5 to 8 WAE had an average decrease of 360 kg ha^{-1} wk^{-1} delay in treatment.

In 2001, only the untreated check had lower corn yield than the weed-free check. Linear regression of 2001 corn yields suggested that treatments between 2 to 5 WAE had an average yield increase of 460 kg ha^{-1} wk^{-1}. Corn yield increases from 2 to 5 WAE were the result of optimizing control during the critical period (4 to 5 WAE) as opposed to early glyphosate applications (2 to 3 WAE), which allow broadleaf signalgrass resurgence in sufficient density and duration of interference to reduce yield. Treatments >5 WAE had an average yield decrease of 570 kg ha^{-1} wk^{-1} that glyphosate treatment was delayed.

Corn yields in 2002 from treatments made 6 to 8 WAE were lower than the weed-free check due to broadleaf signalgrass interference before the treatment was applied. In addition, the 6 and 7 WAE treatments had less yield reduction than the 8 WAE treatment and the untreated check. Further evaluations using linear regression determined that glyphosate treatments between 2 to 5 WAE did not differ. However, yields following the 5 WAE glyphosate application had an average decrease of 740 kg ha^{-1} wk^{-1} of delay.

Corn yields from all sequential applications at Knoxville were similar to the weed-free check.

When examined over five field experiments, broadleaf signalgrass reduced corn yield by 490 kg ha^{-1} wk^{-1} (r^2= 0.79) that glyphosate application was delayed beyond 5 WAE. Sequential applications of glyphosate at 2 and 4; 2, 4, and 6; or 2, 4, 6, and 8 WAE were effective in controlling yield loss, but in some instances four applications reduced corn yield. While broadleaf signalgrass can interfere with corn and reduce yield, glyphosate applied as a single application from 3 to 5 WAE or as sequential applications at 2 and 4 WAE can virtually eliminate yield loss. However, consideration must be given to the entire weed population in properly timing glyphosate applications to prevent weed interference and optimize corn yield potential.

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CHAPTER 1
LITERATURE REVIEW

Introduction

Broadleaf signalgrass (*Brachiaria platyphylla* (Griseb.) Nash) is a major problem in corn fields in the southern United States. It is a troublesome weed primarily because it is a prolific seed producer and its tolerance of widely used herbicides, especially primisulfuron in corn (Chamblee et al. 1982a; Gallaher et al. 1999). Poor control of broadleaf signalgrass with preemergence herbicides frequently occurs in no-till fields primarily due to the delayed germination of broadleaf signalgrass seed. Seed remain dormant on the crop residue until preemergence herbicides are no longer effective in controlling the germinating seeds at which time seeds fall to the soil surface and germinate (Rhodes and Breeden 2002). Because it is difficult to control, broadleaf signalgrass has become competitive in many corn fields and it reduces yields.

History and Habit

Broadleaf signalgrass is a decumbent, spreading, branched, summer annual species that is native to the southeastern and southcentral United States. It can be found in fields from Florida to North Carolina and west to Texas and Oklahoma (Lorenzi and Jeffery 1987). Broadleaf signalgrass has prostrate stems that are bent and often rooting at the lower nodes (McCarty et al. 2001). Leaf blades range from 4 to 12 cm long, 6 to 12 mm wide, and a ligule with a narrow membrane of fringed hairs up to 0.8 mm long with a pubescent sheath margin (Hitchcock and Agnes 1971). It is often pubescent throughout

the lower leaves (Stucky et al. 1980). Seeds are usually 3 mm long and finely wrinkled with inrolled margins (Stucky et al. 1980; Lorenzi and Jeffery 1987; Hitchcock and Agnes 1971). Flowering of broadleaf signalgrass occurs from June to October (Hitchcock and Agnes 1971; Lorenzi and Jeffery 1987), producing between 5460 and 32,140 seed m^{-2}, varying due to crop rotation (Johnson and Coble 1986).

Broadleaf signalgrass was not recognized as a significant weed problem in Tennessee corn (*Zea mays*) as late as the 1970's (Ashburn and Burns 1974). Today, it is the most troublesome weed in corn fields in Tennessee. Increased corn production in the southern United States has lead to greater than 2 million hectares of broadleaf signalgrass infestations (Hayes, personal communication[1]). Broadleaf signalgrass has also been named among the ten most troublesome weeds in corn fields in Alabama, Kentucky, Mississippi, North Carolina, South Carolina, and Texas (Webster 2000).

A study conducted by Taylorson and Brown (1977) analyzed the effects of accelerated loss in seed dormancy of broadleaf signalgrass. The study concluded that light exposure or accelerated dormancy loss had no effect on broadleaf signalgrass germination. Simpson (1990) reported that the glume, lemma, and palea influenced dormancy in *Brachiaria* species. These studies showed that removal of the glume, lemma, and palea increased germination to 97%. The hard, shiny lemma and palea are also believed to restrict oxygen diffusion to the embryo. When the seed was soaked in hydrogen peroxide, germination was stimulated; however, prolonged exposure in water caused a reduction in seed germination.

[1] R.M. Hayes, The University of Tennessee, Jackson: Personal communication.

Effects of Grass Interference on Corn Yield

Grass species compete with corn for light, nutrients, and water. Increased grass densities can cause a shortage of the resources required by corn, which can decrease yield. Studies on season-long johnsongrass competition in corn have reported that grain yields can be reduced 18 to 50% and stover yields by 37 to 67% with johnsongrass populations of 2.6 m^{-1} (Perry 1983). Determining when weeds begin to interfere with a crop permits optimum timing of herbicide applications for desired weed control (Minotti and Sweet 1981). The critical grass-free requirement of corn is 2 to 4 weeks after planting (Willian 1992). Periods of 10 weeks or more of johnsongrass competition in corn delayed the transition from vegetative to reproductive stage (Perry 1983). Lozanovski et al. (1975) reported that strong season-long competition from johnsongrass in corn reduced soil moisture content, decreased corn leaf area, and reduced corn dry weight by 67%.

Krueger and Kirksey (1993) reported that corn yields were affected by application timings of nicosulfuron for broadleaf signalgrass control. Yields were similar to the weed-free check with nicosulfuron applied at the 2 to 4 leaf stage; however, yields were reduced when treatments were delayed to the tiller stage (5 weeks after planting). In another study, broadleaf signalgrass reduced corn yields by 33 to 92% and severely reduced corn biomass (Lewis and Husketh 1979).

Grass weeds serve as overwintering sites for insects which vector disease, feed on, and injure corn. The corn leaf aphid overwinters in multiple grass species commonly found in corn (Bessin 2001). When the aphids reach the adult stage, they fly from the grass weeds and infest corn. The aphids can cause physiological damage, yield loss, and

transmit viruses such as the maize dwarf mosaic virus (Bessin 2001; Willian 1992). Therefore, grass control in corn is important to prevent competition, insect infestations, corn biomass reductions, and ultimately yield loss.

Broadleaf Signalgrass Management

Several herbicides control broadleaf signalgrass in corn. Preemergence control recommendations suggest metolachlor (2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide), acetochlor (2-chloro-N-(ethoxymethyl)-N-(2-ethyl-6-methylphenyl)acetamide), or dimethenamid (2-chloro-N-[(1-methyl-2-methoxy)ethyl]-N-(2,4-dimethyl-thien-3yl)acetamide) tank-mixed with atrazine (6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine). Nicosulfuron (2-[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sufonyl]-N,N-dimethyl-3-pyridinecarboxamide) is recommended for postemergence control in corn. Late-escapes of broadleaf signalgrass can be controlled using paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) post-directed. Clearfield® corn, with use of imidazolinones herbicides, and Roundup Ready® corn, with glyphosate (N- (phosphonomethyl) glycine) herbicide, controlled broadleaf signalgrass (Rhodes and Breeden 2002). Mueller and Hayes (1997) reported that tilled plots had better control of broadleaf signalgrass than no-till plots.

A soybean-corn rotation is recommended as a control method for broadleaf signalgrass (Rhodes and Breeden 2002). In broadleaf crops such as cotton and soybeans, broadleaf signalgrass is controlled with graminicides such as fluazifop ((R)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanic acid), clethodim ((E,E)-(±)-2-[1-[[(3-chloro-2-propenyl)oxy]imino]propyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-

cyclohexen-1-one), or sethoxydim 2-[-1(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one), or with glyphosate in glyphosate-resistant crops.

Glyphosate

Glyphosate is a non-selective, foliar-applied herbicide that is absorbed through the leaves and translocated primarily in the symplast, and accumulates in the roots, immature leaves, and meristem (Ahrens 1994; Martin and Edgington 1981). Some plants have been observed to have apoplastic translocation, but in most cases no apoplastic movement is observed. Glyphosate inhibits 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase, which produces EPSP in the shikimic acid pathway. Inhibition of the EPSP leads to a depletion of chorismate, a precursor to the production of the aromatic amino acids tryptophan, tyrosine, and phenylalanine that are required for protein synthesis (Ahrens 1994).

Glyphosate is adsorbed rapidly and tightly to soil particles. Soil textures and soil pH have minimal effect on the adsorption of glyphosate. Glyphosate adsorption correlates with the amount of vacant phosphate sorption sites and adsorption may occur through binding of the phosphonic acid moiety. High levels of metallic cations in clay soils increase the amount of glyphosate adsorbed. Strong adsorption to soils is evidenced in part by low phytotoxicity with soil applications. Glyphosate controls many annual and perennial weeds, but is highly phytotoxic to annual grasses. Crops can be seeded or transplanted immediately into treated areas (Ahrens 1994). Glyphosate can be safely applied on glyphosate-resistant crops to control troublesome weeds. Postemergence applications can be made overtop of glyphosate-resistant corn from emergence through the V8 stage (eight leaves with collars) or until corn is 76 cm in height.

CHAPTER 2
OPTIMUM GLYPHOSATE TIMING AND EFFECTS OF BROADLEAF SIGNALGRASS ON CORN YIELD

Introduction

Broadleaf signalgrass is a major problem in corn fields in the southern United States. Increased corn production in the southern region has led to greater than 2 million hectares of broadleaf signalgrass infestations (Hayes, personal communication[2]). Broadleaf signalgrass has been named among the top ten most troublesome weeds in corn fields in Alabama, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Texas (Webster 2000). It has become a troublesome weed primarily because it is a prolific seed producer, and it is tolerant of many widely used herbicides, especially primisulfuron in corn (Chamblee et al. 1982a; Gallaher et al. 1999). Broadleaf signalgrass escapes control with preemergence herbicides in no-till fields primarily due to the delayed germination of broadleaf signalgrass seed. Delayed germination is due to unfavorably cool temperatures when corn is planted and due to seed remaining dormant on the crop residue until rain or residue decay allows seed-soil contact to occur (Rhodes and Breeden 2002).

Increased grass densities can cause a shortage of the resources required by corn, which can decrease corn yield. Studies on season-long johnsongrass competition in corn have reported that corn grain yields can be reduced 18 to 50% and stover yields by 37 to 67% with johnsongrass populations of 2.6 plants m^{-1} (Perry 1983). Determining when

[2] R.M. Hayes, The University of Tennessee, Jackson: Personal communication.

weeds begin to interfere with a crop permits optimum application timing of herbicides to achieve weed control (Minotti and Sweet 1981). The critical grass-free requirement of corn is 2 to 4 weeks after planting (Willian 1992). Johnsongrass competition in corn for 10 or more weeks delayed the transition from vegetative to reproductive stage (Perry 1983). Lozanovski et al. (1975) reported that strong season-long competition from johnsongrass in corn reduced soil moisture content, decreased corn leaf area, and reduced corn dry weight by 67%.

Krueger and Kirksey (1993) reported that corn yields were affected by application timings of nicosulfuron for broadleaf signalgrass control. Yields were similar to the weed-free check with nicosulfuron applied at the 2 to 4 leaf stage; however, yields were reduced when treatments were delayed to the tiller stage (5 wks after planting). In another study, broadleaf signalgrass reduced corn yields by 33 to 92% and severely reduced corn biomass (Lewis and Husketh 1979).

Several herbicides control broadleaf signalgrass in corn. Postemergence control recommendations suggest nicosulfuron (2-[[[[(4,6-dimethoxy-2-pyrimi-dinyl)amino] carbonyl]amino]sufonyl]-N,N-dimethyl-3-pyridinecarboxamide) for postemergence control in corn. Imidazolinone-tolerant corn, with use of imidazolinones herbicides, and glyphosate-resistant corn, with glyphosate (N- (phosphonomethyl) glycine) herbicide, effectively controls broadleaf signalgrass (Rhodes and Breeden 2002).

The primary objective of this research was to determine the effect of broadleaf signalgrass competition on no-till corn grain yields. The second objective was to determine the optimum time for applying glyphosate for broadleaf signalgrass control in corn.

Materials and Methods

Broadleaf Signalgrass Interference in Corn

Broadleaf signalgrass interference and management research was conducted in the summers of 2001 and 2002 at the West Tennessee Experiment Station in Jackson and at the Knoxville Experiment Station, Knoxville, TN in 2000 to 2002. Asgrow® 738RR corn was planted using a four-row no-till planter at a rate of 68,000 seeds ha^{-1}. Tests were fertilized according to The University of Tennessee recommendations. Plots were 3 m wide and 7.6 m long. Treatments were replicated four times in a randomized complete block design. Critical data was obtained from the two center rows.

Broadleaf weeds were removed from all plots, including the weedy check using selective herbicides. Grass species other than broadleaf signalgrass were removed by hand. Broadleaf signalgrass was controlled in the weed-free check by applications of metolachlor PRE, and nicosulfuron POST. Any weeds that escaped herbicide treatments in the weed-free check were removed by hand-hoeing. Broadleaf signalgrass plants were counted 2 weeks after corn emergence (WAE) to check for plot uniformity. Plants were measured from a 1 m^2 area between the two center rows of each plot.

Linear regression was used to illustrate and analyze numeric corn yield trends related to broadleaf signalgrass interference. Due to yield mean comparisons reflecting two possible yield trends, 5 WAE was used as the crucial point for data analysis. Broadleaf signalgrass interference was evaluated between 2 to 5 WAE and from 6 to 8 WAE to determine yield loss due to interference over time.

Jackson

The experiment at Jackson was established on an area with a natural infestation (~30 plants m^{-2}) of broadleaf signalgrass. Corn was planted on April 11, 2001 and 2002 on a Dexter loam. In 2001, the test was treated with glyphosate 0.84 kg ae ha^{-1} on April 2. The test was treated with lambda-cyhalothrin 20 g ai ha^{-1} at planting. Dicamba (3,6-dichloro-2-methoxybenzoic acid) at 0.56 kg ai ha^{-1} was applied to the entire test on May 3 to control dicot weeds.

On April 10, 2002, glyphosate at 0.84 kg ae ha^{-1} was applied as a preplant burndown to the test area. Lambda-cyhalothrin at 22 g ai ha^{-1} was applied to the test on April 11. On May 16, the test was treated with dicamba (0.28 kg ai ha^{-1}) to remove dicot weeds. On June 11, bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) at 0.43 kg ai ha^{-1}, was applied in the row using a backpack sprayer to control dicot weeds.

Herbicides were applied using a tractor-mounted CO_2 boom sprayer. When the corn reached a height no longer accessible by tractor, a CO_2 backpack sprayer was utilized for herbicide applications. All treatments were applied at 94 L ha^{-1} of aqueous solution. Glyphosate 0.84 kg ae ha^{-1} was applied as single applications at 2, 3, 4, 5, 6, 7, and 8 WAE and as sequential applications at 2 and 4 WAE; 2, 4, and 6 WAE; 2, 4, 6, and 8 WAE. The test contained a weed-free and untreated check for yield comparisons. Corn phytotoxicity was evaluated at each subsequent treatment and prior to harvest. Broadleaf signalgrass control was evaluated at 4, 6, 8 WAE and prior to harvest. Broadleaf signalgrass biomass was determined before plant senescence from a 1 m^2 area between the two center rows of each plot, and was used as a measure of broadleaf signalgrass control.

Corn grain was harvested from the two center rows of each plot using a small plot combine. Corn was harvested on September 5, 2001 and September 6, 2002, and yields were adjusted to 15.5% moisture. Analysis of variance (ANOVA) was conducted using Proc mixed (SAS 1996) and means were separated by Fisher's least significant difference test (P=0.05). Broadleaf signalgrass control evaluations were arc sine transformed prior to ANOVA.

Knoxville

The experiments in Knoxville were established on an area with an extremely heavy infestation (150 to 300 plants m^{-2}) of broadleaf signalgrass. Corn was planted on April 18, 2000, May 1, 2001, and April 17, 2002 on a Sequatchie silt loam. Paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) at 0.84 kg ai ha^{-1} and nonionic surfactant at 0.25% v/v was applied on April 13, 2000, April 26, 2001, and April 12, 2002 to control weeds present before planting. Bromoxynil at 0.43 kg ai ha^{-1} was applied using a backpack sprayer to control dicot weeds. All grass weed species that emerged in the test plots other than broadleaf signalgrass were removed by hand.

At Knoxville, all treatments were applied with a CO_2 backpack sprayer calibrated to deliver 94 L ha^{-1} at 4.8 km/h. Treatments at Knoxville were the same as those at Jackson. Corn phytotoxicity was evaluated 2 WAT. Broadleaf signalgrass control was evaluated where appropriate at 4, 6, and 8 WAE, and prior to harvest.

Corn grain was harvested from the two center rows for each plot using a small plot combine. Corn was harvested on September 25, 2000, October 3, 2001, and September 19, 2002, and yields were adjusted to 15.5% moisture. Analysis of variance (ANOVA) was conducted using Proc mixed (SAS 1996) and means were separated by Fisher's least

significant difference test (P=0.05). Broadleaf signalgrass control evaluations were arc sine transformed prior to ANOVA.

Results and Discussion

At Jackson 2001 and Knoxville 2000 to 2002 moisture was adequate throughout most of the season. However, at Jackson 2002 moisture was adequate from planting to 8 WAE and became dry from 8 WAE to nearly harvest (Table 2-1).

Due to treatment by year, treatment by location, and location by year interactions, data for this study could not be pooled; therefore, data are presented by year and location.

Broadleaf Signalgrass Interference in Corn, Jackson

Corn yields at Jackson in 2001 and 2002 were not significantly reduced by broadleaf signalgrass interference, compared with the weed-free treatment (Table 2-2 & 2-3). The effect of broadleaf signalgrass interference in corn was not substantial, possibly due to low density (~30 plants m^{-2}), adequate rainfall (Table 2-1), and proper nutrient levels.

In Jackson 2001 to 2002, linear regression curves were utilized to evaluate numeric corn yield differences related to broadleaf signalgrass interference and glyphosate application timings (Figure 2-1). In 2001, broadleaf signalgrass competition from 2 to 5 WAE had an average increase in corn yields of 248 kg ha^{-1} wk^{-1} due possibly to resurgence of broadleaf signalgrass following the early glyphosate applications. Corn yields in plots with broadleaf signalgrass interference from 6 to 8 WAE steadily decreased. Broadleaf signalgrass competition greater than 5 WAE had an average yield decrease of 500 kg ha^{-1} wk^{-1} the treatment was delayed (Figure 2-1). In 2002, broadleaf signalgrass interference did not reduce corn yield when not controlled from 2 to 5 WAE,

Table 2-1. Weekly precipitation (cm) prior to and throughout the duration of the tests, Jackson (2001-2002) and Knoxville (2000-2002).

	Jackson		Knoxville		
WAP	2001	2002	2000	2001	2002
-1	0.8	0.9	2.7	0.0	0.5
0	0.0	0.0	0.5	0.0	0.0
1	4.2	0.1	0.8	1.0	0.5
2	1.2	1.4	4.1	0.9	3.6
3	0.0	0.5	2.4	3.2	9.0
4	0.0	2.1	0.7	5.7	3.7
5	1.0	4.0	0.4	1.8	1.5
6	7.1	2.5	15.8	0.8	0.0
7	0.7	1.4	0.8	0.5	0.0
8	12.5	4.5	3.2	3.2	2.1
9	2.4	5.2	1.5	1.2	0.5
10	0.1	0.1	4.7	2.9	0.3
11	0.0	0.7	2.7	0.0	2.6
12	0.8	0.1	0.7	6.0	0.5
13	0.8	0.0	3.6	12.3	6.2
14	1.5	0.8	0.4	0.1	3.0
15	0.3	0.6	0.9	2.4	2.0
16	9.3	0.0	4.9	2.6	2.0
17	0.0	0.1	2.4	0.5	0.0
18	5.7	2.3	0.0	5.8	0.6
19	0.0	7.4	0.9	0.5	2.3
20	4.9	3.3	0.9	0.0	0.1
21	3.7	0.0	1.5	5.7	0.0
22	0.1	0.0	0.0	0.6	1.2
23	-	-	1.8	0.8	11.9
24	-	-	6.6	-	-
Total	57.1	37.9	64.8	58.4	54.0

[a]WAP = Weeks after planting

Table 2-2. Broadleaf signalgrass interference in corn as affected by removal at different time intervals with glyphosate (0.84 kg ae ha^{-1}), Jackson 2001.

WAE[a]	Control[b] (%)	Corn yield (kg ha^{-1})	Broadleaf signalgrass biomass (g m^{-2})[b]
Untreated	0	10700	746
2	70	10200	203
3	88	10400	<10
4	95	10400	<10
5	99	11100	0
6	99	10700	0
7	99	10300	0
8	99	9500	0
2; 4	97	10200	<10
2; 4; 6	99	10200	0
2; 4; 6; 8	99	8700	0
Weed-free	99	10500	0
LSD (0.05)	17	1380	5

[a]WAE = Glyphosate application timing (weeks after corn emergence).
[b]Prior to harvest.

Table 2-3. Broadleaf signalgrass interference in corn as affected by removal at different time intervals with glyphosate (0.84 kg ae ha^{-1}), Jackson 2002.

WAE[a]	Control[b] (%)	Corn yield (kg ha^{-1})	Broadleaf signalgrass biomass (g m^{-2})[b]
Untreated	0	8400	127
2	40	9000	31
3	89	8900	<10
4	97	8300	<10
5	99	9300	0
6	96	8500	<10
7	93	8600	<10
8	98	8200	<10
2; 4	95	8500	<10
2; 4; 6	95	9000	<10
2; 4; 6; 8	99	8400	0
Weed-free	99	8700	0
LSD (0.05)	6	1070	24

[a]WAE = Glyphosate application timing (weeks after corn emergence).
[b]Prior to harvest.

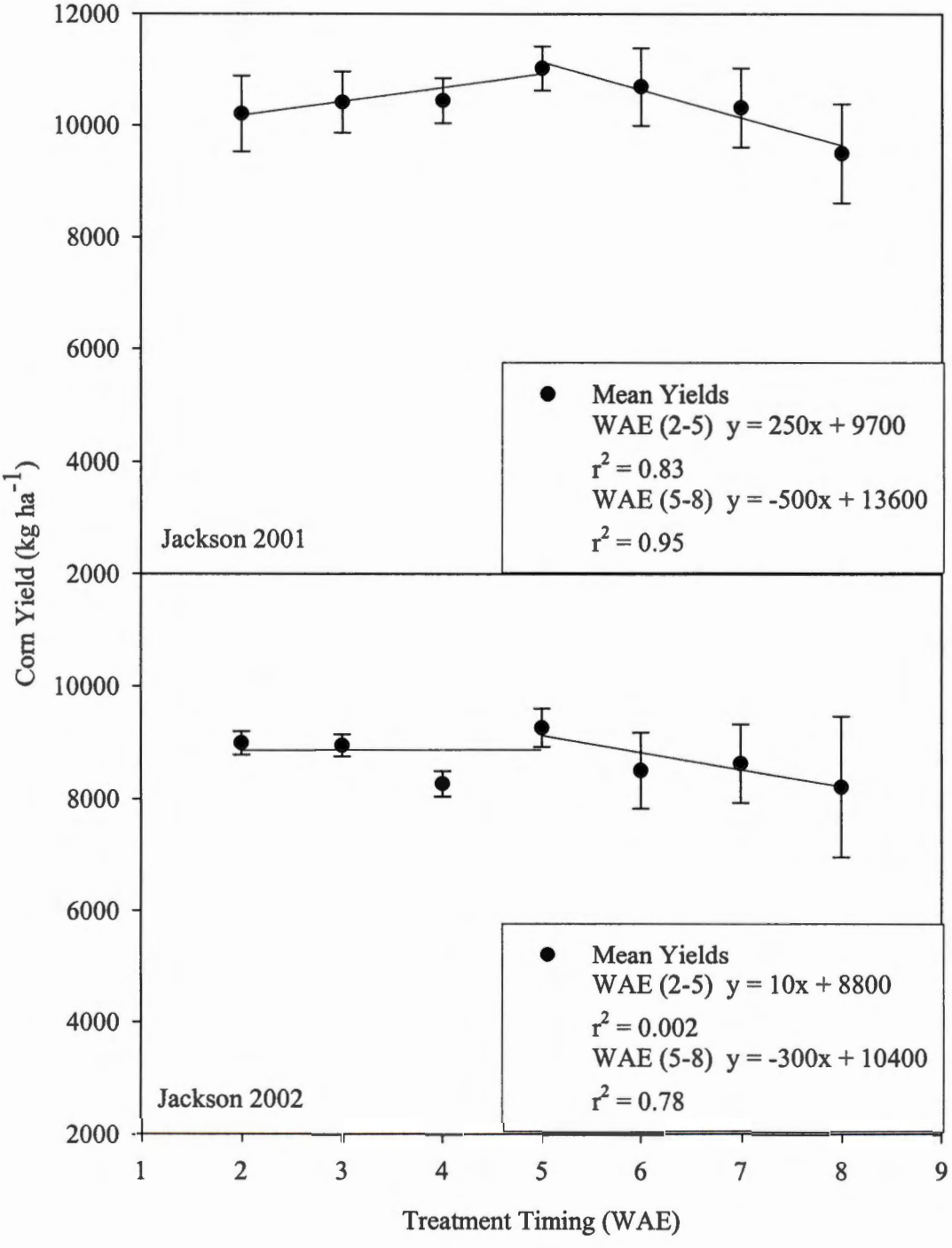

Figure 2-1. Linear regression of mean corn yields in plots with broadleaf signalgrass interference from 2 to 5 WAE and 5 to 8 WAE, Jackson 2001-2002.

while broadleaf signalgrass interference from 6 to 8 WAE had an average yield decrease of 300 kg ha^{-1} wk^{-1} the treatment was delayed (Figure 2-1).

Corn yields with sequential glyphosate treatments in 2001 and 2002 were similar to the weed-free treatment, except for the 2, 4, 6, and 8 WAE treatment in 2001 (Tables 2-2 and 2-3). Yield reduction in the 2, 4, 6, and 8 WAE sequential treatment may have been caused by the high number of glyphosate applications made on the corn, possibly causing yield reduction by overloading the corn plants with glyphosate. However, yield reduction was not related to broadleaf signalgrass interference.

Broadleaf Signalgrass Interference in Corn, Knoxville

Corn yields at Knoxville in 2000 to 2002 were reduced by broadleaf signalgrass interference, compared with the weed-free treatment (Tables 2-4, 2-5, and 2-6). In 2000, plots with broadleaf signalgrass interference from 7 to 8 WAE had lower corn yields than the weed-free treatment, and were similar to the untreated check (Table 2-4). Yield means reflected the effects of near season-long broadleaf signalgrass competition. Corn yield variations among treatments were attributed to high broadleaf signalgrass density levels (150 to 300 plants m^{-2}). Timely rainfall may have had some impact on yield variation, reducing the level of competition in plots with lower broadleaf signalgrass densities. Perry (1983) reported similar results, where corn yield variations due to johnsongrass interference were a reflection of differences in rainfall and johnsongrass densities. Corn yields between 2 to 5 WAE did not differ due to broadleaf signalgrass interference, while treatments applied 5 to 8 WAE had an average yield decrease of 360 kg ha^{-1} wk^{-1} the glyphosate treatment was delayed (Figure 2-2).

Table 2-4. Broadleaf signalgrass interference in corn as affected by removal at different time intervals with glyphosate (0.84 kg ae ha^{-1}), Knoxville 2000.

WAE [a]	Control[b] (%)	Corn yield (kg ha^{-1})
Untreated	0	6500
2	99	9700
3	99	9700
4	99	10200
5	99	9000
6	99	8300
7	99	7100
8	99	7000
2; 4	99	8900
2; 4; 6	99	8900
2; 4; 6; 8	99	8900
Weed-free	99	9600
LSD (0.05)	1	1890

[a]WAE = Glyphosate application timing (weeks after corn emergence).
[b]Prior to harvest.

Table 2-5. Broadleaf signalgrass interference in corn as affected by removal at different time intervals with glyphosate (0.84 kg ae ha^{-1}), Knoxville 2001.

WAE [a]	Control[b] (%)	Corn yield (kg ha^{-1})
Untreated	0	6300
2	97	8900
3	97	8900
4	99	9000
5	98	8400
6	98	7800
7	97	7000
8	97	7000
2; 4	97	9000
2; 4; 6	96	9400
2; 4; 6; 8	96	8900
Weed-free	99	8400
LSD (0.05)	3	1760

[a]WAE = Glyphosate application timing (weeks after corn emergence).
[b]Prior to harvest.

Table 2-6. Broadleaf signalgrass interference in corn as affected by removal at different time intervals with glyphosate (0.84 kg ae ha^{-1}), Knoxville 2002.

WAE [a]	Control [b] (%)	Corn yield (kg ha^{-1})
Untreated	0	4000
2	88	7000
3	98	6500
4	98	6900
5	97	7000
6	90	5200
7	78	5200
8	80	4600
2; 4	98	7200
2; 4; 6	97	7000
2; 4; 6; 8	99	6800
Weed-free	99	7000
LSD (0.05)	13	630

[a]WAE = Glyphosate application timing (weeks after corn emergence).
[b]Prior to harvest.

In 2001, only the untreated check had a lower corn yield than the weed-free treatment. However, corn yields in plots with broadleaf signalgrass interference from 6 to 8 WAE were similar to the untreated check (Table 2-5). Corn yields in 2001 suggest that broadleaf signalgrass interference was not significant. Nevertheless, there were trends for reduced corn yield with longer duration of broadleaf signalgrass interference. Linear regression of 2001 corn yields suggested that treatments between 2 to 5 WAE had an average corn yield increase of 460 kg ha^{-1} wk^{-1}. Corn yield increases from 2 to 5 WAE were the result of optimizing control at the critical period (4 to 5 WAE) as opposed to early glyphosate applications (2 to 3 WAE), which allow broadleaf signalgrass in sufficient density and duration of interference to reduce yield. Treatments > 5 WAE had

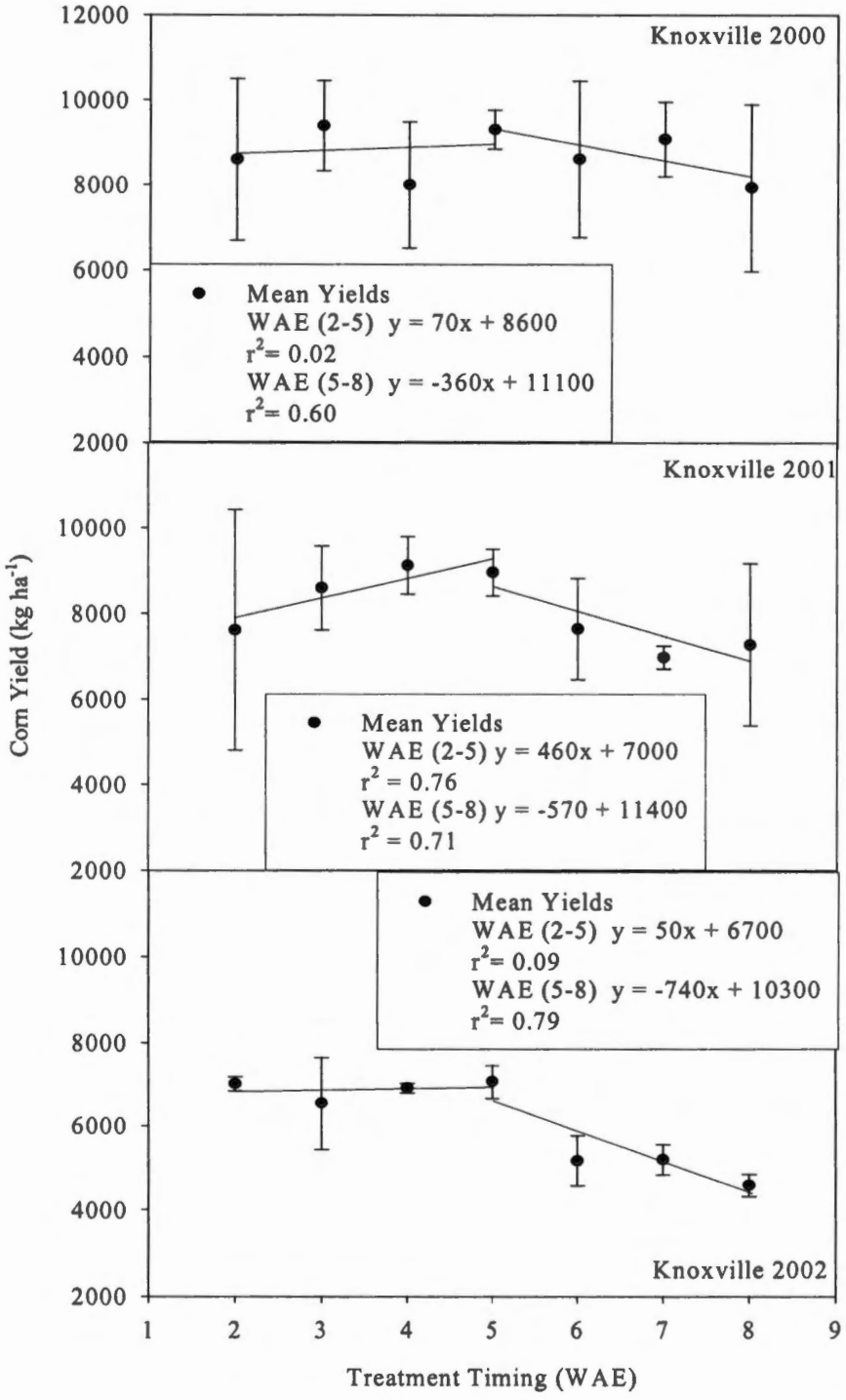

Figure 2-2. Linear regression of mean corn yields in plots with broadleaf signalgrass interference from 2 to 5 WAE and 5 to 8 WAE, Knoxville 2000-2002.

an average yield decrease of 570 kg ha^{-1} wk^{-1} that glyphosate treatments were delayed (Figure 2-2).

Corn yield in 2002 from plots with broadleaf signalgrass interference 6 to 8 WAE were lower than the weed-free treatment. In addition, broadleaf signalgrass interference from 6 to 7 WAE had less yield reduction than interference at 8 WAE and the untreated check (Table 2-6). These results prove that timely applications of glyphosate to remove broadleaf signalgrass interference can improve corn yields. Further analysis using linear regression determined no differences in corn yields from 2 to 5 weeks of broadleaf signalgrass interference. However, corn yields in plots with broadleaf signalgrass interference 6 to 8 WAE had an average decrease of 740 kg ha^{-1} wk^{-1} that glyphosate treatments were delayed (Figure 2-2). Corn yields from sequential applications of glyphosate at Knoxville were similar to those of the weed-free treatment.

Broadleaf Signalgrass Control in Corn, Jackson

All glyphosate treatments controlled broadleaf signalgrass ≥80%. However, at Jackson in 2001 and 2002 a lower overall rating for the 2 WAE treatment was noted (Tables 2-2 and 2-3). Initial control of broadleaf signalgrass was >90%. However, season-long control could not be maintained due to broadleaf signalgrass emerging after the 2 WAE glyphosate treatment and adequate rainfall the remainder of the season. Tharp and Kells (1999) also reported reduced weed control due to weed resurgence following early postemergence (POST) applications of glyphosate. Glyphosate treatments applied 3 WAE or later had nearly complete broadleaf signalgrass control. The untreated check plot had lower control than all treatments including the 2 WAE treatment (Tables 2-2 & 2-3). Sequential applications at Jackson had >95% control of

broadleaf signalgrass in 2001 and 2002. The effectiveness of sequential applications is due to the control of broadleaf signalgrass emerging after early POST applications, Tharp and Kells (1999) reported similar results with giant foxtail.

Fresh weights of broadleaf signalgrass biomass were determined at Jackson in 2001 to 2002. Weights were used as an indicator of broadleaf signalgrass control using glyphosate. In 2001 and 2002, all treatments were similar to the weed-free treatment, except the 2 WAE treatment and the untreated check plot. The broadleaf signalgrass biomass in the 2 WAE treatment was a result of broadleaf signalgrass resurgence after glyphosate was applied, not from plants escaping the initial treatment. The untreated check plot had greater biomass weights than the 2 WAE treatment, since it had not been treated to control the broadleaf signalgrass (Tables 2-2 and 2-3).

Broadleaf Signalgrass Control in Corn, Knoxville

In Knoxville all treatments had ≥90% control of broadleaf signalgrass, except for the 7 and 8 WAE treatments in 2002. The reduced broadleaf signalgrass control at the 7 and 8 WAE treatments were possibly due to high density levels of broadleaf signalgrass (Table 2-6). Sequential applications at Knoxville controlled broadleaf signalgrass >95% in 2000 to 2002.

Corn Injury

No visual corn injury related to glyphosate applications was observed in the experiments at Jackson or Knoxville for 2000 to 2002. However, yield reduction in the 2, 4, 6, and 8 WAE sequential treatment may have been caused by the late timing of glyphosate applied to the corn causing loss of pollen viability (Thomas et al. 2003).

CHAPTER 3
SUMMARY AND CONCLUSIONS

Glyphosate provides an effective option to control broadleaf signalgrass in corn. However, with sufficient early-season moisture, germination of broadleaf signalgrass following early (2 to 3 WAE) glyphosate applications may occur. Therefore, optimum single application timing of glyphosate for season-long broadleaf signalgrass control in corn is between 4 to 5 WAE. In situations with broadleaf signalgrass resurgence, sequential applications were effective at controlling broadleaf signalgrass throughout the season.

Broadleaf signalgrass, being much smaller than corn, does not compete with corn for light, but appears to compete primarily for water and perhaps for some nutrients. Field tests conducted in 2000 to 2002 at Jackson and Knoxville indicated broadleaf signalgrass causes yield reduction. However, lower broadleaf signalgrass densities, adequate moisture, and good nutrient levels lessen the amount of reduction caused by broadleaf signalgrass interference. Perry (1983) reported variations in corn yields with johnsongrass interference due to rainfall and uniformity of johnsongrass densities. Corn yields were reduced between 18 to 50% due to johnsongrass interference. Competition of broadleaf signalgrass with no-till corn for more than 5 WAE reduced yields from 5 to 25%. Differences between johnsongrass interference and broadleaf signalgrass interference were likely due to johnsongrass being a more vigorous and competitive weed

than broadleaf signalgrass. Chamblee et al. (1982b) found that broadleaf signalgrass interference in peanuts for more than 5 WAE caused 16% peanut seed yield reductions.

At Jackson, under moist soil conditions throughout most of the season, broadleaf signalgrass did not reduce corn yields. However, corn yield trends indicate an average decrease of 300 to 500 kg ha^{-1} wk^{-1} that glyphosate applications to control broadleaf signalgrass were delayed beyond 5 WAE.

At Knoxville, periods of moisture stress caused broadleaf signalgrass interference to reduce corn yields. Corn yields were reduced by broadleaf signalgrass an average of 364 to 738 kg ha^{-1} wk^{-1} that treatment with glyphosate was delayed beyond 5 WAE. Krueger and Kirksey reported broadleaf signalgrass interference >4 WAE reduced corn yields, however, test result differences could have been due to different broadleaf signalgrass densities and soil type.

Sequential applications of glyphosate controlled broadleaf signalgrass and prevented corn yield reduction from broadleaf signalgrass interference. However, yield reduction in the 2, 4, 6, and 8 WAE sequential treatment may have been caused by the late timing of glyphosate applied to the corn causing loss of pollen viability (Thomas et al. 2003).

While broadleaf signalgrass can interfere with corn and reduce yield, glyphosate applied as a single application from 3 to 5 WAE or as sequential applications at 2 and 4 WAE can virtually eliminate yield loss. However, consideration must be given to the entire weed population in properly timing glyphosate applications to prevent weed interference and optimize corn yield potential.

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APPENDIX A
DAILY RAINFALL

Table A-1. Daily rainfall (cm) at Jackson, April to October 2001.

Day	April	May	June	July	Aug	Sept	Oct
1	0.1	0.0	5.8	0.0	0.0	1.7	0.0
2	0.0	0.0	0.0	0.0	0.0	0.1	0.0
3	0.0	0.0	1.0	0.0	0.0	0.1	0.0
4	0.0	0.0	1.2	0.0	0.0	0.5	0.0
5	0.8	0.0	0.9	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.8	0.0	0.0	3.1
7	0.0	0.0	2.4	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.4	0.0	0.0
9	0.0	0.0	0.0	0.0	0.3	0.1	0.0
10	0.0	0.0	0.0	0.0	0.1	0.0	0.0
11	0.0	0.0	0.0	0.0	0.9	0.0	2.8
12	1.4	1.0	0.0	1.3	0.0	0.0	4.7
13	2.1	0.0	0.0	0.1	2.0	0.0	1.9
14	0.0	0.0	0.0	0.0	2.0	0.0	4.7
15	0.7	0.0	0.1	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.1
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.4	0.0	0.3	0.0	2.4	0.0
20	0.0	0.6	0.0	0.0	0.0	0.1	0.0
21	0.0	4.7	0.0	0.0	0.0	0.0	0.0
22	0.0	1.4	0.0	0.0	0.0	0.0	0.0
23	0.0	0.1	0.0	0.0	0.0	0.0	0.0
24	1.2	0.1	0.0	0.0	0.0	0.7	0.0
25	0.0	0.0	0.0	4.0	0.0	0.0	1.4
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	4.9	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.6	0.2	0.7	0.0	0.0	0.0
30	0.0	0.0	0.6	4.6	0.5	0.0	0.0
31	0.0	3.5	0.0	0.0	0.8	0.0	0.0
Total	6.3	12.4	12.2	12.0	11.8	5.8	18.7

Table A-2. Daily rainfall (cm) at Jackson, April to October 2002.

Day	April	May	June	July	Aug	Sept	Oct
1	0.4	0.5	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.1	0.0	0.9
3	0.1	0.5	0.0	0.1	0.0	0.0	0.0
4	0.0	1.6	0.0	0.0	0.0	0.0	2.7
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.9	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	2.2
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.9	0.3	0.0	0.0	0.0	0.0	0.0
10	0.0	0.6	0.0	0.0	0.0	0.0	3.1
11	0.0	0.7	4.3	0.1	0.2	0.0	5.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	2.5	0.1	0.3	0.0	0.0	0.0
14	0.0	0.0	0.0	0.1	2.1	0.0	0.0
15	0.0	0.0	0.0	0.4	0.3	0.0	0.0
16	0.0	0.0	0.0	0.0	0.2	2.2	0.0
17	0.0	0.1	0.0	0.0	2.7	0.4	0.0
18	0.1	2.3	0.0	0.0	0.0	1.2	0.0
19	0.0	0.0	0.0	0.0	4.2	1.3	0.2
20	0.0	0.0	0.0	0.0	0.0	0.0	0.9
21	0.0	0.0	0.0	0.0	0.0	2.5	0.0
22	0.3	0.0	0.0	0.0	0.0	4.9	0.0
23	0.0	0.0	0.0	0.1	0.2	0.0	0.0
24	0.0	0.0	0.0	0.4	0.2	0.0	0.0
25	1.1	0.0	0.0	0.0	2.9	0.0	0.0
26	0.0	0.0	0.7	0.0	0.0	0.0	0.1
27	0.0	0.5	0.2	0.0	0.0	2.6	0.0
28	0.1	0.0	0.0	0.0	0.0	18.2	0.2
29	0.0	1.0	0.0	0.0	0.0	0.0	1.2
30	0.0	4.5	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.8	15.0	6.2	2.2	13.6	33.2	16.3

Table A-3. Daily rainfall (cm) at Knoxville, April to October 2000.

Day	April	May	June	July	Aug	Sept	Oct
1	0.0	0.0	0.0	0.0	0.4	0.0	0.0
2	0.6	0.0	0.0	0.0	0.0	0.0	0.0
3	2.7	0.9	0.0	0.0	0.3	1.5	0.0
4	4.8	0.7	0.2	0.0	0.1	0.0	0.0
5	0.1	0.8	2.5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.5	0.7	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	1.4	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.7	0.0	0.0	2.4	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.7	0.0	0.0	1.1	0.0	0.0	0.0
13	0.3	0.0	0.0	0.8	0.0	0.0	0.0
14	1.7	0.0	0.0	1.7	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	1.3	0.0	0.0	0.0	0.0
17	0.0	0.0	0.2	0.0	0.0	0.0	0.0
18	0.1	0.0	0.6	0.0	0.0	0.0	0.1
19	0.0	0.0	1.4	0.0	0.0	0.0	0.0
20	0.0	0.4	0.0	0.4	0.0	1.4	0.0
21	0.6	0.2	0.2	0.0	0.8	0.0	0.0
22	0.0	0.3	2.5	0.0	0.0	0.3	0.0
23	0.0	0.3	0.0	0.0	0.0	1.1	0.0
24	0.1	12.5	0.0	0.6	0.0	4.4	0.0
25	2.9	1.7	0.0	0.3	0.1	1.0	0.0
26	0.3	0.3	0.0	0.0	0.0	0.0	0.0
27	0.0	0.6	0.0	0.0	0.0	0.0	0.0
28	0.9	0.6	0.0	0.0	0.9	0.0	0.1
29	0.0	0.3	2.7	0.4	0.0	0.0	0.0
30	0.0	0.0	0.0	2.4	0.0	0.0	0.0
31	0.0	0.0	0.0	1.3	0.0	0.0	0.0
Total	17.1	20.1	12.1	9.8	5.0	9.9	0.2

Table A-4. Daily rainfall (cm) at Knoxville, April to October 2001.

Day	April	May	June	July	Aug	Sept	Oct
1	0.2	0.0	0.8	0.0	0.0	1.1	0.0
2	0.0	0.0	0.6	0.0	0.0	0.2	0.0
3	0.1	0.0	0.3	0.0	0.0	2.9	0.0
4	0.6	0.0	0.1	0.0	0.1	0.4	0.0
5	0.0	0.0	0.0	2.8	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.8
7	0.0	0.9	0.7	0.0	0.0	0.0	0.1
8	0.0	0.1	0.1	0.0	0.0	0.0	0.0
9	0.0	0.4	0.0	0.1	0.0	0.1	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.4	0.0	0.0	2.4	0.0	0.1
13	3.2	0.0	0.0	0.0	0.0	0.0	0.1
14	0.1	0.0	0.4	0.0	0.2	0.0	0.9
15	0.5	0.0	0.0	0.0	0.0	0.0	0.0
16	1.0	0.0	0.1	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.1	0.0	0.0
18	0.0	0.0	0.0	0.0	0.6	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.4	0.0	0.5	1.8	2.8	0.0
21	0.0	0.0	0.3	0.1	0.0	0.1	0.0
22	0.0	2.8	0.0	5.4	0.0	0.0	0.0
23	0.0	2.3	1.3	0.0	0.0	0.0	0.0
24	0.0	0.3	0.0	0.0	0.0	2.8	0.0
25	0.0	1.5	0.0	0.0	0.4	0.6	0.9
26	0.0	0.0	1.6	0.3	0.1	0.0	0.0
27	0.0	0.0	0.0	0.1	0.0	0.0	0.0
28	0.0	1.4	0.0	0.3	0.0	0.0	0.0
29	0.0	0.1	0.3	5.6	0.0	0.0	0.0
30	0.0	0.0	1.0	6.1	0.8	0.0	0.0
31	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Total	5.7	10.8	7.5	21.2	7.2	10.9	2.7

Table A-5. Daily rainfall (cm) at Knoxville, April to October 2002.

Day	April	May	June	July	Aug	Sept	Oct
1	0.4	3.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.1	0.0	0.0	0.0	0.0	0.0
3	0.0	3.9	0.0	0.3	0.7	0.0	0.0
4	0.0	1.9	0.0	0.3	0.0	0.0	0.0
5	0.0	0.2	0.1	0.0	0.0	0.0	0.1
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	2.0	0.0	0.0	0.0	0.9
8	0.0	0.3	0.0	0.0	0.0	0.0	0.1
9	0.1	0.0	0.0	0.0	0.0	0.0	0.0
10	0.5	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.5	0.0	0.5	0.0	0.0	0.8
12	0.0	0.0	0.0	0.1	0.0	0.0	0.2
13	0.0	0.0	0.0	1.2	0.0	0.0	0.2
14	0.0	2.8	0.5	4.1	0.0	0.7	0.0
15	0.0	0.0	0.0	0.4	0.0	0.5	3.4
16	0.0	0.0	0.0	0.6	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.1	0.0	0.0
18	0.0	1.5	0.0	0.6	0.5	0.2	0.0
19	0.0	0.0	0.3	0.5	0.0	0.0	0.1
20	0.0	0.0	0.0	0.7	1.1	0.0	0.2
21	0.0	0.0	0.0	0.7	0.0	4.3	0.0
22	0.5	0.0	0.0	0.0	0.0	5.4	0.0
23	0.0	0.0	0.0	0.1	0.0	1.9	0.2
24	0.0	0.0	0.0	0.2	1.0	0.0	0.0
25	2.5	0.0	0.0	0.0	0.2	0.1	0.3
26	0.0	0.0	0.2	0.0	0.1	2.1	0.1
27	0.0	0.0	1.1	0.0	0.1	1.3	0.3
28	0.0	0.0	0.7	0.0	0.0	0.1	2.5
29	1.1	0.0	0.6	1.7	0.0	0.0	1.9
30	0.0	0.0	0.0	0.0	0.0	0.0	0.1
31	0.0	0.0	0.0	1.3	0.0	0.0	0.0
Total	5.1	14.1	5.5	13.1	3.7	15.4	11.3

APPENDIX B
MAX/MIN TEMPERATURES (°C)

Table B-1. Max/Min Temperatures (°C), Jackson, Tennessee 2001.

Day	April		May		June		July		Aug		Sept		Oct	
1	11	4	17	2	29	16	22	17	34	23	23	21	23	6
2	14	4	16	4	27	11	23	14	33	23	26	21	26	7
3	11	6	24	12	28	14	27	14	33	24	26	22	28	9
4	12	6	26	18	28	13	24	14	32	21	28	21	27	12
5	7	-1	24	17	29	14	30	19	33	22	30	21	27	14
6	7	-2	24	18	27	14	28	21	33	22	32	23	27	6
7	8	-3	29	19	26	16	28	21	33	24	32	22	17	2
8	11	3	30	17	26	14	26	19	28	24	31	22	20	4
9	14	-1	29	19	26	14	29	17	32	24	31	21	23	7
10	9	-4	31	21	27	15	28	15	30	25	29	14	23	10
11	17	1	32	21	29	18	29	17	29	23	26	12	26	14
12	21	8	31	15	30	16	31	18	29	22	29	13	20	17
13	18	5	27	13	25	9	32	20	31	22	32	16	23	18
14	19	-1	24	13	26	12	33	23	30	19	31	16	22	12
15	20	7	22	13	30	14	32	22	30	17	27	12	22	8
16	18	8	24	11	32	18	29	16	31	20	25	13	23	6
17	8	2	17	4	31	20	31	16	30	18	27	14	14	2
18	5	-1	11	0	32	21	34	18	32	21	28	18	16	2
19	13	2	16	4	31	20	34	22	30	22	30	19	21	4
20	13	6	23	7	25	18	32	21	29	15	26	13	22	8
21	9	3	23	16	30	18	32	20	30	18	27	14	25	9
22	17	2	27	18	26	12	32	18	32	21	28	17	26	12
23	18	3	28	17	21	12	26	14	36	24	31	16	27	15
24	21	8	27	9	24	14	28	14	34	22	31	16	27	21
25	13	-2	19	4	21	8	29	14	34	22	17	7	28	6
26	9	-2	22	7	21	9	31	13	33	22	18	3	20	2
27	8	-5	26	12	25	13	31	19	34	21	21	4	17	0
28	12	-1	29	12	29	18	28	18	28	20	25	7	11	-2
29	13	5	30	12	23	13	29	18	31	21	23	10	16	0
30	14	7	29	14	27	15	29	20	31	21	23	11	19	1
31	14	8			22	18			33	21			22	3

Table B-2. Max/Min Temperatures (°C), Jackson, Tennessee 2002.

Day	April		May		June		July		Aug		Sept		Oct	
1	9	-3	13	4	22	17	32	19	32	23	32	22	28	19
2	13	3	22	10	29	21	32	20	35	22	32	21	28	21
3	14	-6	28	4	23	12	33	21	34	22	33	21	31	21
4	-1	-9	12	7	13	12	34	24	37	24	33	21	27	21
5	3	-7	13	7	21	289	34	22	37	23	34	21	29	14
6	17	1	14	1	25	11	31	20	37	23	33	15	23	12
7	18	6	18	2	29	13	26	16	34	20	34	18	27	12
8	19	12	23	5	30	22	27	16	31	16	33	21	18	10
9	24	14	21	14	29	17	32	20	33	17	32	20	23	11
10	17	-2	18	8	23	13	31	22	34	19	33	18	21	16
11	11	-2	24	9	17	13	26	21	34	22	35	19	21	17
12	14	4	26	14	29	14	30	21	33	21	31	14	21	17
13	11	7	27	18	29	14	32	23	32	22	30	14	23	13
14	16	7	27	18	16	6	32	21	32	21	32	18	17	5
15	24	6	27	18	23	8	27	13	30	21	26	21	16	6
16	28	7	31	19	26	14	28	15	28	22	31	21	17	7
17	12	7	29	20	28	18	27	15	27	22	31	21	16	6
18	14	11	29	18	25	8	29	16	32	22	28	21	17	6
19	16	13	32	20	16	4	31	18	33	21	30	22	22	8
20	17	12	31	20	19	8	32	21	33	23	31	22	17	11
21	12	4	31	21	20	7	32	19	33	21	27	17	13	10
22	13	-5	29	12	19	6	33	19	34	22	27	17	19	8
23	6	-3	22	9	23	10	32	19	34	23	26	12	21	7
24	14	4	22	12	26	13	31	22	32	22	24	11	18	11
25	22	12	29	10	28	16	32	22	33	21	24	14	18	13
26	24	2	18	7	29	19	32	21	31	19	21	18	19	15
27	4	-1	17	10	26	17	32	21	29	18	20	18	18	12
28	14	3	26	12	29	18	29	20	30	20	27	16	17	13
29	24	9	31	10	29	18	30	21	29	19	28	14	19	13
30	26	9	24	11	25	17	32	22	30	19	29	17	19	8
31	12	9			29	17			31	21			11	8

Table B-3. Max/Min Temperatures (°C), Knoxville, Tennessee 2001.

Day	April		May		June		July		Aug		Sept		Oct	
1	13	7	27	12	27	13	31	19	33	21	24	19	21	5
2	13	2	26	12	27	11	29	19	29	21	26	19	24	7
3	14	4	28	13	24	12	32	20	32	21	28	21	25	8
4	13	8	29	13	24	12	30	21	27	21	24	19	26	9
5	23	12	30	13	29	17	31	18	30	21	29	19	26	9
6	19	13	31	14	29	18	27	18	31	20	31	19	24	10
7	26	13	29	17	31	19	30	16	33	21	32	18	15	3
8	28	12	20	14	23	21	28	19	32	21	31	18	18	2
9	28	13	18	12	29	16	33	21	32	22	31	18	19	3
10	28	14	23	12	28	13	29	21	33	22	31	19	21	4
11	31	14	26	12	29	14	29	21	31	22	26	17	24	6
12	29	16	28	13	28	16	34	18	31	22	28	15	24	11
13	23	14	24	9	31	14	31	21	29	23	31	16	23	16
14	24	9	23	6	33	18	29	13	29	19	29	16	26	17
15	23	11	26	11	31	18	29	14	31	18	29	12	23	6
16	22	7	31	15	32	20	29	14	32	19	24	9	22	6
17	20	5	31	17	29	14	32	14	32	20	24	11	22	0
18	8	-1	32	17	32	15	33	19	30	17	26	11	14	0
19	15	-2	32	17	33	16	29	21	30	17	27	12	19	0
20	19	-1	30	17	33	18	30	22	31	18	21	16	21	2
21	22	4	27	18	32	18	32	21	28	14	26	13	23	6
22	26	11	29	18	33	19	32	21	28	14	27	14	25	6
23	28	13	22	8	25	17	31	21	31	14	28	14	26	9
24	28	13	23	8	26	13	33	21	32	18	28	14	27	12
25	19	9	23	12	28	14	33	21	30	21	19	7	27	8
26	21	3	22	8	27	15	30	23	31	20	17	4	21	7
27	22	4	23	8	26	15	30	22	30	21	19	4	16	1
28	24	6	27	15	28	17	33	22	28	19	23	6	9	-3
29	28	7	27	15	29	18	29	23	29	21	21	7	13	-3
30	27	10	26	11	29	19	28	22	32	19	21	6	17	-1
31			27	13			32	21	27	19			21	1

Table B-4. Max/Min Temperatures (°C), Knoxville, Tennessee 2002.

Day	April		May		June		July		Aug		Sept		Oct	
1	13	6	24	8	31	19	33	21	32	21	32	19	28	16
2	18	3	23	17	32	19	34	21	33	21	32	18	29	18
3	26	8	28	13	33	20	34	21	35	19	33	19	30	18
4	14	2	14	11	34	21	33	18	34	20	34	19	30	18
5	14	0	17	11	35	19	32	20	35	20	36	18	29	18
6	15	-1	25	11	32	21	37	22	34	21	34	16	29	13
7	14	-1	27	12	30	16	34	18	32	15	34	17	29	13
8	22	-1	28	17	31	17	34	21	32	14	34	17	21	12
9	24	10	29	18	31	17	33	22	31	15	34	17	24	13
10	21	11	28	18	31	17	33	21	32	17	35	16	21	17
11	24	11	23	15	31	15	33	19	31	18	36	16	21	18
12	27	11	29	16	32	16	32	20	32	18	32	13	23	18
13	25	12	29	16	32	17	31	21	33	18	31	13	27	18
14	27	14	29	6	33	17	23	20	34	18	33	17	23	10
15	25	12	21	6	26	13	28	21	33	19	30	20	20	10
16	29	13	23	8	26	12	31	21	33	21	27	19	16	12
17	31	16	27	13	26	12	32	21	32	21	30	19	18	5
18	29	14	28	8	29	14	32	21	32	20	29	19	16	4
19	31	16	14	3	32	16	31	21	32	20	27	21	18	9
20	31	18	17	3	33	16	29	20	31	20	32	18	18	13
21	31	18	17	4	33	16	29	20	33	20	31	19	18	12
22	29	13	17	3	31	13	33	20	35	21	31	19	21	7
23	22	5	21	6	32	13	32	21	36	21	24	16	21	8
24	22	7	24	8	32	20	32	20	36	23	26	15	22	12
25	18	9	27	11	32	21	31	21	33	19	27	17	18	13
26	19	3	28	11	32	21	30	22	30	19	20	16	16	14
27	16	6	29	13	33	21	31	22	30	17	22	16	18	14
28	22	6	28	14	31	21	32	22	31	17	24	16	21	16
29	26	9	27	14	30	22	31	22	31	17	27	14	19	16
30	22	7	30	15	32	20	33	22	31	18	29	15	23	14
31			30	18			33	21	31	18			15	7

VITA

Jason Lee Alford was born in Martin, Tennessee on November 24, 1976. He is one of three sons born to Mr. and Mrs. Larry Alford of Bradford, Tennessee. He received his primary and secondary education in the Gibson County, Tennessee school systems and graduated from Gibson County High School in May 1995.

In August 1995, he entered the University of Tennessee in Martin, Tennessee. While completing his degree, he was a pitcher for the UTM baseball team. In May 2000 he received his Bachelor of Science degree in Plant and Soil Science. In January 2001 he entered the Graduate School at the University of Tennessee in Knoxville, Tennessee as a graduate research assistant in the Plant Sciences and Landscape Systems Department. On May 26, 2001, he wed the former Miss Brandy Rachelle Wood of Trenton, Tennessee. He received the Master of Science degree with emphasis in Weed Science from the University of Tennessee, Knoxville in May 2003.

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