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Summer fallow and in-crop weed management programs in sugarcane (Saccharum spp. hybrids): control of perennial weeds and purple nutsedge (Cyperus rotundus L.) interference

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SUMMER FALLOW AND IN-CROP WEED MANAGEMENT PROGRAMS IN
SUGARCANE (*SACCHARUM* SPP. HYBRIDS): CONTROL OF PERENNIAL
WEEDS AND PURPLE NUTSEDGE (*CYPERUS ROTUNDUS* L.) INTERFERENCE

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The School of Plant, Environmental, and Soil Sciences

by
Luke M. Etheredge, Jr.
B.S., Texas A&M University, 2000
M.S., Texas A&M University, 2003
May 2007

To my graduate committee, Dr. Jim Griffin, Dr. Mike Salassi, Dr. Eric Webster, Dr. Ben Legendre, Dr. Jeff Hoy, and Dr. Donnie Miller each of you have offered guidance when it was needed and I greatly appreciate it. I feel like I have learned so much from each one of you at different times along the way and I look forward to learning more. Thank you for taking the time to share knowledge with people.

I would like to say a special thanks to the crews at St. Gabriel and Ben Hur research farms for allowing me the opportunity to work amongst you and for always giving me a helping hand when I needed something. You people make research happen and without your help it would have been difficult to accomplish my goals.

Dr. Freddie Martin, your leadership in the Department of Agronomy and Environmental Management has made it educational and fun to be a part of the department. I loved the crawfish boils and pot lunches that brought us all together like a big family. It made a non-Louisiana resident feel at home.

There are so many fellow students that I have had the opportunity to work with and share this experience with. I would like to thank each one of you for everything that you have done to help me accomplish things that I could have never accomplished on my own. To Curtis Jones, thank you for recruiting me into the weed science program and teaching me the ropes. To Wilson Judice, Joey Boudreaux, John Hebert, and Matt Gravois, thank you for all your hard work, you guys made it happen and what a blessing it was to be surrounded by gentlemen like you. I could have never done it without you. I feel honored to call each one of you a friend and hope that we can continue this relationship throughout the rest of our lives.

To everyone involved I will never forget the last four and a half years that I have spent in the weed science program, the invaluable lessons learned, the friendships made, and the tremendous

learning experience. I will truly cherish this experience for the rest of my life and thank you for making it possible. Memories and experiences are forgettable unless you have someone to share them with.

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ABSTRACT

In fallowed sugarcane fields, perennial weeds and sugarcane regrowth must be controlled to maximize productivity of sugarcane in the first production year. Isopropylamine salt of glyphosate applied in April at 1.68 kg ai/ha to 15 cm sugarcane provided 85% control 28 d after treatment (DAT). Control of sugarcane 56 DAT with isopropylamine and potassium salt formulations of glyphosate averaged 83% for 1.12 kg/ha. Bermudagrass control with glyphosate at 1.12 kg/ha was 86% 40 DAT and increased to 98% with a sequential application at 1.12 kg/ha. In comparing various combinations of tillage and glyphosate in summer fallow programs, bermudagrass ground cover was 37% in November for tillage alone compared to no more than 7% ground cover for the tillage/glyphosate and no-tillage/glyphosate programs. Perennial weed control was greater when glyphosate replaced a tillage operation. Purple nutsedge tubers were planted in 26.5 L pots with a surface area of $0.093m^2$ at densities of 0, 1, 2, 4, 8, and 16 tubers/pot along with a single node cutting of 'LCP 85-384' sugarcane to evaluate interference. At 64 days after planting, both purple nutsedge shoot and root (including tubers) dry weight increased as initial tuber density increased. Based on sugarcane shoot dry weight, critical weed density was four nutsedge tubers/pot. Using root dry weight, critical weed density was one nutsedge tuber/pot. The sugarcane variety 'L 97-128' was more competitive with purple nutsedge than LCP 85-384, 'Ho 95-988', and 'HoCP 96-540'. In a shade response study, 30% shade reduced nutsedge shoot dry weight 75% compared with full sunlight. Field studies were conducted to evaluate purple and yellow nutsedge control in sugarcane with herbicides applied postemergence (POST) in September around 5 weeks after planting. Halosulfuron at 53.0 or 70.6 g/ha averaged 80% 4 weeks after treatment (WAT) and 77% 6 WAT. Control with the trifloxysulfuron at 15.7 g ai/ha was no more than 71% 6 WAT. Injury to sugarcane was not

observed 6 WAT for either herbicide. In April of the following year, nutsedge control with the

halosulfuron treatments averaged 74% compared with 44% for the trifloxysulfuron treatments,

but sugarcane shoot population did not differ.

CHAPTER 1

INTRODUCTION

Sugarcane (*Saccharum* spp. hybrids) is a subtropical, perennial crop grown commercially for sugar only in Florida, Louisiana, and Texas within the continental U.S. Preserving the sugarcane industry is an underlying objective for most sugarcane research programs in Louisiana. In order to achieve this objective, researchers are currently conducting research aimed at minimizing inputs without sacrificing production or pest control. Australian sugarcane farmers have used no-tillage (NT) to reduce tractor hours, fuel consumption, and maintenance costs without adversely affecting productivity (Anonymous 1991). Conservation tillage practices can range from NT to some level of reduced tillage. In other crop production systems, cultural practices, such as reduced tillage, NT, or crop rotation programs have been accepted and implemented as a means to reduce inputs. In 2001 in the U.S., reduced tillage was used on almost 42 million hectares representing 36.6% of the planted cropland (Anonymous 2002). Sugarcane producers up to now have not been forced to consider a shift toward reduced tillage programs because of industry stability. The 2002 Farm Bill included a Conservation Security Program that provided incentive payments for environmental stewardship (Anonymous 2005). Specifically, this program provides a cost share payment that requires 30% coverage of the soil surface with plant residue on a year-round basis. Due to current cultural practices in Louisiana, especially during planting, a true NT system is not feasible in sugarcane; however, some form of conservation tillage might be adaptable.

SOIL PROPERTIES AND EROSION

The major benefits of conservation tillage include reduced soil erosion and chemical run-off (Papendick et al. 1986). Previous research has shown that a minimum of 20% residue cover on

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the soil surface is necessary to reduce soil erosion (Beyaert et al. 2002; Moldenhauer et al. 1983). Improved soil physical properties associated with NT planting have been documented (Griffith et al. 1986). Long-term studies showed that NT systems resulted in greater cation exchange capacity, organic matter (OM), and nutrients when compared to conventional tillage systems (Edwards et al. 1992; Lal et al. 1994; Unger 1991). Similar results were reported in Louisiana where OM in the top 15 cm of soil with a NT system in cotton was greater when compared to conventional and ridge till systems (Boquet et al. 1997). Research has shown that soil carbon and nitrogen levels decline after years of cultivation (Hass et al. 1957; Tiessen et al. 1982; Young et al. 1960) and that this decline can be minimized or eliminated by conservation tillage practices (Dick 1983; Lamb et al. 1985). Kennedy and Hutchinson (2001) concluded that the higher OM content in a NT system would lead to improved soil structure and less soil impedance of cotton root growth. Colwick and Barker (1975) found that minimum tillage reduced soil compaction. Soil compaction increases with increased wheel traffic and is considered detrimental to crop production (Coats 2001).

Reductions in tillage and use of cropping systems that maximize residue addition to the soil surface have been efficient agricultural practices to maintain or increase OM in Brazil (Bayer et al. 2000a, b). The benefit of increasing OM has not only improved soil structure and water-nutrient relationships, but also increased the ability to store carbon (C) in the soil and reduce atmospheric CO_2, a greenhouse gas (Janzen et al. 1999; Lal et al. 1998b, 1999). With reduced tillage systems, it is expected that OM sequestration will increase if residue C is not lost as CO_2 to the atmosphere because of tillage induced decomposition. The adoption of best management practices, such as reduced tillage by farmers, may help reverse the atmospheric enrichment of

CO_2 resulting from U.S. emissions outside agriculture by sequestering C in soil (Lal et al. 1998a, 1998b).

FALLOW FIELD WEED MANAGEMENT

Conservation tillage and weed control are intimately linked, and the ability to control weeds, herbicide cost, and benefits of conservation tillage must all be considered when determining the feasibility of a conservation tillage program (Koskinen and McWhorter 1986). The sustainability of diverse reduced tillage systems is dependent on the development of economical and effective weed management programs (Derksen et al. 2002). Historically, sugarcane producers have relied heavily on frequent tillage operations during the fallow period for weed control. In a typical fallow program, the sugarcane stubble is destroyed in the spring or early summer, and fields are prepared for replanting in August and September. In Louisiana, four to six harvests are made from a single planting of sugarcane (Anonymous 2001). Replanting is necessary due to reduced sugarcane plant population associated with disease and weed pressure over time. During the spring and summer fallow period, producers are able to control perennial weeds that have established over the crop cycle with postemergence (POST) application of glyphosate and/or timely tillage operations (Anonymous 2007). Perennial weed management is likely the most important objective of any fallow field weed control program. In most fallow fields in Louisiana, perennial weeds such as bermudagrass [*Cynodon dactylon* (L.) Pers.] and/or johnsongrass [*Sorghum halapense* (L.) Pers.] are present. With the sugarcane row top not disturbed over the 3 to 5 year crop cycle and with current herbicide in-crop programs mostly ineffective on perennial weeds, fallowed fields can be heavily infested with weeds. A successful weed control program during the fallow period is critical to maximizing sugarcane yields over the multi-year crop cycle (Griffin et al. 2006 and Richard 1995 and 1997). Previous research has

shown that bermudagrass infestation levels increase with each successive crop and is more detrimental to sugarcane production in the ratoon crops than in the plant cane crop (Richard 1995).

NUTSEDGE COMPETITION AND CONTROL

Johnsongrass, bermudagrass, and purple nutsedge (*Cyperus rotundus* L.) rank 1, 2, and 7, respectively, as the most troublesome weeds in sugarcane in Louisiana (Anonymous 2004). However, in recent years, purple nutsedge has become more problematic in Louisiana sugarcane fields. In the 1950's, when less than 10% of cotton (*Gossypium hirsutum* L.) acreage in the Mississippi Delta was treated with herbicides, purple nutsedge was not listed among the top 10 problem weeds (Wills 1977). In 1961, 75% of cotton acreage in the Mississippi Delta was treated with herbicides, and by 1963, purple nutsedge ranked as the second most severe weed on sandy soils. Purple and yellow nutsedge (*Cyperus esculentus* L.) are herbaceous perennials that are among the world's worst weeds (Stoller and Sweet 1987). Holm et al. (1997) listed purple nutsedge as the world's worst weed. This status is related to its perennial nature, longevity of viable tubers, and prolific tuber production (Bariuan et al. 1999).

Competitiveness is the relative ability of a plant to obtain a specific resource when in competition with another plant (Gibson and Liebman 2003). According to Aldrich and Kremer (1997), competition between weeds and crops occurs when some factor, such as water, nutrients, or sunlight, is insufficient to meet the needs of both the weed and the desired plant. Field studies conducted in Brazil showed that purple nutsedge at 58 to 246 shoots/m^2 reduced sugarcane yield 14% and at shoot populations of 675 to 1198/m^2 sugarcane yield was reduced 45% (Durigan 2005). Leon et al. (2001) reported in greenhouse experiments that initial purple nutsedge tuber densities of more than 180/m^2 reduced fresh weight of cotton and soybean (*Glycine max* L.

Merr.). Keeley and Thullen (1975) found yellow nutsedge capable of reducing yields of furrow-irrigated cotton when allowed to compete for periods of four or more weeks.

The ability of sugarcane to produce significant plant growth and shading could play a major role in developing management programs for nutsedge in Louisiana sugarcane. Even though nutsedge under ideal conditions can have tremendous growth potential, its growth can be affected by shading from the crop. Purple nutsedge shoot population and shoot dry weight were reduced 47 and 67%, respectively, when exposed to 40% shade for 50 d (Santos et al. 1997). Shading significantly reduced dry-matter production, leaf-area production, and rhizome and tuber formation of both purple and yellow nutsedge, and there was no difference between species in response to shade (Patterson 1982).

In general, both purple and yellow nutsedge are relatively tolerant to many herbicides used in agronomic crops (Webster and Coble 1997). Several acetolactate synthase (ALS)-inhibiting herbicides control purple and yellow nutsedge, including chlorimuron (Reddy and Bendixen 1988), imazapic (Richburg et al. 1994), imazaquin (Nandihalli and Bendixen 1998), imazethapyr (Richburg et al. 1993), and pyrithiobac (Wilcut 1998). None of these herbicides, however, are currently labeled for use in sugarcane. Also in sugarcane, soil applied herbicides are mostly ineffective on nutsedge (Anonymous 2007). Recently, new compounds labeled in Louisiana sugarcane, such as halosulfuron and trifloxysulfuron, that also target ALS, have been found to be effective on nutsedge (McElroy et al. 2003; Webster and Coble 1997; Vencill et al. 1995). In planning weed control programs for nutsedge, whether purple or yellow nutsedge, the goal should be to reduce the ability of nutsedge to reestablish and produce a heavy tuber population. Previous research has shown that tuber population can increase rapidly under good growing conditions (Doll and Piedrahita 1982; Etheredge et al. 2006; Hauser 1962; Rao 1968; Smith and

Fick 1937). Due to the competitive ability of nutsedge with sugarcane (Etheredge et al. 2006)

and difficulty in controlling nutsedge species with currently labeled herbicides in sugarcane

(Anonymous 2007), there is a need to develop a management program for nutsedge control in

sugarcane.

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CHAPTER 2

EFFICACY AND ECONOMICS OF SUMMER FALLOW CONVENTIONAL AND REDUCED TILLAGE PROGRAMS FOR SUGARCANE

<u>INTRODUCTION</u>

In 2005, sugarcane production in Louisiana accounted for about 16% of the total sugar production in the U.S. (Anonymous 2005b). Sugarcane is a subtropical, perennial crop that is grown commercially for sugar only in Florida, Louisiana, and Texas within the continental U.S. Preserving the sugarcane industry is an underlying objective for most sugarcane research programs in Louisiana. In order to achieve this objective, researchers are currently conducting research aimed at minimizing inputs without sacrificing production or pest control. In other crop production systems, cultural practices, such as reduced tillage, no-tillage (NT), or crop rotation programs, have been accepted and implemented as a means to reduce inputs. Sugarcane producers up to now have not been forced to consider these practices because of industry stability. Compared with other crops, profit margins for sugarcane have been such that growers have not entertained ideas to shift production practices to reduce costs. In cotton (*Gossypium hirsutum* L.), more than half of the fuel required to produce the crop is consumed by tillage operations after harvest and before plants emerge (Cannon and Stapleton 1977). The 2002 Farm Bill included a Conservation Security Program that will provide incentive payments for environmental stewardship. Specifically, this program provides a cost share payment that requires 30% coverage of the soil surface with plant residue on a year-round basis (Anonymous 2005a).

Over the past years, corn, soybean, rice, and cotton producers have shifted toward conservation tillage programs. Conservation tillage was used on over 71 million acres in the United States in 1989 and increased to over 103 million acres by 2002 (Anonymous 2002). The major benefits of

conservation tillage include reduced soil erosion and chemical run-off (Papendick et al. 1986).
However, these benefits are difficult to economically quantify and are short-term. Other benefits
have been observed over long periods of time. A 16 year study conducted in Indiana on a silty
clay loam soil showed that reduced tillage in a corn/soybean rotation system reduced soil pH and
increased cation exchange capacity (CEC) and availability of calcium and magnesium (Hickman
2002). Other long-term studies showed that NT systems resulted in greater CEC, organic matter
(OM), and nutrients when compared to conventional tillage systems (Edwards et al. 1992; Lal et
al. 1994; Unger 1991). Similar results were reported in Louisiana where OM in the top 15 cm of
soil with a NT system in cotton was greater when compared to conventional and ridge till
systems (Boquet et al. 1997). Kennedy and Hutchinson (2001) concluded that the higher OM
content in a NT system would lead to improved soil structure and less soil impedance of cotton
root growth. OM content is directly related to OM decomposition rates which are five times
greater in warm, wet tropical and subtropical regions than under temperate conditions (Sanchez
and Logan 1992). Reductions in tillage and use of cropping systems that maximize residue
addition to the soil surface have been efficient agricultural practices to maintain or increase OM
in Brazil (Bayer et al. 2000a, b). The benefit of increasing OM has not only improved soil
structure and water-nutrient relationships, but also increased the ability to store carbon (C) in the
soil and reduce atmospheric CO_2, a greenhouse gas (Janzen et al. 1999; Lal et al. 1998b, 1999).
With reduced tillage systems, it is expected that OM sequestration will increase if residue C is
not lost as CO_2 to the atmosphere because of tillage induced decomposition. The adoption of
best management practices, such as reduced tillage by farmers, may help reverse the atmospheric
enrichment of CO_2 resulting from U.S. emissions outside agriculture by sequestering C in soil
(Lal et al. 1998a, 1998b).

In Louisiana, four to six harvests are made from a single planting of sugarcane (Anonymous 2001). Replanting is necessary due to reduced sugarcane plant population associated with disease and weed pressure over time. In a typical fallow program, the sugarcane stubble is destroyed in the spring or early summer, and fields are prepared for replanting in August and September. During the fallow period, producers are able to control perennial weeds that have established over the crop cycle with postemergence (POST) application of glyphosate and/or timely tillage operations (Anonymous 2007). The fallow period is possibly one of the most critical times for perennial weed management because once the sugarcane is planted, the row top will not be mechanically disturbed for the remainder of the multi-year crop cycle. Therefore, management of perennial weeds in fallow is essential to maximize yields in the plant cane (first production year) and ratoon crops. Historically, sugarcane producers have relied heavily on frequent tillage operations during the fallow period for weed control. However, with the recent increase in fuel and labor costs, and the decrease in cost of glyphosate products, a NT or reduced tillage system may be practical. Contrary to NT systems in other crops, failure to achieve complete destruction of the previous sugarcane crop, because of its perennial nature, could be an obstacle to success in the fallow period. As sugarcane farms become larger, use of conventional tillage programs in fallowed fields is less feasible. This research addressed the potential use of reduced tillage programs in fallowed sugarcane fields with heavy perennial weed pressure in respect to control of both weeds and sugarcane, and the effect on the subsequent plant-cane crop. Economics of various reduced tillage, NT, and conventional programs were compared.

<div align="center">

MATERIALS AND METHODS

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Sugarcane and Bermudagrass Control with Glyphosate. For a NT system to be successful during the fallow period, weeds as well as sugarcane must be controlled. In the first study, field

experiments were conducted in 2004 and 2005 at the Sugar Research Station in St. Gabriel, LA, on a Commerce silt loam soil (fine-silty, mixed, superactive, non-acid, thermic Fluvaquentic Endoaquepts) with 1.0% OM and a pH of 5.9. This study evaluated application timing and rates of glyphosate for control of third ratoon (fourth production year) 'LCP 85-384' sugarcane emerging from the winter dormant period. Sugarcane was treated with the isopropylamine salt of glyphosate[1] at four application timings and four rates. The experimental design was a randomized complete block with four replications and plot size was 1.8 m (one sugarcane row) by 12.2 m. Experiments included 16 treatments arranged in a 4 by 4 factorial treatment arrangement with a nontreated control included for comparison. The first application of glyphosate was made when average sugarcane canopy height was 15 cm and 3 subsequent applications were made at 2 week intervals when average sugarcane canopy height was 25, 40, and 45 cm. Specific application dates were April 2, April 15, May 4, and May 15, 2004, and April 5, April 20, May 5, and May 16, 2005. At each timing, glyphosate was applied at 1.12, 1.68, 2.24, or 2.80 kg ai/ha using a CO_2-pressurized backpack sprayer calibrated to deliver 140 L/ha at a spray pressure of 170 kPa.

   A second study was conducted at the St. Gabriel Research Station in St. Gabriel, LA, on a Commerce silt loam soil (fine-silty, mixed, superactive, non-acid, thermic Fluvaquentic Endoaquepts) with 1.0% OM and a pH of 5.9 in 2004 and then repeated in 2005 on privately owned land near Henderson, LA, on a Baldwin silty clay loam soil (fine, montmorillonitic, thermic Vertic Ochraqualfs) with 1.5% OM and a pH of 5.8. Isoproylamine and potassium salt glyphosate formulations applied at several rates were evaluated for control of sugarcane stubble. Sugarcane cultivar LCP 85-384 (third ratoon) was treated when average sugarcane canopy height

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[1] Roundup UltraMax, an isopropylamine salt of glyphosate plus surfactant. Monsanto Company, 800 North Lindbergh Boulevard, St. Louis, MO 63167.

was 25 cm on April 21, 2004, and April 28, 2005. The experimental design was a randomized

complete block with four replications, and plot size was 1.8 m (one sugarcane row) by 12.2 m.

Experiments included 15 treatments arranged in a 3 by 5 factorial treatment arrangement with a

nontreated control included for comparison. Glyphosate formulations were Roundup

WeatherMAX[2], Roundup OriginalMAX[3], Roundup UltraMax[1], Mirage[4], and Honcho Plus[5].

Each glyphosate formulation was applied at rates of 1.12, 2.24, or 3.36 kg/ha using a tractor-

mounted compressed air sprayer in 2004 and a CO_2-pressurized backpack sprayer in 2005 both

calibrated to deliver 93.5 L/ha at a spray pressure of 140 kPa. A nonionic surfactant[6] was added

at 0.25% (v/v) to only the Mirage formulation since it is the only formulation where surfactant

addition was indicated on the label. Visual control of sugarcane was determined 14, 28, and 42

days after treatment (DAT) for the rate by timing study (first study) and 21, 35, and 56 DAT for

the rate by formulation study (second study) based on a scale of 0 to 100% with 0 = no control

and 100 = all plants present at application dead with no regrowth.

A third study was conducted at the Henderson, LA, location in 2004 and 2005 that evaluated

glyphosate as single and sequential applications for bermudagrass control in fallowed sugarcane

fields. The experimental design was a randomized complete block with four replications

utilizing 3.7 m (two sugarcane rows) by 12.2 m plots. Experiments included 16 treatments

arranged in a 4 by 4 factorial treatment arrangement with a nontreated control included for

comparison. Glyphosate was applied at 1.12, 1.68, 2.24, or 2.80 kg/ha to actively growing

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[2] Roundup WeatherMAX, a potassium salt of glyphosate plus surfactant. Monsanto Company, 800 North Lindbergh Boulevard, St. Louis, MO 63167.
[3] Roundup OriginalMAX, a potassium salt of glyphosate plus surfactant Monsanto Company, 800 North Lindbergh Boulevard, St. Louis, MO 63167.
[4] Mirage, an isopropylamine salt of glyphosate without surfactant. Loveland Products Inc., P.O. Box 1286, Greeley, CO 80632.
[5] Honcho Plus, an isopropylamine salt of glyphosate plus surfactant. Monsanto Company, 800 North Lindbergh Boulevard, St. Louis, MO 63167.
[6] Induce, a mixture of alkylarylpolyoxyalkane ether and free fatty acids. Helena Chemical Co., 225 Schilling Blvd., Collierville, TN 38017.

bermudagrass on May 29, 2004, and June 14, 2005, when stolons were 15 to 25 cm long. A

sequential application of glyphosate at 1.12, 1.68, 2.24, or 2.80 kg/ha was made on July 8, 2004,

and July 21, 2005, when the bermudagrass stolons were 5 to 15 cm long. The glyphosate

formulation used was Roundup UltraMax[1] and application was made using a tractor-mounted

compressed air sprayer calibrated to deliver 93.5 L/ha at a spray pressure of 140 kPa.

   Visual control of bermudagrass was determined 40 d after the initial application (the same day

the sequential application was applied) and again at 18 d after the sequential application based on

a scale of 0 to 100% with 0 = no control and 100 = all plants present at application dead and no

new plants emerged. Additional bermudagrass control ratings were not made because rows were

worked and fields were planted after the last rating.

Tillage/Weed Control Programs Study. In 2004 and 2005, research was conducted at three

locations across the sugarcane growing region of Louisiana. Each location was chosen due to

natural infestations of bermudagrass and/or johnsongrass that had developed over the 4 to 5

previous years. The soil type at Henderson, LA, was a Baldwin silty clay loam soil (fine,

montmorillonitic, thermic Vertic Ochraqualfs) with 1.5% OM and a pH of 5.8. The soil type at

St. Gabriel, LA, was a Commerce silt loam soil (fine-silty, mixed, superactive, non-acid, thermic

Fluvaquentic Endoaquepts) with 1.0% OM and a pH of 5.9. At the St. James, LA, location the

soil type was a Commerce silty clay loam (fine-silty, mixed, superactive, non-acid, thermic

Fluvaquentic Endoaquepts) with 1.7% OM and a pH of 6.7.

   Experiments consisted of six tillage/weed control programs during the fallow period (April-

August) arranged in a randomized complete block design with four replications. Plot sizes were

5.5 m (three sugarcane rows) by 46 m at Henderson, 5.5 m by 27 m at St. Gabriel, and 5.5 m by

76 m at St. James. Plot sizes were large to accommodate tillage programs. Fallow programs

consisted of tillage only, tillage in combination with glyphosate application, and NT in combination with glyphosate application. Specific programs evaluated are shown in Table 2.1. For fallow programs 1 through 4, sugarcane stubble and row integrity were mechanically destroyed with two passes of a disk [tillage treatment 1 (T1)] and represented conventional practices used in sugarcane culture. Other tillage treatments (T2 and T3) consisted of mechanical destruction of weeds by making one pass across each plot with a disk. Final tillage treatment (T4) consisted of mechanical destruction of weeds using two passes with a 3-row hipper which, rebuilt rows in preparation for planting.

In some of the fallow programs, glyphosate and/or a preemergence (PRE) herbicide treatment was included (Table 2.1). All herbicide applications were made with a tractor-mounted compressed air sprayer calibrated to deliver 93.5 L/ha at a spray pressure of 183 kPa. Timing of herbicide applications and tillage treatments throughout the fallow period (April-August) were determined by field and weather conditions and were conducted as needed for each program. Specific dates for tillage treatments and herbicide applications are shown in Table 2.1. Preemergence herbicides were applied immediately following the rebedding tillage operation in the reduced tillage program (Fallow program 4) and approximately three weeks after the initial glyphosate application (G1) in the NT program (Fallow program 6). Preemergence herbicide treatments consisted of a premix of hexazinone at 0.59 kg ai/ha plus diuron at 2.10 kg ai/ha[7]. All glyphosate (Roundup UltraMax[1]) applications were made at 2.80 kg/ha to actively growing weeds. When morningglory (*Ipomoea* spp.) were present, 2,4-D at 0.56 kg ai/ha was applied with glyphosate.

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[7] DuPont K4®, DuPont Crop Protection Walker's Mill, Barley Mill Plaza Wilmington, Delaware 19880-0038.

Table 2.1. Summer fallow weed control programs in sugarcane involving tillage and herbicides evaluated at Henderson, St. Gabriel, and St. James, LA in 2004.[a]

	Summer fallow tillage and herbicide treatment							
	Tillage treatment[b]				Glyphosate[c]			Pre-emergence[d]
Fallow program	T1	T2	T3	T4	G1	G2	G3	P1
	--mo/d--							
1	4/16; 4/20; 4/22	6/28; 6/21; 5/27	7/13; 7/22; 6/17	8/8; 8/18; 7/22	-- --	-- --	-- --	-- --
2	4/16; 4/20; 4/22	6/28; 6/21; 5/27	-- --	7/13; 7/22; 6/17	-- --	-- --	7/27; 8/18; 7/28	-- --
3	4/16; 4/20; 4/22	-- --	-- --	6/28; 6/21; 5/27	-- --	7/8; 7/12; 6/17	7/27; 8/18; 7/28	-- --
4	4/16; 4/20; 4/22	-- --	-- --	5/11; 5/12; 5/27	-- --	-- --	7/13; 8/6; 7/13	5/11; 5/12; 5/27
5	-- --	-- --	-- --	-- --	4/16; 4/20; 4/22	6/28; 6/21; 6/17	7/13; 8/6; 7/28	-- --
6	-- --	-- --	-- --	-- --	4/16; 4/20; 4/22	-- --	7/13; 7/20; 7/13	5/11; 5/12; 5/13

[a] Dates for the various treatments represent each location of the study in 2004, Henderson, St. Gabriel, and St. James, LA, respectively.

[b] T1 = First tillage operation conducted to destroy old sugarcane stubble and knock downs rows which consisted of two passes across the field with a 6 m disk; T2 = One pass across the field with a 6 m disk; T3 = One pass across the field with a 6 m disk; T4 = Final tillage using two passes with a 3-row hipper to rebuild the rows.

[c] Glyphosate was applied postemergence at 2.80 kg ai/ha. G1-3 = glyphosate applications.

[d] Preemergence application consisted of a premix of hexazinone at 0.59 kg ai/ha plus diuron at 2.10 kg ai/ha. P1 = preemergence application.

At the end of the fallow period in August 2004, all plots were planted with sugarcane variety LCP 85-384 either as whole stalks (Henderson and St. Gabriel) or sectioned stalks (billets) (St. James) depending on grower preference and machinery available. To evaluate the effects of the various weed control programs implemented during the fallow period, the entire experimental area received a broadcast preemergence application of a premix of hexazinone at 0.59 kg/ha plus diruon at 2.10 kg/ha at planting immediately after rows were packed. Additionally, all plots at each location from this point until harvest received standard weed control programs and cultural practices depending on grower preference.

Sugarcane shoot population was determined 35 d after planting (DAP) (2004) and in April 2005. Sugarcane stalk height, measured from the soil surface to the collar of the youngest leaf on 10 randomly selected stalks, was recorded in June 2005. Sugarcane was harvested in December 2005, using a commercial single-row chopper harvester and a dump wagon fitted with three weigh cells capable of being tared between plots to determine total sugarcane yield. Data were collected only from the center row of each 3-row plot. Before harvesting, samples of 10 randomly selected stalks were hand harvested and weighed to determine average stalk weight. Stalk samples were then crushed, and the juice was extracted for analysis of sugar concentration using standard methodology (Chen and Chou 1993). Sugar yield was calculated by multiplying theoretical recoverable sugar by sugarcane yield.

Bermudagrass ground cover was estimated visually based on a scale of 0 (no cover) to 100% (total cover of row top and sides) in October and in November 2004 at the Henderson and St. James locations. Visual control of johnsongrass was determined in November 2004 at the Henderson and St. Gabriel locations based on a scale of 0 to 100% with 0 = no control and 100 = no plants present. The majority of johnsongrass plants that were present in November had

developed from rhizomes rather than seeds, and data would, therefore, represent the effectiveness of the fallow programs.

Statistical and Economic Analysis. Data for each study were subjected to the Mixed Procedure in SAS[8]. Years or locations, replications (nested within years or location), and all interactions containing either of these effects were considered random effects (Carmer et al. 1989). All other variables (glyphosate rate, timing, formulation, and fallow program) were considered fixed effects. Considering year or location as environmental or random effects permits inferences about treatments to be made over a range of environments (Carmer et al. 1989; Hager et al. 2003). Least square means were calculated, and mean separation was performed at $P \leq 0.05$. Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998).

In regard to economic analysis, because differences in sugar yield were not significant, gross return for each fallow program could not be calculated. The change in tillage cost (number of tillage operations) and herbicide cost (number and type of applications) for the reduced tillage and NT programs were compared to the full-tillage conventional program (six tillage operations; two for T1 and T4 and one for T2 and T3), and the change in net return was calculated. Tillage cost was figured based on number of passes across each plot depending on implement used (Salassi and Breaux 2006). All costs were estimated based on equipment that was 5.5 to 6 m wide (3 sugarcane rows spaced 183 cm apart). Differences in herbicide cost were based on sprayer application cost ($15.33/ha) plus herbicide cost (glyphosate = $10.05/kg ai and/or premix of hexazinone plus diuron = $20.66/kg ai). The cost of 2,4-D was not included in the cost analysis because it was not used with every glyphosate application at all three locations.

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[8] SAS institute. 2003. SAS User's Guide: Statistics. Version 9.1. SAS Institute. SAS Campus Drive, Cary, NC 27513.

RESULTS AND DISCUSSION

Sugarcane and Bermudagrass Control with Glyphosate. The first objective of a fallow weed control program is to destroy the sugarcane stubble. Historically, producers have relied on tillage to accomplish this task. If a NT fallow program is to be successful, herbicides must provide complete destruction of sugarcane stubble so that the subsequent planting operation is not hindered. In the glyphosate rate by timing study, a significant interaction between glyphosate rate and timing was not observed for sugarcane control 14 DAT, but was observed at 28 and 42 DAT (Table 2.2). However, there were significant glyphosate rate and glyphosate timing main effects at 14 DAT. Initial control of sugarcane was slower than expected 14 DAT (Table 2.2). When averaged across application timings as glyphosate rate increased sugarcane control increased, but maximum control was only 73% 14 DAT. Averaged across glyphosate rates, sugarcane control 14 DAT was greatest when glyphosate was applied to sugarcane no more than 25 cm tall (maximum control 77%), but control decreased to 62 and 51% when application was made to 40 and 45 cm sugarcane, respectively. At 28 DAT, when glyphosate was applied at 1.68, 2.24, or 2.80 kg/ha to 15 or 25 cm sugarcane, control was at least 92 and 85%, respectively. When glyphosate application was delayed until sugarcane reached a height of 40 cm, control was maximized at 78% for 1.68 kg/ha and at 45 cm control was maximized at 86% for 2.24 kg/ha. At 42 DAT, sugarcane was controlled at least 90% when glyphosate was applied at all rates to 15 cm sugarcane. When glyphosate was applied to 25 and 40 cm sugarcane, control was maximized at 1.68 kg/ha (91 and 86% control, respectively). However, when glyphosate was applied to 45 cm sugarcane, 2.24 kg/ha of glyphosate was needed to obtain 86% control.

Results show that control of sugarcane stubble with glyphosate is both rate and growth stage

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Table 2.2. Sugarcane control 14, 28, and 42 d after treatment (DAT) as affected by glyphosate rate and timing of application.[a]

Glyphosate rate	Application timing[b] (cm)				
	15	25	40	45	Avg.
kg ai/ha	--14 DAT[c]--				
1.12	65	64	53	39	55 d[c]
1.68	72	78	59	50	65 c
2.24	79	80	69	52	70 b
2.80	78	86	69	63	73 a
Avg.	73 a[c]	77 a	62 b	51 c	
	--28 DAT--				
1.12	85 cde[c]	73 gh	74 gh	57 i	-- --
1.68	92 ab	85 bcde	78 efg	68 h	-- --
2.24	92 ab	89 abcd	83 cdef	76 fg	-- --
2.80	95 a	89 abc	81 def	79 efg	-- --
	--42 DAT--				
1.12	90 bcd[c]	82 fg	82 fg	68 h	-- --
1.68	95 ab	91 abcd	86 de	76 g	-- --
2.24	95 ab	94 abc	89 bcd	86 def	-- --
2.80	96 a	94 ab	91 abcd	88 cd	-- --

[a] A significant application timing by glyphosate rate interaction was not observed 14 DAT but was observed 28 and 42 DAT. At 14 DAT significant glyphosate rate and application timing effects were observed.

[b] In 2004 and 2005 application timing corresponded to an average sugarcane canopy height. Specific application dates were April 2, April 15, May 4, and May 21, 2004, and April 5, April 20, May 5, and May 16, 2005, for 15, 25, 40, and 45 cm, respectively.

[c] Data for percent control represent an average across two years. Glyphosate rate and application timing means (14 DAT) and glyphosate rate by application timing means (28 and 42 DAT) followed by the same letter are not significantly different (P > 0.05). Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998).

dependent. The most economical rate for sugarcane control would be 1.12 kg/ha when sugarcane is 15 cm, 1.68 kg/ha for 25 to 40 cm sugarcane, and 2.24 kg/ha when sugarcane is 45 cm. In a typical sugarcane fallow program, an additional glyphosate application would be made to control late emerging weeds. This follow-up application should further increase sugarcane control such that stubble is completely destroyed and will not affect planting operations in August. It appears feasible from the standpoint of controlling the sugarcane stubble that a NT fallow program can be successful.

In the glyphosate rate by formulation study, a significant interaction between glyphosate rate and glyphosate formulation was not observed at any of the rating dates (Table 2.3). In addition, there were no significant effects due to glyphosate formulation, but significant effects due to glyphosate rate were observed. This study, unlike the earlier study, included glyphosate at 3.36 kg/ha, and the rating date was extended to 56 DAT. At each rating date, sugarcane control increased as rate of glyphosate increased with application to 25 cm sugarcane (Table 2.3). Sugarcane control with glyphosate at 3.36 kg/ha was 84, 92, and 95% at 21, 35, and 56 DAT, respectively. Sugarcane control with 1.12 kg/ha was 83% 56 DAT, which may be acceptable economically if a follow-up application of glyphosate is scheduled. When comparing glyphosate formulations, considerable difference in price exists. Based on this study in regard to controlling sugarcane stubble, it would be possible for a producer to use a more economical glyphosate formulation to reduce input cost.

In most fallow fields in Louisiana, perennial weeds, such as bermudagrass and/or johnsongrass are present. With the sugarcane row top not disturbed over the 3 to 5 year crop cycle and with current herbicide in-crop programs ineffective on perennial weeds (Anonymous 2007), fallowed fields can be heavily infested with weeds. A successful weed control program during the fallow

Table 2.3. Sugarcane control 21, 35, and 56 d after treatment (DAT) as affected by glyphosate rate and formulation.[a]

	Glyphosate formulation[b]					
Glyphosate rate	Roundup WeatherMAX	Roundup OriginalMAX	Roundup UltraMax	Mirage[c]	Honcho Plus	Avg.
kg ai/ha	------------------------------------21 DAT--					
1.12	56	54	56	53	57	55 c[d]
2.24	71	75	72	73	74	73 b
3.36	84	84	83	84	84	84 a
	------------------------------------35 DAT--					
1.12	73	74	75	72	76	74 c
2.24	85	87	84	85	85	85 b
3.36	91	91	90	93	94	92 a
	------------------------------------56 DAT--					
1.12	84	82	85	81	86	83 c
2.24	91	92	93	92	90	91 b
3.36	96	95	94	95	95	95 a

[a] Treatments were applied on April 21, 2004 and April 28, 2005 when sugarcane canopy height averaged 25 cm. A significant glyphosate rate by formulation interaction was not observed at any of the rating dates, but a significant rate effect was observed.
[b] Roundup WeatherMAX and Roundup OriginalMAX, potassium salt of glyphosate plus surfactant, Monsanto Company, 800 North Lindbergh Boulevard, St. Louis, MO 63167. Roundup UltraMax and Honcho Plus, isoproplyamine salt of glyphosate plus surfactant, Monsanto Company. Mirage, isopropylamine salt of glyphosate without surfactant, Loveland Products Inc., P.O. Box 1286, Greeley, CO 80632.
[c] A surfactant was added at 0.25% v/v.
[d] Glyphosate rate means for each rating date followed by the same letter are not significantly different ($P > 0.05$). Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998).

period is critical to maximizing sugarcane yields over the multi-year crop cycle (Griffin et al. 2006; Richard 1995 and 1997). In the bermudagrass control study, the 40 DAT rating reflected control only from the initial glyphosate application. Glyphosate applied to bermudagrass runners 15 to 25 cm in length at 1.12 to 2.80 kg/ha provided 86 to 88% control 40 DAT (Table 2.4). The levels of bermudagrass control were similar to the levels of sugarcane control obtained with glyphosate (Tables 2.2 and 2.3). At 18 d after the sequential glyphosate application, bermudagrass control was at least 97% regardless of rate of glyphosate applied, either initially or sequentially. Results show for bermudagrass control in fallowed sugarcane fields that multiple applications of glyphosate at lower rates can be more effective than a single application at a higher rate. Bermudagrass was effectively controlled with sequential glyphosate applications of 1.12 kg/ha. Miller et al. (1999) reported that bermudagrass ground cover in September and October prior to planting was less than 6% following sequential applications of glyphosate at 3.4 kg/ha followed by 2.2 kg/ha during the fallow period, but lower rates of glyphosate were not evaluated. Although not evaluated in the sugarcane control studies, it would be expected that sequential applications of glyphosate at 1.12 kg/ha would also completely destroy sugarcane stubble. Based on this research, control of both sugarcane stubble and bermudagrass with glyphosate can be expected when a reduced till or NT fallow program is used.

Tillage/Weed Control Programs Study. Differences in sugarcane shoot population, height, sugarcane yield, and sugar yield among the various fallow programs were not observed (Table 2.5). In 2004, sugarcane shoot population 35 DAP averaged 12,600/ha and increased to an average of 22,610/ha by April 2005. Sugarcane height in June 2005 averaged 194 cm and sugarcane yield in December averaged 74.6 mt/ha with a sugar yield average of 10,030 kg/ha. Results indicate that sugarcane production was not negatively affected by reducing the number

Table 2.4. Bermudagrass control 40 d after the initial treatment (DAT) and 18 d after the sequential treatment as affected by glyphosate rate.[a]

Initial application	Sequential application (kg ai/ha)				
	1.12	1.68	2.24	2.80	Avg.
kg ai/ha	----------------------------------40 DAT[b]----------------------------------				
1.12	--	--	--	--	86 b[c]
1.68	--	--	--	--	86 ab
2.24	--	--	--	--	87 ab
2.80	--	--	--	--	88 a
	----------------------------------18 DAT----------------------------------				
1.12	98	98	97	99	98 a
1.68	97	99	98	99	98 a
2.24	97	99	98	99	98 a
2.80	99	98	98	99	99 a

[a] Initial treatments were applied May 29, 2004 and June 14, 2005 when average length of bermudagrass runners were 15 to 25 cm. Sequential treatments were applied July 8, 2004 and July 24, 2005 to bermudagrass stolons 5 to 15 cm.
[b] Data represent level of control from the initial application because the sequential application had not been made.
[c] Glyphosate rate treatment means for each rating date followed by the same letter are not significantly different ($P > 0.05$). Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998).

Table 2.5. Sugarcane response in the first production year following various summer fallow weed control programs.[a]

| Fallow program[b] | Shoot population | | Sugarcane height[c] | Sugarcane yield | Sugar yield |
| | 35 DAP 2004 | April 2005 | June 2005 | Dec. 2005 | Dec. 2005 |
	--------------------no./ha--------------------		---------cm---------	----1,000 kg/ha----	-------kg/ha--------
1	11,610	22,110	192	71.3	9,550
2	12,550	21,530	192	73.2	9,920
3	12,510	22,110	198	75.7	10,100
4	13,420	24,580	196	77.5	10,410
5	12,070	22,680	192	76.5	10,310
6	13,410	22,620	192	73.5	9,900
P-value > F[d]	0.607	0.441	0.069	0.119	0.239

[a] Data averaged across three locations, Henderson, St. Gabriel, and St. James, LA for 2004 and 2005. DAP = days after planting.

[b] See Table 2.1 for specific fallow weed control programs. All fallow programs received a premix of hexazinone at 0.59 kg ai/ha plus diruon at 2.10 kg ai/ha applied at planting in August 2004 and then a standard weed control program during the 2005 production year.

[c] Sugarcane height was measured from the soil surface to the upper most leaf collar.

[d] Based on (P < 0.05) differences among the various fallow programs for the parameters measured were not detected. Specific P-values are provided for each parameter.

of tillage operations or by eliminating tillage all together during the fallow period. It should be noted, however, that although not significant, both sugarcane and sugar yield for the tillage alone fallow program (Fallow program 1) were numerically less ($P = 0.119$ and 0.239, respectively) compared with the other fallow programs. The impact that this might have had on the subsequent ratoon crop was not measured.

   Even though sugarcane production was not affected by the fallow programs, weed control was affected (Table 2.6). Bermudagrass ground cover was 34% in October and 37% in November for the tillage alone fallow program (Fallow program 1) compared to no more than 7% ground cover for the other fallow programs. There was no difference in bermudagrass control among the tillage/glyphosate or NT/glyphosate fallow programs (Fallow programs 2-6). Miller et al. (1999) and Richard (1997) found that substitution of one or two tillage operations with a glyphosate application in a sugarcane fallow program increased bermudagrass control over that observed with tillage alone. In the present study, tillage alone was not an effective management program for bermudagrass. Johnsongrass control was 73% for the tillage alone fallow program (Table 2.6). Where at least one application of glyphosate replaced a tillage operation or where a NT/glyphosate program was used, johnsongrass was controlled equally and at least 83%. Although bermudagrass and johnsongrass control was less for the tillage alone fallow program, sugarcane was able to compensate and sugarcane and sugar yield was not reduced (Table 2.5). As noted previously, experiments were not continued to evaluate the impact that bermudagrass and johsongrass could have had on the ratoon crops. Previous research has shown that bermudagrass infestation levels increase with each successive crop and is more detrimental to sugarcane production in the ratoon crops than in the plant-cane crop (Richard 1995).

Table 2.6. Perennial weed control in sugarcane in October and November following various summer fallow weed control programs.

| Fallow program[c] | Bermudagrass ground cover[a] | | Johnsongrass control[b] |
	Oct. 2004	Nov. 2004	Nov. 2004
--%---			
1	34 a[d]	37 a	73 b
2	7 b	2 b	86 a
3	4 b	2 b	86 a
4	7 b	2 b	84 a
5	3 b	2 b	87 a
6	4 b	7 b	83 a

[a] Data averaged across two locations, Henderson and St. James, LA.

[b] Data averaged across two locations, Henderson and St. Gabriel, LA.

[c] See Table 2.1 for specific fallow weed control programs. All fallow programs received a premix of hexazinone at 0.59 kg ai/ha plus diruon at 2.10 kg ai/ha applied at planting in August 2004 and then a standard weed control program during the 2005 production year.

[d] Treatment means for each rating date followed by the same letter are not significantly different (P > 0.05). Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998).

Although sugarcane and sugar yields for the fallow programs were not different, the calculated net return values provided additional insight. Differences in net return among the various fallow programs were a function of the difference in tillage costs (number of tillage operations performed) and in herbicide cost (number of glyphosate applications and use of PRE herbicide) (Tables 2.1 and 2.7). Compared with a tillage only fallow program (Fallow program 1), eliminating one tillage operation (Fallow program 2) reduced tillage cost $18.84/ha; elimination of two tillage operations (Fallow programs 3 and 4) reduced tillage cost $37.68/ha and elimination of all tillage operations (Fallow programs 5 and 6) reduced tillage cost $110.93/ha (Table 2.7). However, when a glyphosate application replaced a tillage operation the herbicide cost increased $43.47/ha per glyphosate application and when hexazinone plus diuron was applied PRE to replace a tillage operation (Fallow programs 4 and 6), herbicide cost increased $71.36/ha. When a tillage operation was replaced with a glyphosate application, net return decreased $24.63/ha (Fallow program 2) and twice that at $49.26/ha when two tillage operations were replaced with two glyphosate applications (Fallow program 3). When a tillage operation was replaced with application of hexazinone plus diuron, net return decreased an additional $52.52/ha (Fallow program 4). For the NT programs (Fallow programs 5 and 6), only three total herbicide applications were needed and substituted for six tillage operations. Net returns still decreased compared to the conventional tillage only fallow program and were $19.48/ha for Fallow program 5 and $47.37/ha for Fallow program 6.

Selection of a fallow program in sugarcane should be based on weed spectrum and economics. From a perennial weed control standpoint, all fallow programs evaluated that used a glyphosate application to replace a tillage operation were more effective than a conventional tillage alone program. However, economically, the conventional tillage alone program was by far the least

Table 2.7. Cost and net return analysis of summer fallow weed control programs.

Fallow program[a]	Summer tillage and herbicide treatment			Change in cost/ha vs. conventional tillage only (Fallow program 1)		
	Total tillage operations	Glyphosate application	PRE application	Tillage[b]	Herbicide[c]	Net return[d]
	-----------------------no.---------------------			-------------------------------------$/ha-------------------------------------		
1	6	0	0	-- --	-- --	-- --
2	5	1	0	18.84	(43.47)	(24.63)
3	4	2	0	37.68	(86.94)	(49.26)
4	4	1	1	37.68	(114.83)	(77.15)
5	0	3	0	110.93	(130.41)	(19.48)
6	0	2	1	110.93	(158.30)	(47.37)

[a] See Table 4 for specific fallow weed control programs. All fallow programs received a premix of hexazinone at 0.59 kg ai/ha plus diruon at 2.10 kg ai/ha applied at planting at the three locations in August 2004 and then a standard weed control program during the 2005 production year.

[b] Conventional program (Fallow program 1) tillage cost at $110.93/ha total cost ($45.26/ha direct, $51.22/ha fixed, and $14.45/ha labor). Data represent change in tillage cost for each fallow program vs. conventional program tillage cost.

[c] Conventional herbicide program (Fallow program 1) cost at $0.00 total cost. Data represent a change in herbicide cost (includes application costs) for each program vs. conventional tillage only fallow program. Values in parentheses represent a loss.

[d] Represents change in tillage costs plus change in herbicide cost. Values in parentheses represent a loss.

expensive program compared to other programs where herbicide was used. When perennial weeds are problematic, producers should use glyphosate to assure successful weed control and to provide the plant-cane crop with the competitive advantage over weeds. In this study, herbicide cost for glyphosate was based on the Roundup UltraMax[1] formulation. Results from this research show that less expensive glyphosate formulations are equally effective in controlling sugarcane when applied at the equivalent rate of active ingredient. Additionally, in the bermudagrass sequential and sugarcane control studies, the glyphosate rate effective on bermudagrass and sugarcane was half that used in the fallow program study, which would further reduce cost. A fallow program in sugarcane that includes one or two timely applications of glyphosate in combination with a reduced tillage or a NT program can be effective in controlling both perennial weeds and sugarcane stubble. However, use of a preemergence herbicide did not add any value to the fallow program and only increased input cost. In a NT program, conservation of soil moisture, when drought conditions occur during the fallow period, could affect emergence, growth, and eventually yield of planted sugarcane. Since neither weed control nor sugarcane production was negatively affected when the NT fallow program was used, growers would be more likely to consider governmental conservation programs that provide cost share payment (Anonymous 2005).

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CHAPTER 3

PURPLE NUTSEDGE (*CYPERUS ROTUNDUS*) INTERFERENCE WITH SUGARCANE AND RESPONSE TO SHADE

<u>INTRODUCTION</u>

Sugarcane is a subtropical, perennial crop that is grown commercially for sugar only in Florida, Louisiana, and Texas within the continental United States. In 2005, sugarcane production in Louisiana accounted for about 16% of the total sugar production (sugarcane and sugarbeets) in the U.S. (Anonymous 2005). In Louisiana, four to six harvests are made from a single planting. Over time disease and weed pressure reduce sugarcane plant density and yield potential such that fields are fallowed and replanted. During the spring and summer fallow period, postemergence (POST) application of glyphosate and/or timely tillage operations can be used to control perennial weeds. The fallow period is considered critical for perennial weed management because once sugarcane is planted, row tops are not disturbed for the remainder of the multi-year crop cycle.

Johnsongrass [*Sorghum halapense* (L.) Pers.], bermudagrass [*Cynodon dactylon* (L.) Pers.], and purple nutsedge rank first, second, and seventh, respectively, as the most troublesome weeds in sugarcane in Louisiana (Anonymous 2004). However, in recent years, purple nutsedge has become more problematic in Louisiana sugarcane fields. In the 1950's, when less than 10% of cotton (*Gossypium hirsutum* L.) acreage in the Mississippi Delta was treated with herbicides, purple nutsedge was not listed among the top 10 problem weeds (Wills 1977). In 1961, 75% of cotton acreage in the Mississippi Delta was treated with herbicides, and by 1963, purple nutsedge ranked as the second most severe weed on sandy soils. The increase in purple nutsedge infestation over the last few years in sugarcane in Louisiana is likely due to the poor control obtained with glyphosate applied during the summer fallow period prior to replanting of

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sugarcane in August and September (Anonymous 2007). Also contributing to the purple

nutsedge problem could be the limited herbicide options available for use in the crop along with

the expanded use of the dinitroaniline herbicides, trifluralin and pendimethalin, that reduce grass

competition and release purple nutsedge (Dotray et al. 2001; Grichar and Nester 1997; Webster

and Coble 1997). When competition from other weeds was reduced with herbicides in Hawaii, a

native weed population of 14 nutsedge shoots/m^2 changed to 317 shoots/m^2 in 30 d

(Romanowski and Nakagawa 1967). Holm et al. (1997) listed purple nutsedge as the world's

worst weed; this status is related to its perennial nature, longevity of viable tubers, and prolific

tuber production (Bariuan et al. 1999). Purple nutsedge can produce tubers 21 to 23 d following

shoot emergence (Hauser 1962; Smith and Fick 1937). A plant germinating from one tuber

produced 64 tubers in 90 d in the greenhouse (Doll and Piedrahita 1982) and 99 tubers under

field conditions (Rao 1968).

   Competitiveness is the relative ability of a plant to obtain a specific resource when in

competition with another plant (Gibson and Liebman 2003). According to Aldrich and Kremer

(1997), competition between weeds and crops occurs when some factor, such as water, nutrients,

or sunlight, is insufficient to meet the needs of both the weed and the desired plant. Competition

from bermudagrass reduced sugarcane and sugar yields 5 to 17% each year of a 3-yr crop cycle

(Richard 1993). Bermudagrass biomass in July increased by 340% from the plant-cane (first

production year) to first-ratoon crop (second production year) and 490% between the first-and

second-ratoon (third production year) crops. Full-season johnsongrass competition reduced

sugarcane and sugar yields 23 and 17% in the plant-cane crop and 42 and 35% in the first-ratoon

crop, respectively (Millhollon 1995). Richard (1997) reported greater sugarcane shoot

population in the fall after planting and sugar yield at the end of the first growing season when herbicides were applied during the fallow period to control johnsongrass.

Purple nutsedge interference reduced okra (*Hibiscus esculentus* L.) and tomato (*Lycopersicon esculentum* Mill.) yields 62 and 53%, respectively (William and Warren 1975). Leon et al. (2001) reported in greenhouse experiments that initial purple nutsedge tuber densities of more than 180/m^2 reduced fresh weight of cotton and soybean (*Glycine max* L. Merr.). Also, purple nutsedge was found to have superior competitive ability compared to corn (*Zea mays* L.) (Tour and Froud-Williams 2002). Purple nutsedge root, rhizome, tuber, and shoot dry weight increased with increased photoperiod (Williams 1978). Keeley and Thullen (1978) found similar results with yellow nutsedge (*Cyperus esculentus* L.). Even though nutsedge under ideal conditions can have tremendous growth potential, its growth can be affected by shading from the crop. Purple nutsedge shoot population and shoot dry weight were reduced 47 and 67%, respectively, when exposed to 40% shade for 50 d (Santos et al. 1997). Shading significantly reduced dry matter, leaf area, and rhizome and tuber formation of both purple and yellow nutsedge, and there was no difference in response to shade between species (Patterson 1982). Field studies have shown that canopy shading from most crops greatly inhibits the growth of both purple and yellow nutsedge contributing to their control (Jordan-Molero and Stoller 1978).

Purple nutsedge tuber sprouting occurs optimally between 25 and 35 C with 80 to 90% sprouting occurring within 10 to 14 d (Aleixo and Valio 1976; Shamsi et al. 1978; Ueki 1969). In Louisiana when sugarcane is planted in August, average soil temperatures are around 30 C , but when sugarcane regrowth following the winter dormant period occurs in early March, soil temperatures average around 18 C (Anonymous 2006), a period when sugarcane should be highly competitive with nutsedge. Field studies conducted in Brazil showed that purple nutsedge

at 58 to 246 shoots/m^2 reduced sugarcane yield 14%, and at shoot populations of 675 to 1198/m^2, sugarcane yield was reduced 45% (Durigan 2005). This research was conducted in tropical areas unlike the more temperate sugarcane growing area of Louisiana. The competitiveness of purple nutsedge and its response to shade were evaluated under growing conditions corresponding to the time sugarcane is planted in Louisiana in August and September (interference study) and in May through July when shading from the crop canopy could affect weed competition (shade study). The interference study also evaluated at planting competitive ability of several sugarcane cultivars.

MATERIAL AND METHODS

Interference Studies. Research was conducted in August 2005 at the Ben Hur Research Farm near Baton Rouge, LA. The experimental design was a randomized complete block design with five replications. One study evaluated growth response of sugarcane to varying purple nutsedge tuber densities (density study) and the other study compared the competitiveness of sugarcane cultivars with purple nutsedge (cultivar study). For both studies, in which experiments were repeated once, 26.5 L pots with a surface area of 0.093m^2 were used and placed outside under a drip irrigation watering system that delivered 1.0 cm of water per day. The soil mixture used was one part sterilized Commerce silt loam (fine-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquepts), one part sterilized sand, and one part Jiffy Mix Plus[9].

In the density study, 0, 1, 2, 4, 8, and 16 purple nutsedge tubers were planted per pot along with one sugarcane seed piece of the cultivar 'LCP 85-384'. In the cultivar study, the sugarcane cultivars, LCP 85-384, 'Ho 95-988', 'HoCP 96-540', and 'L 97-128' were planted with 0 and 4 purple nutsedge tubers per pot. For each sugarcane cultivar, the seed piece was planted in the

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[9] A sterile soil mix with an optimal blend of sphagnum and vermiculite with MagAmp slow release fertilizer (7-40-6). Jiffy Products of America, Inc., 600 Industrial Parkway, Norwalk, OH 44857.

center of the pot at a 45° angle to the ground with the bud facing upward and 1.3 cm below the soil surface. Purple nutsedge tubers were planted 5.1 cm deep and spaced evenly, using a grid to mark the locations, around the sugarcane seed piece. Both the density and the cultivar study were planted on August 9, 2005 and again on August 25, 2005. Each study was terminated 64 d after planting (DAP).

For the density study, purple nutsedge shoot population was determined 14, 25, 38, 49, and 64 DAP. To quantify sugarcane response, shoot population was determined 49 and 64 DAP and primary sugarcane height was measured 38, 49, and 64 DAP. Sugarcane height for the primary shoot was measured from the soil surface to the last visible leaf collar. Also at 64 DAP, fresh weight shoot (above-ground) biomass of both purple nutsedge and sugarcane were recorded. Roots were washed free of soil and separated to determine fresh weight root (below-ground) biomass for both purple nutsedge and sugarcane. Root weight of purple nutsedge also included tubers. Fresh weight samples were dried at 60 C for 48 hours and reweighed to determine root and shoot dry weight biomass of both purple nutsedge and sugarcane. Also collected at this time were number of purple nutsedge tubers produced over the duration of the study for each density treatment.

In the sugarcane cultivar study, sugarcane primary shoot height was measured 38, 49, and 64 DAP along with shoot population 49 and 64 DAP. Sugarcane height was determined as previously described. At 64 DAP, root and shoot dry weight biomass for both purple nutsedge and sugarcane and tuber population were determined as described for the density study.

Shade Study. A purple nutsedge shade study was conducted in the summer of 2005 near Port Allen, LA, in an abandoned sugarcane field with a heavy, natural infestation of purple nutsedge. The soil type was a Commerce silt loam (fine-silty, mixed, superactive, nonacid, thermic

Fluvaquentic Endoaquepts) with 1.8% organic matter and a pH of 6.5. The experimental design was a randomized complete block design with four replications and two experiments were conducted in 2005. The first experiment was initiated on May 25, 2005, and the second experiment was initiated on August 2, 2005. Shade intensities of 0, 30, 50, 70, and 90% (100, 70, 50, 30, or 10% of full sun light) were based on the light interception levels of black polypropylene fabric[10] shading material. Shade intensities expressed as photosynthetically active radiation (PAR) with the polypropylene fabric were confirmed within three percent using an AccuPAR Linear PAR Ceptometer[11]. Shade enclosures (0.61 x 0.61 x 0.61m) were constructed using wood frames wrapped in polypropylene fabric on the four sides and top with the bottom left open.

The entire experimental area was tilled to a depth of 10.2 cm with a rotary tiller and treated with atrazine at 2.25 kg ai/ha plus pendimethalin at 2.13 kg ai/ha to eliminate competition from other weeds. Purple nutsedge shoot population and height data were collected 28, 42, and 56 d after tillage and placement of shade enclosures on the soil surface. Also at 56 d, all purple nutsedge plants under each enclosure were clipped at the soil surface and shoot fresh weight was determined. Plant height was measured from the base of the plant to the longest leaf tip on 10 randomly selected plants from each plot. Shoots were dried at 60 C for 48 hours and reweighed to determine shoot dry weight biomass. No attempt was made to quantify underground biomass.

Statistical Analysis. In both the interference and shade studies, data were subjected to the Mixed Procedure in SAS[12]. Each experiment was considered an environment sampled at random as suggested by Carmer et al. (1989). Environment, replications (nested within environment), and all interactions containing either of these effects were considered random effects. All other

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[10] DeWitt Company, 905 S. Kings Highway, Sikeston, MO 63801
[11] Decagon Devices, Inc., 950 NE Nelson Court, Pullman, WA 99163
[12] SAS Institute. 2003. SAS User's Guide: Statistics. Version 9.1. SAS Institute. Cary, NC.

variables were considered fixed effects. Considering experiments as environmental or random

effects permits inferences about treatments to be made over a range of environments (Carmer et

al. 1989; Hager et al. 2003). Least square means were calculated and mean separation was

performed at $P \leq 0.05$. Letter groupings were converted using the PDMIX800 macro in SAS

(Saxton 1998).

RESULTS AND DISCUSSION

   Interference Studies. In the density, study purple nutsedge growth and development was very

rapid when exposed to optimal growing conditions in August when sugarcane would be planted

in Louisiana. At 14, 25, and 38 DAP, an increase in the number of purple nutsedge shoots was

observed as initial tuber density increased from 0 to 16/pot (Table 3.1). At 49 DAP, shoot

production continued to increase as tuber density increased, but differences were not observed

between 4 and 8 tubers/pot. By 49 DAP, it was apparent that soil volume in the pot was

beginning to limit growth of purple nutsedge. At 64 DAP, purple nutsedge shoot population was

87.4/pot where the initial tuber density was 16/pot. Shoot population 64 DAP was equal for 1

and 2 tubers/pot and for 4 and 8 tubers/pot, but in all cases shoot population was less than the 16

tuber density. From the first sampling date 14 DAP until the last sampling date 64 DAP, purple

nutsedge shoot population increased 3.9-fold for the 16 tuber density and 19.5-fold for the 1

tuber density. The lower increase in shoot population observed over time for the higher initial

tuber densities is likely due to intraspecific competition (Williams et al. 1977).

   At 64 DAP, both shoot and root (including tubers) dry weight increased as initial tuber density

increased (Table 3.1). For both variables, differences were not observed between 4 and 8

tubers/pot. For the tuber density treatments, purple nutsedge root dry weight averaged 3.4 times

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Table 3.1. Purple nutsedge growth response to co-planting of several tuber densities with a single node segment of 'LCP 85-384' sugarcane.[a]

Initial tuber density	Shoot population					Shoot dry weight	Root dry weight	Tuber population
	14 DAP	25 DAP	38 DAP	49 DAP	64 DAP	64 DAP	64 DAP	64 DAP
no./pot	------------------------------no./pot---------------------------------					-------------g/pot--------------		no./pot
0	0 e[b]	0 f	0 f	0 e	0 d (0)[c]	0 e	0 e	0 f (0)[d]
1	1.3 e	5.1 e	8.4 e	13.0 d	25.3 c (19.5)	6.7 d	22.4 d	37.3 e (37.3)
2	3.4 d	11.0 d	16.1 d	20.3 c	37.0 c (10.9)	13.4 c	39.4 c	66.4 d (33.2)
4	7.5 c	23.5 c	29.3 c	33.8 b	58.1 b (7.7)	20.4 b	70.0 b	114.8 c (28.7)
8	12.5 b	30.7 b	35.9 b	38.7 b	59.3 b (4.7)	20.8 b	72.4 b	137.2 b (17.2)
16	22.7 a	45.6 a	51.8 a	57.9 a	87.4 a (3.9)	27.4 a	102.7 a	186.3 a (11.6)

[a] Nutsedge and sugarcane planted in August in 26.5 L pots with a surface area of 0.093m^2. Pots were placed outside under a drip irrigation watering system. Root dry weight represents both roots and tubers. DAP = d after planting.

[b] Data represent an average across two experiments. Treatment means within each column followed by the same letter are not significantly different (P > 0.05). Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998).

[c] Values in parentheses represent the increase in purple nutsedge shoot population from 14 to 64 DAP. For example 19.5 = 19.5-fold increase from 14 to 64 DAP.

[d] Values in parentheses represent the increase in purple nutsedge tuber population from the initial tuber density to 64 DAP. For example 37.3 = 37.3-fold increase.

that of shoot dry weight, showing that partitioning of carbohydrate favored below ground growth over that of shoots. Tubers act as both source and sink of food materials, particularly of available carbohydrates, and shoot formation occurs in succession (Singh and Singh 1981). In this study, root dry weight data included both roots and tubers. Although tuber weight was not determined, a sizeable percentage of the root dry weight was represented by tubers. This is supported by the tuber population present 64 DAP (Table 3.1). Tuber population increased as initial tuber density increased. At 64 DAP, 37.3 tubers/pot were produced following an initial tuber density of 1/pot compared with 186.3 tubers/pot where the initial tuber density was 16/pot, a 5-fold difference. As also noted for purple nutsedge shoot population, the change in purple nutsedge tuber population from the initial tuber density to 64 d later was less as the initial tuber density increased. Again, this is a reflection of the intraspecific competition that occurred.

At 49 DAP, shoot population of LCP 85-384 sugarcane was reduced with all tuber densities evaluated (Table 3.2). However, by 64 DAP, sugarcane shoot population was equivalent for the weed free control and for 1 and 2 tubers/pot (8.5 shoots/pot average) and greater than for 4 or more tubers/pot (4.9 shoots/pot average). Sugarcane primary shoot height 38, 49, and 64 DAP followed the same response as for shoot population, and height was decreased with initial tuber densities of 4 or more, but was not reduced at lower tuber densities. This same response was also observed for sugarcane shoot dry weight 64 DAP. Shoot dry weight averaged 24.9 g/pot for the weed free control and for 1 and 2 tubers/pot compared with an average of 8.2 g/pot for the 4, 8, and 16 tuber densities. In contrast, all tuber densities decreased sugarcane root dry weight compared with the weed free control. With 1 and 2 tubers/pot, sugarcane root dry weight was reduced an averaged of 50% compared with the weed free control. At the higher tuber densities, sugarcane root dry weight was reduced an average of 85%. Results show that purple nutsedge

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Table 3.2. Sugarcane growth response to co-planting of a single node segment of 'LCP 85-384' sugarcane with several purple nutsedge tuber densities.[a]

Initial tuber density	Shoot population		Height			Shoot dry weight	Root dry weight
	49 DAP	64 DAP	38 DAP	49 DAP	64 DAP	64 DAP	64 DAP
no./pot	--------------no./pot-----------		-------------------------cm-------------------------			---------------g/pot--------------	
0	4.8 a[b]	8.6 a	15.2 a	21.6 a	30.2 a	28.5 a	14.6 a
1	2.2 b	8.5 a	13.4 a	20.9 a	30.0 a	24.2 a	8.0 b
2	1.8 b	8.5 a	13.3 a	20.8 a	29.5 a	22.1 a	6.7 b
4	0 c	5.4 b	9.8 b	15.8 b	24.1 b	10.0 b	2.9 c
8	0.4 c	4.8 b	10.4 b	15.2 b	22.1 b	7.9 b	1.9 c
16	0 c	4.6 b	9.3 b	14.9 b	21.6 b	6.7 b	1.6 c

[a] Nutsedge and sugarcane planted in August in 26.5 L pots with a surface area of $0.093m^2$. Pots were placed outside under a drip irrigation watering system. DAP = d after planting.
[b] Data represent an average across two experiments. Treatment means within each column followed by the same letter are not significantly different ($P > 0.05$). Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998).

competition was more detrimental to sugarcane root growth than shoot growth. The 50% average reduction in sugarcane root growth observed from initial tuber populations of 1 and 2/pot did not correspond to a significant reduction in shoot dry weight. In developing alternative control strategies, it is important to know the critical weed density (Cousens 1991; Radosevich 1987). Based on shoot growth response to purple nutsedge competition, the critical weed density of purple nutsedge with LCP 85-384 sugarcane would be 40 tubers/m^2 (4 tubers/pot). However, based on root growth response of LCP 85-384 sugarcane, 10 tubers/m^2 would represent the critical weed density. In sugarcane culture in Louisiana, it would be important that sugarcane develops a root system adequate to sustain viability of plants into the winter period and that also would support aggressive emergence and growth of plants after the winter dormant period. This research indicates that purple nutsedge is highly competitive with sugarcane, especially root development, and that control measures should be implemented at planting to ensure adequate plant populations in the first production year.

In the sugarcane cultivar study, a significant cultivar by initial tuber density interaction was not observed for any of the parameters measured. Averaged across sugarcane cultivars, purple nutsedge planted at an initial tuber density of 4/pot with a single sugarcane node segment produced 54.8 shoots and 113.9 tubers/pot in 64 d (Table 3.3). Purple nutsedge shoot and root (including tubers) dry weight was 20.6 and 64.7 g/pot, respectively.

Averaged across initial tuber densities of 0 and 4 tubers/pot, L 97-128 height 49 and 64 DAP was greater when compared with LCP 85-384 and Ho 95-988, but equal to that of HoCP 96-540 (Table 3.4). L 97-128 shoot population 49 and 64 DAP was greater compared with the other varieties. Shoot and root dry weight 64 DAP for L 97-128 averaged 2.0 and 1.7 times that, respectively, of the other three cultivars. Shoot population and shoot and root dry weight were

Table 3.3. Purple nutsedge growth response 64 days after co-planting of 4 tubers/pot and a single node segment of four sugarcane cultivars.[a]

Initial tuber density	Shoot population	Shoot dry weight	Root dry weight	Tuber population
no./pot	no./pot	--------------------g/pot------------------		no./pot
0	0 b	0 b	0 b	0 b
4	54.8 a[b]	20.6 a	64.7 a	113.9 a

[a] Nutsedge and sugarcane planted in August in 26.5 L pots with a surface area of 0.093m^2. Pots were placed outside under a drip irrigation watering system. Root dry weight represents both roots and tubers.

[b] Data represent an average across two experiments. Data averaged across sugarcane cultivars, 'LCP 85-384', 'Ho 95-988', 'HoCP 96-540', and 'L 97-128'.

Table 3.4. Sugarcane growth response to co-planting of a single node segment of four sugarcane cultivars with 4 purple nutsedge tubers/pot.[a]

Cultivar[b]	Height			Shoot population		Shoot dry weight	Root dry weight
	38 DAP	49 DAP	64 DAP	49 DAP	64 DAP	64 DAP	64 DAP
	--------------------cm--------------------			------------no./pot------------		-------------g/pot-------------	
LCP 85-384	14.7 ab	18.7 bc	27.6 b	2.4 b	7.3 b	18.2 b	8.5 b
Ho 95-988	12.2 b	17.7 c	25.7 b	2.0 b	7.6 b	21.2 b	7.4 b
HoCP 96-540	12.5 b	21.5 ab	29.7 ab	2.3 b	6.1 b	22.8 b	9.7 b
L 97-128	16.0 a[c]	22.2 a	33.2 a	5.6 a	11.7 a	41.5 a	14.6 a
Initial tuber density[b]							
4/pot	11.9*[d]	17.7*	25.6*	1.1*	5.8*	14.2*	4.5*
	(25%)	(21%)	(21%)	(77%)	(45%)	(62%)	(71%)

[a] Nutsedge and sugarcane planted in August in 26.5 L pots with a surface area of $0.093m^2$. Pots were placed outside under a drip irrigation watering system. DAP = d after planting.
[b] Significant sugarcane cultivar and tuber density main effects were observed but the variety x tuber density interaction was not significant for any of the parameters measured.
[c] Data represent an average across two experiments and tuber densities of 4 and 0 tubers/pot. Treatment means within each column followed by the same letter are not significantly different (P > 0.05). Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998).
[d] Data averaged across sugarcane cultivars for the initial tuber density of 4 tubers/pot. An asterisk (*) denotes that data were significantly different from the weed free (0 tubers/pot) treatment. Values in parentheses represent percent reduction versus the weed free control.

equivalent for LCP 85-384, Ho 95-988, and HoCP 96-540. Of the sugarcane varieties evaluated, L 97-128 was the first to emerge and produce tillers, giving it more of a competitive advantage with purple nutsedge. Averaged across sugarcane cultivars, 4 purple nutsedge tubers/pot resulted in a decrease in all sugarcane growth parameters when compared with the weed free control (Table 3.4). At 64 DAP, sugarcane height, shoot population, and shoot and root dry weight biomass were decreased 21, 45, 62, and 71%, respectively. These results indicate that even though L 97-128 was more competitive with purple nutsedge than the other cultivars evaluated, its growth was still greatly affected by weed competition of 4 purple nutsedge tubers/pot. L 97-128 would be a good cultivar to grow in fields with a suspected purple nutsedge problem, but an effective herbicide program should be implemented to assure stand establishment.

   Shade Study. For 30% shade, the lowest shade level imposed, purple nutsedge shoot population was reduced 35.3, 33.8, and 52.9% at 28, 42, and 56 d, respectively, compared with the full sunlight (no shade) control (Table 3.5). Purple nutsedge height at 56 d was not negatively affected by 30% shade, but shoot dry weight was reduced 74.8% compared to full sunlight. Shoot population, height, and shoot dry weight were each equivalent for 30 and 50% shade treatments. Santos et al. (1997) reported that after 50 d, 40% shading reduced purple nutsedge shoot number by 47% and shoot dry weight by 67%. Patterson (1982) reported that after 62 d, 40% shading reduced purple nutsedge shoot number by 61% and total dry weight by 67%. Reductions in shoot population and dry weight noted in these studies approximate those observed in the present study. In the present study, purple nutsedge shoot population, height, and shoot dry weight were each equivalent for the 70 and 90% shade treatments. Shoot population and shoot dry weight at 56 d for the 70 and 90% shade treatments were reduced an average of 81.5 and 92.1%, respectively, compared with full sunlight. In contrast, purple

Table 3.5. Purple nutsedge growth response to shade.[a]

| Shade level | Shoot population | | | Height | Shoot dry weight |
	28 d	42 d	56 d	56 d	56 d
%	--------------------no./0.37m^2------------------			cm	g/0.37m^2
0	37 a[b]	78 a	136 a	23.7 c	46.1 a
30	24 b	52 b	64 b	21.5 c	11.6 b
50	15 bc	33 bc	53 b	25.1 bc	7.6 bc
70	10 c	20 c	22 c	31.7 ab	3.2 c
90	9 c	20 c	29 c	33.9 a	4.1 c

[a] Shade enclosures (0.61 x 0.61 x 0.61m) were constructed of wood and wrapped in polypropylene fabric shading material on four sides and top. Shade enclosures were placed on the soil after the experimental area was tilled to a depth of 10.2 cm using a rotary tiller. Data were collected 28, 42, and 56 d after tillage and placement of shade enclosures.

[b] Data represent an average across two experiments. Treatment means within each column followed by the same letter are not significantly different (P > 0.05). Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998).

nutsedge height at 56 d for the 70 and 90% shade treatments increased an average of 38.4%

compared with full sunlight. Since this was a field study, no attempt was made to quantify

below ground effects of shade on purple nutsedge. It is noteworthy that purple nutsedge was

able to persist under a 90% shade environment, which may explain why it is becoming more

problematic in Louisiana and Florida sugarcane. In research conducted in Louisiana, the

sugarcane varieties LCP 85-384, L 97-128, HoCP 96-540, and Ho 95-988 did not differ in regard

to the amount of PAR that penetrated the crop canopy to ground level (Jones et al. 2006). In

mid-June PAR at ground level averaged 48% and decreased to an average of 24% by early July.

By late July PAR at ground level was 9%, sufficient to sustain growth of purple nutsedge based

on the current study.

   Results clearly show that purple nutsedge can be highly competitive with sugarcane at planting

in August and September. In 64 DAP a 37.3 fold increase in purple nutsedge tuber population

occurred when only one tuber/$0.093m^2$ was planted with a single node segment of LCP 85-384

sugarcane (Table 3.1). At the lowest density evaluated of one tuber/$0.093m^2$ sugarcane root dry

weight was reduced 45.2%, but shoot dry weight was not affected (Table 3.2). An initial tuber

density of 4 tubers/$0.093m^2$ was needed to reduce sugarcane shoot dry weight. Full season

competition of high populations of purple nutsedge (160 plants/$0.1m^2$ at 5 to 7 weeks after

planting) resulted in significant vegetable crop losses in Brazil even with transplanted vegetable

crops (William and Warren 1975). In comparing competitiveness of sugarcane varieties with

purple nutsedge L 97-128 produced more shoots and greater shoot and root dry weight when

compared with LCP 85-384, HoCP 96-540, and Ho 95-988 (Table 3.4). Based on shoot and root

dry weight after 64 d of competition with purple nutsedge, L 97-128 was almost twice as

competitive as the other varieties. Even though 30% shade reduced purple nutsedge shoot dry

weight by 75% plants were able to persist for 56 d under 90% shade (Table 3.5).

   Since PRE herbicides labeled in sugarcane have little activity on purple nutsedge and POST

herbicides will not provide complete control (Anonymous 2007) purple nutsedge is expected to

become more problematic over time. In Louisiana, sugarcane planted in August and September

is winter killed and reemerges usually in March to start the plant cane crop. At this time of the

year cool soil temperatures around 18 C (Anonymous 2006) would inhibit optimal germination

and growth of purple nutsedge from tubers (Aleixo and Valio 1976; Shamsi et al. 1978; Ueki

1969). The ability of sugarcane to produce significant plant growth and shading before purple

nutsedge emerges in the spring would further reduce purple nutsedge competition.

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CHAPTER 4

NUTSEDGE (*CYPERUS* SPP.) CONTROL PROGRAMS IN NEWLY PLANTED SUGARCANE

<u>INTRODUCTION</u>

Sugarcane is a perennial crop and in Louisiana, four to six harvests are made from a single planting. The first harvest year is the plant cane crop and consecutive years are stubble crops. In Louisiana, sugarcane is planted using whole stalk or billet seed pieces in August to allow the crop enough time to establish before the winter dormant period. Regrowth from stubble occurs in March of the following year. Environmental conditions, weeds, insects, and/or diseases can have a significant impact on plant cane stand establishment and a weekened stand can have a residual effect throughout the multi-year crop cycle. Weed problems are addressed during the spring and summer fallow period with postemergence (POST) application of glyphosate and/or timely tillage operations (Anonymous 2007). Once sugarcane is planted in August, a preemergence (PRE) herbicide is applied after rows are packed to prevent weed establishment and competition in newly emerging sugarcane. Weed competition during the early stage of sugarcane development can reduce shoot production and root system establishment, which are critical to maximizing production in the first year (Richard 1997).

Over the past few years, sugarcane growers have reported an increase in purple and yellow nutsedge (*Cyperus* spp.) infestations. The increase in nutsedge in sugarcane in Louisiana is likely due to the poor control obtained with glyphosate applied during the summer fallow period (Anonymous 2007). Also contributing to the nutsedge problem could be the limited herbicide options available for use in the crop along with the expanded use of the dinitroaniline herbicides, trifluralin and pendimethalin, that reduce grass competition and release nutsedge (Dotray et al. 2001; Grichar and Nester 1997; Webster and Coble 1997a).

Purple nutsedge (*Cyperus rotundus* L.) and yellow nutsedge (*Cyperus esculentus* L.) are herbaceous perennials that are among the world's worst weeds (Stoller and Sweet 1987). Holm et al. (1997) listed purple nutsedge as the world's worst weed; this status is related to its perennial nature, longevity of viable tubers, and prolific tuber production (Bariuan et al. 1999). Purple nutsedge is capable of producing tubers 21 to 23 d following shoot emergence (Hauser 1962; Smith and Fick 1937). A plant germinating from one tuber produced 64 and 99 tubers in just 90 d under greenhouse (Doll and Piedrahita 1982) and field conditions (Rao 1968), respectively. Purple nutsedge can be a strong competitor with crops. Purple nutsedge interference reduced okra (*Hibiscus esculentus* L.) and tomato (*Lycopersicon esculentum* Mill.) yields 62 and 53%, respectively (William and Warren 1975). Leon et al. (2001) reported in greenhouse experiments that initial purple nutsedge tuber densities of more than 180/m^2 reduced fresh weight of cotton (*Gossypium hirsutum* L)and soybean (*Glycine max* L. Merr.). Also, purple nutsedge was found to have superior competitive ability compared to corn (*Zea mays* L.) (Tour and Froud-Williams 2002). Yellow nutsedge can also be a competitor with crops. Keeley and Thullen (1975) found yellow nutsedge capable of reducing yields of furrow-irrigated cotton when allowed to compete for periods of four or more weeks. Seed cotton yield was decreased 34% when yellow nutsedge was allowed to compete season long. Season-long yellow nutsedge interference with watermelon (*Citrullus lanatus* Thunb.) reduced yields up to 94% (Buker 1999). A yellow nutsedge density of 5 tubers/m^2 caused a 10% reduction in fruit yield of polyethylene-mulched bell pepper (*Capsicum annuum*) (Motis et. al 2003).

In general, both purple and yellow nutsedge are relatively tolerant to many herbicides used in agronomic crops (Webster and Coble 1997b). Several acetolactate synthase (ALS)-inhibiting herbicides control purple and yellow nutsedge, including chlorimuron (Reddy and Bendixen

1988), imazapic (Richburg et al. 1994), imazaquin (Nandihalli and Bendixen 1998), imazethapyr (Richburg et al. 1993), and pyrithiobac (Wilcut 1998). None of these herbicides, however, are currently labeled for use in sugarcane. Relatively new compounds that target ALS are also effective on nutsedge. Halosulfuron reduced purple nutsedge regrowth to less than 5% of the nontreated check following soil and/or foliar applications (Vencill et al. 1995). In corn, a foliar application of halosulfuron at 72 g ai/ha controlled purple nutsedge more than 90% 58 days after planting (DAP) (Webster and Coble 1997b). However, by 120 DAP reinfestation of purple nutsedge occurred. In a greenhouse study, trifloxysulfuron applied at 24.7 g ai/ha 28 DAP decreased purple and yellow nutsedge shoot number 40% at 30 d after treatment (DAT) and 52% at 60 DAT (McElroy et al. 2003). In another study which evaluated absorption, translocation, and metabolism of foliar-applied trifloxysulfuron in purple and yellow nutsedge, less than 53% of the herbicide was absorbed after 96 h (Troxler et al. 2003). Both nutsedge species translocated appreciable amounts of herbicide (30%) out of treated leaves, but neither nutsedge species translocated more than 4% of radiolabeled herbicide to the tubers and roots.

Both halosulfuron and trifloxysulfuron are currently labeled for use in sugarcane. Sulfentrazone, a protoporphyrinogen oxidase inhibitor is also labeled PRE in sugarcane for nutsedge control. In potatoes, sulfentrazone at 110 to 280 g ai/ha PRE or POST controlled purple nutsedge greater than 75% at two of three locations. Due to the competitive ability of nutsedge with sugarcane (Etheredge et al. 2006) and difficulty in controlling nutsedge species with currently labeled herbicides in sugarcane (Anonymous 2007), there is a need to develop a management program for nutsedge control in sugarcane. The objectives of this research were to evaluate sulfentrazone, halosulfuron, and trifloxysulfuon in sugarcane for nutsedge control and

sugarcane tolerance in respect to timing and rates of application and to determine the competitive

effect of nutsedge on growth and establishment of newly planted sugarcane.

MATERIALS AND METHODS

PRE/POST Study. Field experiments were conducted in 2004 near St. James, LA, and White

Castle, LA, to evaluate nutsedge control with herbicides applied both PRE and POST. Specific

locations were selected due to heavy infestations of both purple and yellow nutsedge detected

during the fallow period prior to planting of sugarcane on August 26, 2004, near St. James, LA,

and September 14, 2004, near White Castle, LA. All plots were planted with sugarcane cultivar

'LCP 85-384' either as sectioned stalks (billets) (St. James) or whole stalks (White Castle)

depending on grower preference and machinery available. At the St. James, LA, location the soil

type was a Commerce silty clay loam (fine-silty, mixed, superactive, non-acid, thermic

Fluvaquentic Endoaquepts) with 0.89% OM and a pH of 7.3. The soil type at White Castle, LA,

was also a Commerce silty clay loam with 0.98% OM and a pH of 6.9. The experimental design

was a randomized complete block with 14 treatments (7 PRE treatments, 6 POST treatments, and

a nontreated control) with four replications. Experimental plots consisted of two, 12.2 m long

sugarcane rows spaced 1.8 m apart. Pendimethalin at 2.24 kg ai/ha was applied PRE to the entire

experimental area except where the premix of hexazinone plus diuron[13] was applied to control

annual grasses. Pendimethalin is not active on purple or yellow nutsedge (Anonymous 2007).

PRE treatments consisted of sulfentrazone at 280, 350, or 420 g ai/ha, halosulfuron at 35.3,

53.0, or 70.6 g ai/ha, and hexazinone at 590 g ai/ha plus diuron at 2100 g ai/ha, applied the day

after planting on August 27, 2004, and September 15, 2004, at St. James, LA, and White Castle,

LA, respectively. POST treatments consisted of sulfentrazone and halosulfuron applied at the

same rates as the PRE treatments when average sugarcane canopy was 35 to 45 cm and nutsedge

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[13] DuPont K4®, DuPont Crop Protection Walker's Mill, Barley Mill Plaza Wilmington, Delaware 19880-0038.

species were 15 to 25 cm in height on October 19 and October 26 at St. James, LA, and White Castle, LA, respectively. Nonionic surfactant[14] at 0.25% (v/v) was added to all POST treatments. Herbicide treatments were applied using a tractor-mounted compressed air sprayer calibrated to deliver 93.5 L/ha at a spray pressure of 140 kPa. Visual estimates of nutsedge (purple and yellow nutsedge combined) control were made 7 and 10 weeks after treatment (WAT) for the PRE treatments. Nutsedge control and sugarcane injury ratings were made 3 WAT for POST treatments. Ratings were based on a scale of 0 to 100% with 0 = no control or injury and 100 = all plants present at application dead and no new plants emerged. Sugarcane injury was not observed for the PRE applications. Ratings beyond 3 weeks after POST applications were not made because of the onset of cool weather and reduced weed and crop growth.

Fall POST Study. Field experiments were conducted over the 2005-2006 growing season in New Roads, LA, and Vacherie, LA, to evaluate nutsedge control and sugarcane response with herbicides applied POST. Specific locations were selected due to heavy infestations of nutsedge species that had emerged with the sugarcane crop after planting on August 5, 2005, at New Roads, LA, and August 8, 2005, at Vacherie, LA. All plots were planted with sugarcane variety LCP 85-384 either as billets (Vacherie) or whole stalks (New Roads) depending on grower preference and machinery available. At the New Roads, LA, location the soil type was a Commerce silt loam (fine-silty, mixed, superactive, non-acid, thermic Fluvaquentic Endoaquepts) with 1.5% OM and a pH of 5.7. The soil type at Vacherie, LA, was also a Commerce silt loam with 1.5% OM and a pH of 6.2. The experimental design was a randomized complete block with eight herbicide treatments and a nontreated control for comparison with

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[14] Induce®, a mixture of alkylarylpolyoxyalkane ether and free fatty acids. Helena Chemical Co., 225 Schilling Blvd., Collierville, TN 38017.

four replications. Experimental plots consisted of three 15.2 m long sugarcane rows spaced 1.8

m apart. Clomazone at 1400 g ai/ha plus diuron at 2240 g/ha was applied PRE at planting to the

entire experimental area to control annual grasses and broadleaves. Clomazone has little activity

on purple or yellow nutsedge (Anonymous 2007).

   Treatments consisted of halosulfuron at 53.0 or 70.6 g/ha, halosulfuron at 53.0 g/ha plus 2,4-

D[15] at 1870 g ai/ha, a premix of halosulfuron at 70.6 g/ha plus dicamba at 270 g ai/ha[16] or at

106.0 g/ha plus 410 g/ha, respectively, and trifloxysulfuron at 10.5 or 15.7 g/ha, or

trifloxysulfuron at 10.5 g/ha plus 2,4-D[3] at 1870 g/ha. 2,4-D was evaluated because of local

reports of its activity on nutsedge and the possibility that it may increase control when applied

with either halosulfuron or trifloxysulfuron. The halosulfuron/dicamba premix was evaluated as

a means to reduce cost compared with halosulfuron alone. Treatments were applied when

average sugarcane height was 20 to 25 cm and nutsedge species were 10 to 15 cm in height on

September 9, 2005, at New Roads, LA, and September 12, 2005, at Vacherie, LA. Nonionic

surfactant[2] at 0.25% (v/v) was added to all treatments, except where 2,4-D was used All

treatments were applied using a tractor-mounted compressed air sprayer calibrated to deliver

93.5 L/ha at a spray pressure of 140 kPa.

   Visual estimates of nutsedge (purple and yellow nutsedge combined) control and sugarcane

injury were made 2, 4, and 6 WAT in 2005 based on a scale of 0 to 100% with 0 = no control or

injury and 100 = all plants present at application dead and no new plants emerged. An additional

rating for nutsedge control was made in April 2006, only at the New Roads, LA, location based

on the same scale previously mentioned. Sugarcane shoot population was determined 6 WAT in

2005 and in March 2006. Sugarcane stalk height, measured from the soil surface to the collar of

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[15] Low volatile ester with 0.8 kg ai/L.
[16] Yukon®, Gowan Company, 370 Main Street, Yuma, AZ 85364.

the youngest leaf on ten randomly selected stalks, was recorded in June and August 2006. Stalk population also was determined in August 2006. At each location during the 2006 growing season the entire experimental area received standard weed control programs and cultural practices depending on grower preference. Sugarcane yield and sugar yield were not determined because shortly after the August rating, sugarcane was severely lodged making it impossible to collect data.

Spring POST Study. Field experiments were conducted in 2005 at Loreauville, LA and in 2006 at Franklin, LA, to evaluate nutsedge control and sugarcane response with herbicides applied POST in the spring of the first production year. Specific locations were selected due to heavy infestations of both purple and yellow nutsedge that had either emerged from the winter dormant period with the sugarcane crop that had been planted in August of the previous year or that had not been winter killed. The sugarcane cultivar was 'HoCP 96-540', and both locations were planted as whole stalks. At the Loreauville, LA, location, the soil type was a Loreauville silt loam (fine-silty, mixed, thermic Udollic Ochraqualfs) with 1.5% OM and a pH of 6.4. The soil type at Franklin, LA, was a Baldwin silty clay loam (fine, smectitic, hyperthermic Chromic Vertic Epiaqualfs) with 1.3 OM and a pH of 6.1.

The experimental design at Loreauville, LA, was a randomized complete block with 4 herbicide treatments and a nontreated control with four replications. The experimental design at Franklin, LA, was a randomized complete block with nine herbicide treatments and a nontreated control with four replications. Experimental plots consisted of three, 15.2 m long sugarcane rows spaced 1.8 m apart. Clomazone at 1400 g/ha plus diuron at 2240 g/ha was applied PRE at planting in 2004 at Loreauville, LA, to the entire experimental area to control annual grasses and

broadleaves. Metribuzin at 1680 g ai/ha was applied PRE at planting in 2005 at Franklin, LA, to the entire experimental area to control annual grasses and broadleaves.

Treatments at Loreauville, LA, consisted of halosulfuron at 53.0 or 70.6 g/ha or trifloxysulfuron at 10.5 or 15.7 g/ha. Treatments at Franklin, LA, consisted of halosulfuron at 35.3, 53.0, or 70.6 g/ha, trifloxysulfuron at 5.3, 10.5 or 15.7 g/ha, a premix of halosulfuron at 53.0 g/ha plus dicamba[4] at 200 g/ha or 70.6 g/ha plus 270 g/ha, respectively, or 2,4-D[3] at 1870 g/ha. Treatments were applied POST when average sugarcane height was 20 to 25 cm and nutsedge was 5 to 10 cm in height on March 24, 2005 at Loreauville, LA, and March 8, 2006, at Franklin, LA. Nonionic surfactant[2] at 0.25% (v/v) was added to all treatments, except where 2,4-D was applied alone. All treatments were applied using a tractor-mounted compressed air sprayer calibrated to deliver 140 L/ha at a spray pressure of 183 kPa. Treatments were applied on a band which covered a 91 cm area of the row top. Typically in Louisiana, herbicides are banded following spring tillage where only the row shoulders and middles are worked.

Visual estimates of nutsedge (purple and yellow nutsedge combined) control and sugarcane injury were made 3 and 5 WAT based on a scale of 0 to 100% with 0 = no control or injury and 100 = all plants present at application dead and no new plants emerged. An additional rating for nutsedge control was made at 8 WAT in 2005, at Loreauville, LA, using the same rating scale. Sugarcane shoot population was determined 5 WAT in 2006, only at Franklin, LA. Sugarcane stalk height, measured from the soil surface to the collar of the youngest leaf on 10 randomly selected stalks, was recorded in May and July at both locations. Stalk population also was determined in July of 2006, only at Franklin, LA. All plots within each location during the growing season received standard weed control programs and cultural practices depending on grower preference. Sugarcane yield and sugar yield were not determined.

Statistical Analysis. Data for the PRE/POST and Fall POST Studies were subjected to the Mixed Procedure in SAS[17]. Data for the Spring POST Study for the five treatments in common at both locations (Loreauville and Franklin, LA) also were subjected to the Mixed Procedure in SAS. Years or locations, replications (nested within year or locations), and all interactions containing either of these effects were considered random effects (Carmer et al. 1989). All other variables (application timings and treatments) were considered fixed effects. Considering year or location as environmental or random effects permits inferences about treatments to be made over a range of environments (Carmer et al. 1989; Hager et al. 2003). Least square means were calculated, and mean separation was performed using $P \leq 0.05$. Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998). Data for the Spring POST Study for the 10 treatments evaluated at Franklin, LA in 2006 were subjected to analysis of variance (ANOVA) and means were separated using Fisher's protected LSD test at the 0.05 significance level.

<div align="center">

RESULTS AND DISCUSSION

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PRE/POST Study. In this study, herbicides were applied PRE immediately after sugarcane was planted, and POST applications were made around 6 to 8 weeks after planting when sufficient growth of both nutsedge and sugarcane warranted application. At 7 WAT, halosulfuron applied PRE at 70.6 g/ha controlled nutsedge (purple and yellow combined) 72% (Table 4.1). Control with halosulfuron at 53.0 g/ha was 55% and equivalent to that of sulfentrazone at 280, 350, and 420 g/ha and of hexazinone plus diuron. By 10 WAT, nutsedge control was no more than 43% for any of the PRE treatments, and for the most part, sulfentrazone and halosulfuron applied PRE were no more effective than the hexazinone plus diuron standard. When herbicides were applied POST, halosulfuron at 53.0 and 70.6 g/ha

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[17] SAS institute. 2003. SAS User's Guide: Statistics. Version 9.1. SAS Institute. SAS Campus Drive, Cary, NC 27513.

Table 4.1. Nutsedge control and sugarcane injury following preemergence (PRE) and postemergence (POST) herbicide treatments in newly planted sugarcane.[a]

| Treatment[b] | Rate | Nutsedge control | | | Sugarcane injury |
| | | PRE | | POST | POST |
		7 WAT	10 WAT	3 WAT	3 WAT
	g ai/ha	------------------------------%------------------------------			
Sulfentrazone	280	46 c[d]	33 ab	54 d	19 a
Sulfentrazone	350	52 c	43 a	50 d	18 a
Sulfentrazone	420	47 c	38 ab	61 cd	21 a
Halosulfuron	35.3	64 ab	31 b	65 bc	0 b
Halosulfuron	53.0	55 bc	37 ab	74 ab	0 b
Halosulfuron	70.6	72 a	38 ab	79 a	0 b
Hexazinone + diuron	590 + 2100	51 c	29 b	-- --	-- --
Nontreated	-- --	0 d	0 c	0 e	0 b

[a] PRE applications were made on August 27 and September 15, 2004, immediately after sugarcane was planted, covered, and rows packed. POST applications were made on October 19 and 26, 2004, at St. James and White Castle, LA, respectively. Pendimethalin at 2.24 kg ai/ha was applied across the entire experimental area to eliminate grass competition except where the premix of hexazinone + diuron was applied PRE. Both purple and yellow nutsedge were present and weeds were 15 to 20 cm tall at POST application. Sugarcane was 35 to 45 cm tall at POST application. WAT = weeks after treatment.

[b] Surfactant at 0.25% v/v was added to the POST treatments. The hexazinone plus diuron is a premix sold under the trade name DuPont K4, DuPont Crop Protection Walker's Mill, Barley Mill Plaza Wilmington, Delaware 19880-0038.

[d] Data for percent control and injury represent an average across two locations. Treatment means followed by the same letter are not significantly different ($P > 0.05$). Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998).

controlled nutsedge 74 and 79%, respectively, and control was greater than for all rates of sulfentrazone. Since growth of nutsedge was reduced because of the onset of cool weather, a later rating was not made. Some injury to sugarcane consisting of foliar discoloration and stunting was observed for sulfentazone (18 to 21%) 3 weeks after POST application, but injury was not observed for halosulfuron.

Both sulfentrazone and halosulfuron were ineffective on nutsedge when applied PRE. Lack of PRE control with either sulfentrazone or halosulfuron could be attributed to inactivation of herbicides due to lack of a significant rainfall event before the nutsedge emerged after planting. At both locations, less than 1.27 cm of rain fell within two weeks after application. Even though halosulfuron was more effective on nutsedge than sulfentrazone when applied POST, control with halosulfuron was no more than 80%.

Fall POST Study. In this study, herbicides were applied POST in September around 5 weeks after planting when nutsedge and sugarcane were present. Both halosulfuron and trifloxysulfuron were applied alone and with a low volatile ester 2,4-D formulation. 2,4-D could be used at this time of the year to control broadleaf weeds, and there is sentiment in the industry that ester 2,4-D has activity on nutsedge. Additionally, a commercially available premix of halosulfuron plus dicamba[4] was evaluated. Nutsedge (purple and yellow nutsedge combined) was controlled no more than 44% 2 WAT with the halosulfuron and trifloxysulfuron treatments (Table 4.2). Nutsedge control with all halosulfuron treatments was equivalent and averaged 80% 4 WAT and 77% 6 WAT. Halosulfuron applied POST at 72.0 g/ha to 5 to 8 cm purple nutsedge in corn reduced purple nutsedge shoot population 86% 26 d after treatment (Webster and Coble 1997b). In a potato production system in Texas, halosulfuron applied POST to 15 to 20 cm purple nutsedge at 33.0 g/ha controlled purple nutsedge 95% 28 DAT (Grichar et al. 2003).

Table 4.2. Nutsedge control 2, 4, and 6 weeks after treatment (WAT) in 2005 and in the following spring (2006) following postemergence (POST) herbicide treatments in newly planted sugarcane.[a]

Treatment[b]	Rate	2 WAT 2005	4 WAT 2005	6 WAT 2005	April 2006
	g ai/ha			Nutsedge control ---%---	
Halosulfuron	53.0	40 ab[c]	79 ab	75 abc	78 a
Halosulfuron	70.6	44 a	81 a	78 ab	76 ab
Halosulfuron + 2,4-D	53.0 + 1870	43 ab	81 a	76 ab	78 a
Halosulfuron + dicamba	70.6 + 270	39 b	80 a	75 abc	68 b
Halosulfuron + dicamba	106.0 + 410	43 ab	80 a	79 a	71 ab
Trifloxysulfuron	10.5	39 b	73 c	64 d	43 c
Trifloxysulfuron	15.7	41 ab	74 bc	68 cd	45 c
Trifloxysulfuron + 2,4-D	10.5 + 1870	43 ab	76 abc	71 bc	45 c
Nontreated	-- --	0 c	0 d	0 e	0 d

[a] POST herbicide applications were made 5 weeks after planting on September 9 and 12, 2005 at New Roads, LA, and Vacherie, LA, respectively. Both purple and yellow nutsedge were present and weeds were 10 to 15 cm tall at POST application. Sugarcane at application was 20 to 25 cm.

[b] All herbicides were applied with a surfactant at 0.25% v/v, except where 2,4-D was used. 2,4-D formulation used was a low volatile ester with 0.8 kg ai/L. The halosulfuron plus dicamba treatment is a premix sold under the trade name, Yukon, Gowan Company, 370 Main Street, Yuma, AZ 85364.

[c] Data represent an average across two locations except for the April rating which represents only the New Roads, LA location. Treatment means followed by the same letter are not significantly different ($P > 0.05$). Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998).

Control with the trifloxysulfuron treatments in the present study averaged 74% 4 WAT, and at 6 WAT, control ranged from 64 to 71%. The combination of 2,4-D and trifloxsulfuron slightly improved nutsedge control 6 WAT compared with trifloxysulfuron alone (71 vs. 64%). The true value of treatments for nutsedge control would be the residual effect the following year in the plant cane crop. In April 2006, nutsedge control with the halosulfuron treatments averaged 74% compared with an average of 44% for the trifloxysulfuron treatments (Table 4.2). The combination of dicamba or 2,4-D and halosulfuron or 2,4-D and trifloxsulfuron did not improve nutsedge control.

The effects of the herbicide treatments were also evaluated in sugarcane. For the halosulfuron treatments, sugarcane injury at 2, 4, and 6 WAT was no more than 4% (Table 4.3). In contrast for the trifloxysulfuron treatments, sugarcane was injured an average of 31% 2 WAT and 13% 4 WAT, but injury was not observed 6 WAT. Although nutsedge was controlled 64 to 79% with the halosulfuron and trifloxysulfuron treatments 6 WAT (Table 4.2), sugarcane shoot population 6 WAT was not increased (Table 4.3). However, by March of the following year, sugarcane shoot populations reflected the value of the herbicide treatments (p=0.064). All halosulfuron treatments except halosulfuron applied alone at 53.0 g/ha resulted in greater sugarcane shoot population compared with the nontreated control. Shoot population in March also was increased when trifloxysulfuron was applied at 15.7 g/ha and when trifloxysulfuron at 10.5 g/ha plus 2,4-D at 1870 g/ha. Of interest is that the greater nutsedge control in April 2006 with the halosulfuron treatments compared with the trifloxysulfuron treatments (Table 4.2) was not reflected in differences in sugarcane shoot population among the treatments in 2006. There were also no differences among the herbicide treatments in sugarcane height in June or August or sugarcane

Table 4.3. Sugarcane injury 2, 4, and 6 weeks after treatment (WAT) and shoot population in 2005 and sugarcane shoot population, height, and stalk population in 2006 following postemergence (POST) herbicide treatments for nutsedge control in newly planted sugarcane.[a]

Treatment[b]	Rate	Sugarcane injury			Shoot population		Height[c]		Stalk population
		2 WAT 2005	4 WAT 2005	6 WAT 2005	6 WAT 2005	March 2006	June 2006	August 2006	August 2006
	g ai/ha	------------------%----------------			-----1,000/ha-----		---------cm---------		1,000/ha
Halosulfuron	53.0	4 b[d]	3 b	0	13.4	19.1	122	198	19.2
Halosulfuron	70.6	1 bc	2 b	0	14.2	22.0*[d]	127	198	21.6
Halosulfuron + 2,4-D	53.0 + 1870	0 c	1 b	0	15.6	21.4*	130	209	21.4
Halosulfuron + dicamba	70.6 + 270	2 bc	4 b	0	14.0	19.8*	124	200	21.4
Halosulfuron + dicamba	106.0 + 410	1 bc	4 b	0	14.6	19.9*	130	201	22.2
Trifloxysulfuron	10.5	30 a	13 a	1	14.0	19.4	126	196	20.2
Trifloxysulfuron	15.7	31 a	14 a	1	15.2	20.1*	126	200	19.6
Trifloxysulfuron + 2,4-D	10.5 + 1870	31 a	13 a	0	14.9	22.9*	121	199	20.9
Nontreated	-- --	0 c	0 c	0	11.4	16.3	115	189	19.2
P-value > F[e]	-- --	0.001	0.001	0.446	0.186	0.064	0.173	0.366	0.286

[a] POST herbicide applications were applied 5 weeks after planting on September 9 and 12, 2005 at New Roads, LA, and Vacherie, LA, respectively. Both purple and yellow nutsedge were present and weeds were 10 to 15 cm tall at POST application. Sugarcane at application was 20 to 25 cm.

[b] All herbicides were applied with a surfactant at 0.25% v/v, except where 2,4-D was used. The 2,4-D formulation used was a low volatile ester with 0.8 kg ai/L. The halosulfuron plus dicamba treatment is a premix sold under the trade name, Yukon, Gowan Company, 370 Main Street, Yuma, AZ 85364.

[c] Sugarcane height was measured from the soil surface to the upper most leaf collar.

[d] Data represent an average across two locations; New Roads, LA, and Vacherie, LA. Treatment means followed by the same letter are not significantly different (P > 0.05). Letter groupings were converted using the PDMIX800 macro in SAS (Saxton 1998). An asterisk (*) represents a significant increase in percent shoots compared to the nontreated.

[e] Based on (P < 0.05) differences among treatments for the parameters measured were not detected. Specific P-values are provided for all parameters measured.

stalk population in August of the next year even though residual effect of the fall applied

herbicide treatments on nutsedge control were observed early in the growing season.

Spring POST Study. In this study, halosulfuron and trifloxysulfuron treatments were applied in

March of the first production year. Application was made to sugarcane and nutsedge that had

emerged from the winter dormant period. Some of the nutsedge had not been winter-killed from

the previous year due to a mild winter. Nutsedge (purple and yellow nutsedge combined) control

averaged over two years was 80 and 77% 3 WAT for halosulfuron at 70.6 g/ha and

trifloxysulfuron at 15.7 g/ha, respectively (Table 4.4). For both herbicides, a decrease in

nutsedge control occurred when rate was reduced. By 5 WAT for the two years, nutsedge

control averaged 79% for halosulfuron at 53.0 and 70.6 g/ha and trifloxysulfuron at 15.7 g/ha.

At 8 WAT, nutsedge was controlled in 2005 70% for halosulfuron at 53.0 g/ha, and control was

no more than 61% for the trifloxysulfuron.

   In 2006, additional treatments were included for evaluation, halosulfuron at 35.3 g/ha,

trifloxysulfuron at 5.3 g/ha, a halosulfuron plus dicamba premix, and 2,4-D ester applied alone.

At 3 WAT, all rates of halosufuron and halosulfuron plus dicamba provided equivalent nutsedge

control and averaged 80% (Table 4.4). Trifloxysulfuron controlled nutsedge 74 and 79% at the

two highest rates 3 WAT, but control decreased to 66 when applied at 5.3 g/ha. At 5 WAT

halosulfuron at 53.0 and 70.6 g/ha applied alone or with dicamba provided equivalent control

and averaged 81%. Control for the lower rate of halosulfuron was 64% 5 WAT.

Trifloxysulfuron at 10.5 and 15.7 g/ha 5 WAT controlled nutsedge 71 and 81%, respectively, but

control was 53% when applied at 5.3 g/ha. 2,4-D ester provided no more than 36% nutsedge

control.

Table 4.4. Postemergence (POST) control of nutsedge 3, 5, and 8 weeks after treatment (WAT) with herbicides applied in March as sugarcane regrowth was initiated following the winter dormant period.[a]

		Nutsedge control				
		3 WAT		5 WAT		8 WAT
Treatment[b]	Rate	2-yr. Avg.	2006	2-yr Avg.	2006	2005
	g ai/ha	--%--				
Halosulfuron	35.3	-- --	76 ab	-- --	64 c	-- --
Halosulfuron	53.0	73 b[c]	83 a	77 a[c]	78 ab	70 ab
Halosulfuron	70.6	80 a	80 ab	81 a	81 ab	71 a
Trifloxysulfuron	5.3	-- --	66 c	-- --	53 d	-- --
Trifloxysulfuron	10.5	68 c	74 b	71 b	71 b	56 b
Trifloxysulfuron	15.7	77 ab	79 ab	79 a	81 ab	61 b
Halosulfuron + dicamba	53.0 + 200	-- --	79 ab	-- --	80 ab	-- --
Halosulfuron + dicamba	70.6 + 270	-- --	83 a	-- --	83 a	-- --
2,4-D	1870	-- --	36 d	-- --	30 e	-- --
Nontreated	-- --	0 d	0 e	0 d	0 f	0 c

[a] POST herbicide applications were applied on March 21, 2005 and March 8, 2006 at Loreauville, LA, and Franklin, LA, respectively. Both purple and yellow nutsedge were present and weeds were 5 to 10 cm tall at POST application. Sugarcane at application was 25 to 30 cm.

[b] All herbicides were applied with a surfactant at 0.25% v/v except where 2,4-D was applied alone. The 2,4-D formulation used was a low volatile ester with 0.8 kg ai/L. The halosulfuron plus dicamba treatment is a premix sold under the trade name, Yukon, Gowan Company, 370 Main Street, Yuma, AZ 85364.

[c] Data represent an average across two locations for all treatments except the lowest rates of halosulfuron and trifloxysulfuron, both rates of the premix halsulfuron plus dicamba, and 2,4-D which were only applied in 2006. Letter groupings for 2-year average were converted using the PDMIX800 macro in SAS (Saxton 1998). Treatment means followed by the same letter are not significantly different (P > 0.05). Treatment means in each column (2005 or 2006) followed by the same letter are not significantly different (P > 0.05) using LSD.

Sugarcane injury averaged over two years was as high as 24 and 10% 3 and 5 WAT, respectively, for trifloxysulfuron, but injury was not observed for halosulfuron treatments (Table 4.5). In 2006 when additional treatments were evaluated, sugarcane injury at 3 and 5 WAT increased as trifloxysulfuron rate increased from 5.3 to 15.7 g/ha. For the highest rate of trifloxysulfuron sugarcane was injured 36% 3 WAT and 20% 5 WAT. As noted earlier, sugarcane was not injured with any of the halosulfuron treatments. Injury associated with trifloxysulfuron included white banding on leaves that were in the whorl when application was made and also some stunting. Injury, however, was not reflected in shoot population 5 WAT (Table 4.5).

The residual effect of nutsedge control and sugar cane injury associated with the herbicide treatments was evaluated as the growing season progressed. In comparing treatment means, either averaged across years or for a single year, the level of nutsedge control and sugarcane injury observed with the various treatments (Tables 4.4 and 4.5) were not reflected in differences in sugarcane height in May or June or stalk population in July (Table 4.6). Obviously sugarcane was able to recover from the initial injury from trifloxysulfuron and the level of nutsedge control for the various treatments was sufficient to allow sugarcane to out compete nutsedge. Even though nutsedge was emerged in March when the herbicides were applied, the soil temperature was not conducive to rapid growth and establishment. Holt and Orcutt (1996) reported that nutsedge tuber sprouting occurs above 10 C, but optimal growth occurs between 25 and 30 C. However, sugarcane in Louisiana will often emerge from the winter dormant period in February, and if a killing frost does not occur then by March and April, prolific tillering and growth can occur. In Louisiana when sugarcane is planted in August, average soil temperatures are around 30 C, but when sugarcane regrowth following the winter dormant period occurs in early March,

Tabel 4.5. Sugarcane injury 3 and 5 weeks after treatment (WAT) and shoot population 5 WAT following postemergence herbicides applied in March as sugarcane regrowth was initiated following the winter dormant period.[a]

Treatment[b]	Rate	Sugarcane injury				Shoot population
		3 WAT		5 WAT		5 WAT
		2-yr. Avg.	2006	2-yr. Avg.	2006	2006
	g ai/ha	------------------------------------%----------------------------------				1,000/ha
Halosulfuron	35.3	-- --	0 d	-- --	0 d	18.3
Halosulfuron	53.0	0 b[c]	0 d	0 b[c]	0 d	18.9
Halosulfuron	70.6	0 b	0 d	2 b	0 d	17.0
Trifloxysulfuron	5.3	-- --	20 c	-- --	11 c	16.9
Trifloxysulfuron	10.5	18 a	28 b	7 a	14 b	18.8
Trifloxysulfuron	15.7	24 a	36 a	10 a	20 a	17.3
Halosulfuron + dicamba	53.0 + 200	-- --	0 d	-- --	0 d	17.1
Halosulfuron + dicamba	70.6 + 270	-- --	0 d	-- --	0 d	17.0
2,4-D	1870	-- --	0 d	-- --	0 d	16.9
Nontreated	-- --	0 b	0 d	0 b	0 d	17.6
P-value >F[d]	-- --	-- --	-- --	-- --	-- --	0.891

[a] POST herbicide applications were applied on March 21, 2005 and March 8, 2006 at Loreauville, LA, and Franklin, LA, respectively. Both purple and yellow nutsedge were present and weeds were 5 to 10 cm tall at POST application. Sugarcane at application was 25 to 30 cm.

[b] All herbicides were applied with a surfactant at 0.25% v/v except where 2,4-D was applied alone. The 2,4-D formulation used was a low volatile ester with 0.8 kg ai/L. The halosulfuron plus dicamba treatment is a premix sold under the trade name, Yukon, Gowan Company, 370 Main Street, Yuma, AZ 85364.

[c] Data represent an average across two locations for all treatments except the lowest rates of halosulfuron and trifloxysulfuron, both rates of the premix halsulfuron plus dicamba, and 2,4-D which were only applied in 2006. Letter groupings for 2-year average were converted using the PDMIX800 macro in SAS (Saxton 1998). Treatment means followed by the same letter are not significantly different ($P > 0.05$). Treatment means in each column (2006) followed by the same letter are not significantly different ($P > 0.05$) using LSD.

[d] Based on ($P < 0.05$) differences among treatments for the parameters measured were not detected. Specific P-values are provided for each parameter where differences were not detected.

Table 4.6. Sugarcane height and stalk population in May and July following postemergence herbicides applied in March as sugarcane regrowth was initiated following the winter dormant period.[a]

| Treatment[b] | Rate | Height | | | | Stalk population |
| | | May | | July | | July |
		2-yr. Avg.	2006	2-yr. Avg.	2006	2006
	g ai/ha	-----------------------------cm-----------------------------				1,000/ha
Halosulfuron	35.3	-- --	99	-- --	223	14.8
Halosulfuron	53.0	89[c]	104	215[c]	219	14.6
Halosulfuron	70.6	89	98	219	221	14.5
Trifloxysulfuron	5.3	-- --	100	-- --	213	15.3
Trifloxysulfuron	10.5	93	107	219	227	13.5
Trifloxysulfuron	15.7	86	94	211	213	15.2
Halosulfuron + dicamba	53.0 + 200	-- --	101	-- --	223	13.9
Halosulfuron + dicamba	70.6 + 270	-- --	104	-- --	215	15.2
2,4-D	1870	-- --	100	-- --	215	13.5
Nontreated	-- --	84	92	211	207	13.0
P-value >F[f]	-- --	0.168	0.200	0.096	0.165	0.530

[a] POST herbicide applications were applied on March 21, 2005 and March 8, 2006 at Loreauville, LA, and Franklin, LA, respectively. Both purple and yellow nutsedge were present and weeds were 5 to 10 cm tall at POST application. Sugarcane at application was 25 to 30 cm. Sugarcane height was measured from the soil surface to the upper most leaf collar.

[b] All herbicides were applied with a surfactant at 0.25% v/v except where 2,4-D was applied alone. The 2,4-D formulation used was a low volatile ester with 0.8 kg ai/L. The halosulfuron plus dicamba treatment is a premix sold under the trade name, Yukon, Gowan Company, 370 Main Street, Yuma, AZ 85364.

[c] Data represent an average across two locations for all treatments except the lowest rates of halosulfuron and trifloxysulfuron, both rates of the premix halsulfuron plus dicamba, and 2,4-D which were only applied in 2006. Letter groupings for 2-year average were converted using the PDMIX800 macro in SAS (Saxton 1998).Treatment means followed by the same letter are not significantly different (P > 0.05).

[d] Based on (P < 0.05) differences among treatments for the parameters measured were not detected. Specific P-values are provided for each parameter measured.

soil temperatures average around 18 C (Anonymous 2006), a period when sugarcane should be highly competitive with nutsedge. The variability in plant population in sugarcane fields because of variation in planting/seeding rates can often lead to considerable variation in stands. This may have contributed to the inability to detect significant differences among the treatments in sugarcane height and population, although values were numerically lowest for the nontreated control. In considering sugarcane stalk population in July 2006, halosulfuron increased population 12 to 14%, and 2,4-D which was ineffective on nutsedge, increased population by only 4% (p=0.530). Even so, results from this study suggest that application of halosulfuron or trifloxysulfuron for nutsedge control in the spring would not be economical due to the ability of sugarcane to adequately compete with nutsedge at that time of the year.

In planning weed control programs for nutsedge, whether purple or yellow nutsedge, the goal should be to reduce the ability of nutsedge to reestablish and produce a heavy tuber population. Previous research has shown that tuber population can increase rapidly under good growing conditions (Doll and Piedrahita 1982; Etheredge et al. 2006; Hauser 1962; Rao 1968; Smith and Fick 1937). In sugarcane, soil applied herbicides are mostly ineffective on nutsedge (Anonymous 2007). In this study, sulfentrazone and halosulfuron were more effective when applied POST than PRE, but even PRE application of halosulfuron at 70.6 g/ha controlled nutsedge no more than 80% 3 WAT. Troxler et al. (2003) reported that for trifloxysulfuron, a herbicide also evaluated in the present study, no more than 4% of herbicide was translocated from treated leaves to tubers and roots. Other research has shown that only about 55% of foliar-applied trifloxysulfuron was absorbed by 96 h after treatment of purple and yellow nutsedge. Dayan et al. (1996) reported that the relatively high amount of wax present on the surface of nutsedge leaves may be a factor limiting foliar absorption relative to other weeds lacking similar

epicuticular wax. This could explain the lack of effective long term nutsedge control observed for both of the sulfonylurea herbicides evaluated in the present studies. Ideally, nutsedge control programs in sugarcane should be implemented during the fallow period using glyphosate programs (Anonymous 2007) to reduce the tuber population before sugarcane is replanted. A followup herbicide application could then be made in the newly emerging planted sugarcane. One approach would be to apply herbicide in the fall after nutsedge and sugarcane have emerged, and a second approach would be to wait until the following spring and treat as nutsedge and sugarcane emerge from the winter dormant period. In the present study, fall application of both halosulfuron and trifloxysulfuron were effective in controlling nutsedge. Residual effect of the fall applied treatments the following year was greater for halosulfuron than for trifloxysulfuron. Even so, nutsedge control in the spring was no more than 80%, and sugarcane growth was not hinderd the first production year by nutsedge competition. In the second scenario, when halosulfuron and trifloxysulfuron were applied in the spring, nutsedge control again was maximized at around 80%, and as also noted for the fall application, sugarcane was able to compete with nutsedge and sugarcane growth was not affected. In both the fall and spring application scenarios, trifloxysulfuron was injurious to sugarcane, but recovery was complete.

Both purple and yellow nutsedge are becoming more problematic in sugarcane grown in both Louisiana and Florida. The nutsedge problem should be addressed first in the fallow period to prevent weeds from removing moisture from the seedbeds and causing problems in opening of rows and in covering of planted sugarcane. When nutsedge emerges with the planted sugarcane, a timely application of either halosulfuron or trifloxysulfuron should be made. The reduction in the ability of nutsedge to reestablish a significant underground tuber population will allow sugarcane to establish a stable root system that will help sustain the sugarcane plant through the

wet and cool winter period of inactive growth and promote development of buds that will affect

shoot emergence in the spring. A healthy and vigorous early emerging sugarcane plant is more

competitive with weeds and better able to maximize its yield potential.

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CHAPTER 5

SUMMARY

Although sugarcane is a tropical crop, under Louisiana conditions, sugarcane does not actively grow and above ground fall growth is killed during the winter. Growth is renewed in the spring. In Louisiana, four to six harvests are made from a single planting of sugarcane. Replanting is necessary due to reduced sugarcane plant populations associated with disease and weed pressure over time as well as extreme environmental conditions. When the decision is made to replant, fields are fallowed during the summer and planted in August or September. During the fallow period, producers are able to control perennial weeds that have established over the multi-year crop cycle with glyphosate and/or timely tillage operations. Research was conducted to assess the potential of reduced tillage programs in fallowed sugarcane fields in respect to weed management, sugarcane growth and yield, and economics.

The first objective of a fallow weed control program is to destroy the sugarcane stubble. Historically, producers have relied on tillage to accomplish this task. If a no-tillage (NT) fallow program is to be successful, herbicides must provide complete destruction of sugarcane stubble so that the subsequent planting operation is not hindered. Results from the sugarcane control studies showed that control of sugarcane stubble with glyphosate is both rate and growth stage dependent. The most economical rate for sugarcane control was 1.12 kg ai/ha of glyphosate when sugarcane was 15 cm, 1.68 kg/ha for 25 to 40 cm sugarcane, and 2.24 kg/ha for 45 cm sugarcane. In a typical sugarcane fallow program, an additional glyphosate application would be made to control late emerging weeds. This follow-up application should further increase sugarcane control, such that stubble is completely destroyed and will not affect planting operation in August. It appears feasible from the standpoint of controlling the sugarcane stubble

that a NT fallow program can be successful. In another sugarcane control study where glyphosate formulations at several rates were evaluated, differences in control among isopropylamine and potassium salt formulations were not observed. Results showed that less expensive glyphosate formulations were equally effective in controlling sugarcane when applied at the equivalent rate of active ingredient. It would be possible for a producer to use a more economical glyphosate formulation to reduce input cost.

In respect to bermudagrass control in fallowed sugarcane fields, multiple applications of glyphosate at lower rates were more effective than single applications at higher rates. Bermudagrass was effectively controlled with sequential glyphosate applications of 1.12 kg/ha. Based on this research, control of both sugarcane stubble and bermudagrass with timely applications of glyphosate can be expected when a reduced till or NT fallow program is used.

Selection of a fallow program in sugarcane should be based on weed spectrum and economics. From a perennial weed control standpoint, fallow programs evaluated that used a glyphosate application to replace a tillage operation were more effective than a conventional tillage alone program. However, economically, the conventional tillage alone program was by far the least expensive program compared to those where herbicide was used. Sugarcane production the first year was not negatively affected by reducing the number of tillage operations or by eliminating tillage all together during the fallow period. When perennial weeds are problematic, producers should use glyphosate to assure successful weed control and to provide the plant cane crop with the competitive advantage over weeds. Additionally, in the bermudagrass sequential and sugarcane control studies, glyphosate rate effective on bermudagrass and sugarcane was half that used in the fallow program study, which would further reduce cost. A fallow program in sugarcane that includes one or two timely applications of glyphosate in combination with a

reduced tillage or a NT program can be effective in controlling both perennial weeds and sugarcane stubble. In a NT program, conservation of soil moisture that can affect emergence and growth of planted sugarcane also could be advantageous. Since neither weed control nor sugarcane production was negatively affected when the NT fallow program was used, growers would be more likely to consider governmental conservation programs that provide cost share payment.

In recent years, sugarcane growers have reported an increase in purple and yellow nutsedge infestation in fields and the concern as to the impact of nutsedge on sugarcane production has been expressed. The increase in nutsedge problems in sugarcane in Louisiana is likely due to the poor control obtained with glyphosate applied during the summer fallow period. The literature suggests that purple and yellow nutsedge can be very competitive with other crops. Research evaluated the competitiveness of purple nutsedge with sugarcane, nutsedge response to shade, and nutsedge control programs in sugarcane during the first production year. In research conducted to assess competitiveness of purple nutsedge with sugarcane, various densities of purple nutsedge tubers were planted in 26.5 L pots with a surface area of 0.093 m^2 along with a single node segment of LCP 85-384 sugarcane. At 64 d after planting, a 37.3-fold increase in purple nutsedge tuber population occurred when only one tuber/pot was planted. At the lowest tuber density evaluated (one tuber/pot) sugarcane root dry weight was reduced 45%, but shoot dry weight was not affected. An initial tuber density of four tubers per pot was needed to reduce sugarcane shoot dry weight. In comparing competitiveness of sugarcane cultivars with purple nutsedge, L 97-128 produced more shoots and greater shoot and root dry weight when compared with LCP 85-384, HoCP 96-540, and Ho 95-988. Based on shoot and root dry weight after 64 d of competition with purple nutsedge, L 97-128 was almost twice as vigorous as the other

cultivars. Results showed that purple nutsedge can be highly competitive with sugarcane at planting in August and September, regardless of cultivar.

Research also evaluated purple nutsedge response to shade. In Louisiana, sugarcane planted in August and September is winter killed and reemerges usually in March to start the plant-cane crop. The ability of sugarcane to produce significant plant growth and shading before purple nutsedge emerges in the spring would further reduce purple nutsedge competition. For 30% shade, the lowest shade level imposed, purple nutsedge shoot population was reduced 35.3, 33.8, and 52.9% at 28, 42, and 56 d, respectively, compared with the full sunlight (no shade) control. Also under 30% shade, purple nutsedge shoot dry weight was reduced 74.8% compared to full sunlight. It is noteworthy that purple nutsedge was able to persist for 56 d under a 90% shade environment, which may explain why it is becoming more problematic in Louisiana and Florida sugarcane.

Nutsedge control programs also were evaluated in newly planted sugarcane both in the fall at planting (August application) and after planting (September application) and during the following spring (March application). In the fall study, nutsedge control (purple and yellow nutsedge combined) 10 weeks after treatment (WAT) was no more than 43% for sulfentrazone or halosulfuron applied preemergence. When herbicides were applied postemergence (POST), halosulfuron at 53.0 and 70.6 g/ha controlled nutsedge 74 and 79%, respectively, and control with these treatments was greater than for all rates of sulfentrazone. Even though halosulfuron was more effective on nutsedge than sulfentrazone when applied POST, control with halosulfuron was no more than 80%. When herbicides were applied POST in September around 5 weeks after planting, nutsedge control (purple and yellow nutsedge combined) with all halosulfuron treatments was equivalent and averaged 80% 4 WAT and 77% 6 WAT. Control

with the trifloxysulfuron treatments averaged 74% 4 WAT and at 6 WAT control ranged from 64 to 71%. Although nutsedge was controlled 64 to 79% with the halosulfuron and trifloxysulfuron treatments 6 WAT, sugarcane shoot population 6 WAT was not increased when compared with the nontreated control. However, in the following spring, all halosulfuron treatments except halosulfuron applied alone at 53.0 g/ha resulted in greater sugarcane shoot population compared with the nontreated control. There were no differences among the halosulfuron and trifloxysulfuron treatments in sugarcane height in June or August or sugarcane stalk population in August of the next year; even though residual effects of the fall applied herbicide treatments on nutsedge control were observed early in the growing season. In the spring study, nutsedge control (purple and yellow nutsedge combined) averaged over two years was 80 and 77% 3 WAT for halosulfuron at 70.6 g/ha and trifloxysulfuron at 15.7 g/ha, respectively. For both herbicides, a decrease in nutsedge control occurred when rate was reduced. By 5 WAT for the two years, nutsedge control averaged 79% for halosulfuron at 53.0 and 70.6 g/ha and for trifloxysulfuron at 15.7 g/ha. Sugarcane injury was as high as 24 and 10% 3 and 5 WAT, respectively, for trifloxysulfuron, but injury was not observed for halosulfuron treatments. The residual effect of nutsedge control and sugarcane injury associated with the herbicide treatments was evaluated as the growing season progressed. The levels of nutsedge control and sugarcane injury observed with the various treatments were not reflected in differences in sugarcane height in May or June or stalk population in July. Obviously sugarcane was able to recover from the initial injury from trifloxysulfuron, and the level of nutsedge control for the various treatments was sufficient to allow sugarcane to out compete nutsedge.

In planning weed control programs for nutsedge, whether purple or yellow nutsedge, the goal should be to reduce the ability of nutsedge to reestablish and produce a heavy tuber population.

The nutsedge problem should be addressed first in the summer fallow period to prevent weeds from removing moisture from the seedbeds and causing problems in opening of rows and in covering of planted sugarcane in August. When nutsedge emerges with the planted sugarcane, a timely application of either halosulfuron or trifloxysulfuron can reduce the ability of nutsedge to reestablish a significant underground tuber population. This will allow sugarcane to establish a stable root system that will help sustain the plant through the wet and cool winter inactive growth period and promote development of buds that will affect shoot emergence in the following spring. The ability of sugarcane to produce significant plant growth and shading before nutsedge emerges in the spring would further reduce nutsedge competition. A healthy and vigorous early emerging sugarcane plant would be more competitive with weeds and better able to maximize its yield potential.

VITA

Luke Moss Etheredge, Jr. is the only son of Nancy and the late Luke Etheredge, Sr. Born on April 13, 1978, in Amarillo, Texas, where he spent the first eight years of his life and attended College Hill Elementary. His family then moved to Llano, Texas, back to the family ranch, where his dad became the ranch manager and his mom taught high school chemistry. Luke attended Llano High School and graduated in 1996. Luke then went to Texas A&M University in College Station, Texas, and joined the Corps of Cadets. Luke graduated from Texas A&M University with a Bachelor of Science degree in agronomy in 2000 and then again with a Master of Science degree in agronomy in 2003. He then accepted a position as a research associate with the LSU AgCenter and the Department of Agronomy and Environmental Management at Louisiana State University. Also in 2003 he enrolled in the graduate program under the direction of Dr. Jim Griffin and is currently a candidate for the degree of Doctor of Philosophy in agronomy with a minor in agricultural economics under the direction of Dr. Mike Salassi. His educational and research emphasis is in sugarcane weed science. Following graduation, Luke will be working with Helena Chemical Company as business manager for SugarTech, a division of Helena Chemical Company that specializes in providing healthy seed cane for the Louisiana sugarcane industry.