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An economic analysis of the costs of alternative sugarcane fallow weed control programs

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AN ECONOMIC ANALYSIS OF THE COSTS OF ALTERNATIVE SUGARCANE FALLOW WEED CONTROL PROGRAMS

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ABSTRACT

Economic research was conducted to present estimates of costs per acre associated with fallow sugarcane weed control programs for Louisiana in 2010. The 2010 projected costs are associated with the various phases of sugarcane fallow using different machinery, implements, and weed control practices followed by most growers in the main sugarcane production area of Louisiana. For bermudagrass and johnsongrass weed control treatments, the herbicides applied were Roundup Original Max at 46 oz/A, generic glyphosate at 64 oz/A, DuPont K4 60DG, Trifluralin 4EC at 4 qt/A, and EPTC at 3.5 pt/A. Purple nutsedge weed control treatments included Roundup Original Max at 46 oz/A, generic glyphosate at 64 oz/A, Permit 75DF at 1 oz/A, and Yukon 67.5WG at 6 oz/A. Roundup Original Max at 46 oz/A applied for perennial weed control was more expensive by $30.40 and $15.20 per acre compared with generic glyphosate treatments applied at 64 oz/A. Treatments applied with Roundup Original Max had a higher sugarcane fallow cost compared with treatments using generic glyphosate at current fuel, labor and herbicide input prices. A spreadsheet decision aid was developed which summarizes sugarcane fallow field operations and weed control costs, including equipment used, performance rates, and herbicides applied. These data can be entered by the user for specific farm situations, calculating total variable tillage and weed control costs per acre. Binary and non-binary linear programmings were utilized to determine optimal sugarcane fallow weed control programs for bermudagrass, johnsongrass, and purple nutsedge control. The non-binary LP model selected treatments to achieve desired control of bermudagrass, johnsongrass and purple nutsedge and minimum cost program. In comparison, the binary LP model selected only one treatment that had minimum fallow field operation and weed control cost while satisfying minimum weed control levels. Generic glyphosate cost was found to be sensitive to price

increases to \$0.27 oz/A or above for bermudagrass control, and \$0.33 oz/A for johnsongrass and purple nutsedge control. Fuel prices, directly impacting tillage costs, were found to not be sensitive in determining optimal weed control choices.

CHAPTER 1

INTRODUCTION

Sugarcane is a perennial crop that grows in mostly tropical regions of the world. In the United States, sugarcane is produced in Florida, Louisiana, and Texas in a subtropical environment. Three or four harvests are made from a single planting. The first harvest year is referred to as the plant cane crop and succeeding harvest years are referred to as ratoon or stubble crops. In Louisiana, sugarcane (*Saccharum* spp. hybrids) is planted vegetatively using whole stalks or billet seed pieces in August to allow the crop enough time to establish before the winter dormant period (Anonymous 2010). Sugarcane shoots emerging from lateral buds on planted stalks are killed during winter and growth is re-established in late February or early March (Griffin and Judice 2009).

Sugarcane production in Louisiana is a major contributor to the agricultural economy of the state. The 2009 market value of raw sugar and molasses produced in Louisiana was $752.1 million. The gross farm value of sugarcane harvested was $447.0 million, with an additional $305.1 million value added from first stage processing. In 2009, sugarcane was grown on 417,869 acres by 495 producers in 22 Louisiana parishes. An estimated 390,708 acres were available for harvest for sugar, where 6.5 percent of the total acres were used for seed cane planting material. The total economic impact on the state's economy attributable to sugarcane production, processing, and raw sugar refining is estimated to exceed $3 billion per year (Anonymous 2009). Total estimated sugarcane production costs for Louisiana have risen from $447 per acre in 2005 to a projected $605 per acre in 2010 (Salassi and Deliberto 2010). The demand and supply conditions for nitrogen fertilizer and the increasing price of fuel and fertilizer costs rose substantially over the past several years, where sugarcane variable production costs increased to more than $400 per total farm acre. Projected total sugarcane production costs for the 2010 crop year in Louisiana is in the range of 18 to 22 cents per pound of raw sugar produced, depending upon the harvest yield and rental arrangement (Salassi and Deliberto 2010).

Some environmental conditions, weeds, insects, and/or diseases can have a significant impact on plant cane stand establishment and a poor stand can have a residual effect throughout the multi-year crop cycle. Australian sugarcane farmers have used no-tillage as a main factor to reduce tractor hours, fuel consumption, and maintenance costs without adversely affecting sugarcane productivity (Anonymous 1991). Conservation tillage practices can range from no-tillage to some level of reduced tillage. In 2001 in the U.S., reduced tillage was used on almost 103.74 million acres representing 36.6% of the planted cropland (Anonymous 2002). In 2002, the Farm Bill program started a conservation security program that has provided incentive payments for environmental stewardship. The program provides a cost share payment that requires 30% coverage of soil surface with plant residue on a year round basis (Anonymous 2005). In Louisiana, a no-tillage system is not feasible for most sugarcane farmers, since tillage is critical to maintain row integrity and aids drainage.

Conservation tillage and weed control programs are linked and related to reduce weed pressure, and conservation tillage programs can decrease herbicide cost with the benefits of soil conservation (Koskinen and McWhorter 1986). The different tillage systems utilize variable input combinations in the development of economical and effective weed management programs (Derksen et al. 2002). In a typical fallow program, tillage operations are effective for weed control, especially perennial weeds that have established over the multi-year crop cycle. A combination of tillage with postemergence applications of glyphosate can be very effective in reducing weed pressure in the subsequent sugarcane crop (Anonymous 2010).

PROBLEM STATEMENT

Farms managers make many farm business decisions or choices every day. Some decisions have vital consequences for the farm business, while others are not as crucial. The choices made today may have an immediate impact on the business, or they may take much longer to have an effect. Weed control in fallow sugarcane fields is an important phase in the production of sugarcane critical to ensuring the maximum possible economic returns from the production, harvest and processing of the sugarcane crop. Weeds compete directly with the sugarcane crop for water and plant nutrients. Controlling weeds in fallow fields significantly reduces adverse impacts on sugarcane tonnage and raw sugar yields once the sugarcane crop is planted and later harvested. Currently, sugarcane producers in Louisiana are confronted with a wide array of potential weed problems in fallow fields. There are several combinations of tillage operations and herbicide applications which could be used to combat this issue. Given the wide array of weed control options, herbicide choices, as well as the range in costs of tillage and herbicide application passes over the field, there is a fair degree of uncertainty as to which specific weed control options would provide the desired level of weed control at a minimum cost.

OBJECTIVES

The general objective of this research project is to conduct an economic analysis of the costs of alternative weed control programs which might be used on fallow fields in a sugarcane production system. The specific objectives of this research are:

1) To identify typical weed control options for sugarcane fallow land and to estimate the cost of each of these alternatives.
2) To develop a spreadsheet-based producer decision aid tool to compare the cost of alternative fallow weed control options.

3) To determine economically optimal fallow weed control programs for alternative production situations faced by sugarcane producers using linear programming procedures.

LITERATURE REVIEW

Sugarcane producers have relied heavily on frequent tillage operations and herbicide applications 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 (Anonymous 2001). Once sugarcane is planted in August, a preemergence 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 can reduce shoot production and root system establishment, which are critical to maximizing production in the first year (Richard 1997a). In Louisiana, the three major weed problems in sugarcane fields are bermudagrass (*Cynodon dactylon* L. Pers.), johnsongrass (*Sorghum halepense* L. Pers.), and nutsedge (*Cyperus* spp.).

The competition between ratoon-crop sugarcane and bermudagrass is intensive principally in spring and early summer. The effects of bermudagrass interference begin almost immediately following planting in late summer and continue until the winter dormant period. Once bermudagrass is established, sugarcane stalk populations in plant cane, first ratoon, and second ratoon can be reduced as much as 23%, 15%, and 10 %, respectively (Richard and Dalley 2007). Bermudagrass infestation can be reduced 20% with two glyphosate applications at 46.5 or 69.8 oz/A where it was more effective than tillage only in newly sugarcane planted rows (Richard 1997b). Bermudagrass competition can reduce sugar yields 32% for the plant cane crop and 9% in the ratoon crops. Even with the use of preemergence herbicides, bermudagrass infestation increased over a 3-year crop cycle where even with multiples applications, complete control of bermudagrass with glyphosate could not be achieved (Richard 1993).

Johnsongrass interference in sugarcane fields affects stalk population and a proportional decrease in sugarcane tonnage and raw sugar yield per acre. Johnsongrass reduced cane yield an average of 3% to 23% in the first ratoon, 7% to 42% in the second ratoon as compared to weed-free control (Millhollon 1995). Johnsongrass standing crop were negatively correlated with cane yield, when johnsongrass and cane yield was analyzed using linear regression (Ali et al.1986). Several preemergence control options are available for seedling johnsongrass control including clomazone + diuron, pendimethalin, metribuzin, terbacil, and trifluralin (Anonymous 2010).

Control of purple nutsedge in newly planted sugarcane is critical to sugarcane establishment. Complete control of purple nutsedge is nearly impossible, and its control should be implemented both during the fallow period and in the crop. Purple nutsedge can cause decreases in sugarcane yield of 83% to 85%, respectively (Turner 1984). In a greenhouse study where one-node sugarcane seed pieces were planted along with 4 nutsedge tubers, 115 tubers were present 64 days later, and sugarcane plant height and root and shoot dry weight were reduced with purple nutsedge competition (Etheredge et al. 2006). The control of this weed in sugarcane is limited to a preemergence application of sulfentrazone or a post application of halosulfuron or trifloxysulfuron (Anonymous 2010).

In fallowed areas, glyphosate can be applied in early spring as a substitute for disking to kill the sugarcane ratoon and rhizomatous weeds. When glyphosate was applied over the top of sugarcane at 41.5 oz/A in June, sugarcane yield was reduced by 44% where stalks populations and stalks weights were lowered and immature stalks that survived contained less sugar (Richard 1991).

Sugarcane production can achieve a desired level of raw sugar output by using different combinations of inputs. The factors of production or inputs in sugarcane production are related to nutrition, weed control, disease control, and insect control. Labor (farmer) and capital (land, machinery, and equipment) are important inputs that, in combination with fertilizer, herbicides, fungicides, insecticides, tillage system, are directly related to sugarcane production. A production function describes what is technically feasible when a firm operates efficiently, when the firm uses each combination of inputs as effectively possible (Pindyck 2009). Sugarcane production is not always or generally technically efficient, but it is reasonable to expect that sugarcane production will not waste resources to achieve desired yields and maximum returns.

A firm can adjust its inputs to produce its output with different amounts of labor and capital. In the production of sugarcane, producers must consider whether or not inputs can be varied, if they can change, and over what period of time. Short-run is a period of time in which one or more inputs can not change in production (Pindyck 2009). In sugarcane production, optimal production levels can be evaluated with one variable input, where the output is produced for different amounts of a variable input. In the fallow sugarcane period, the sugarcane yield (kg/ha) can vary depending on herbicide rate and level of control desired, where weeds are controlled with a range of rates according to product labels to achieve the best weed control.

The selection of a fallow weed control program in sugarcane should be based on weed spectrum and economics. Etheredge (2009) reported on fallow programs, for perennial weed control using glyphosate and tillage operations. The glyphosate applications were more effective than a conventional tillage alone program. However, the conventional tillage alone program was the least expensive program compared to herbicides programs. A fallow program in sugarcane that includes one or two timely postemergence applications of glyphosate in combination with a reduced tillage or a non-tillage program can be effective in controlling both perennial weeds and sugarcane stubble. However, use of preemergence herbicides in fallow only increase input cost compared with a non-tillage program that reduce input cost, but conservation of soil moisture during drought conditions could effect emergence, growth and yield of planted sugarcane. Non-tillage fallow programs are more related to governmental conservation programs (Anonymous 2005). Sugarcane producers generally rely heavily on 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 herbicide products, a reduced tillage system may be practical. Roberts et al (2006) suggested that the introduction of herbicide-resistant cotton in Tennessee increased the profitability and led to adoption of conservation-tillage practices. The increased profit potential was due to the substitution of non-residual for residual herbicides that directly contributed to increase soil conservation due to its longevity control. The benefit of reduced soil erosion is one important consideration of herbicide-resistant crop production.

Herbicides are productive inputs affecting farm profits. Sydorovych and Marra (2008) suggested that herbicide attributes can affect the farmer's choice of an herbicide product. The cost associated with herbicide application, including the stage-specific herbicide application cost and material cost directly impact profit, therefore, influencing the farmer's choice. Profit decreases as the pounds of active ingredient sold increases because the chemical companies are selling weed control rather than product. More active ingredient applied for weed control has a direct effect over herbicide cost (Massey 2006).

Mathematical programming models have been used to determine or simulate the optimal solutions within a set of constrained model variables. Salassi (2004) described agribusiness applications of linear programming that are widely used as an operations research tool in economics and business to maximize profits or minimize cost from products produced in agricultural business activities given certain constraints. Hassan (2005) used a linear programming model to determine the optimum cropping pattern as a prerequisite to efficient utilization of available resources of land, water, and capital for Pakistan's agriculture.

GENERAL PROCEDURES

For objective one, typical weed control options were specified for each type of weed species problem to be evaluated. These typical weed control options included alternative combinations of tillage operations and herbicide applications. In addition, alternative herbicide materials which could be applied in a specified weed control option were identified. Variable cost of these weed control options was estimated, including charges for fuel, labor and herbicide material.

Under objective two, a spreadsheet-based producer decision aid tool was developed which will provide users the ability to enter fallow weed control programs for the purpose of estimating and comparing costs. The decision aid will allow for entry of data such as tractor size, implement width, field speed, field efficiency, herbicide rate and other data items necessary to estimate variable weed control costs.

Research conducted under objective three determined economically optimal fallow weed control programs for alternative production situations faced by sugarcane producers. Economically optimal weed control program decisions were developed through the use of linear programming procedures. A decision choice model was developed to optimally choose from a set of fallow weed control alternatives depending upon fallow field weed problems specified. Sensitivity analysis of results allowed evaluating of the impact of herbicide price variability on optimal weed control programs selected.

CHAPTER 2

STUDY PROCEDURES

INTRODUCTION

In a typical fallow program, sugarcane stubble is destroyed in the spring or early summer and fields are replanted in August and September. During the fallow period, tillage and herbicide programs are used to control weeds that establish during the crop cycle. Weed control during the fallow period is critical and directly affects level of weed infestation in the newly planted crop and in the subsequent ratoon crops (Anonymous 2010). The perennial weeds bermudagrass (*Cynodon dactylon* L. Pers.), johnsongrass (*Sorghum halepense* L. Pers.), and purple nutsedge (*Cyperus rotundus* L.) are especially troublesome. Inconsistent control of perennial weeds with herbicides during the sugarcane crop cycle and the inability to till tops of beds contribute to increased weed infestations.

When bermudagrass is established, sugarcane stalk populations in plant cane, first ratoon, and second ratoon can be reduced as much as 23, 15, and 10%, respectively (Richard and Dalley 2007). Preemergence herbicides persist for only around six weeks and applications are often made after bermudagrass green up, control is short lived and inconsistent. There are no postemergence weed control options for bermudagrass control in the sugarcane crop. During the summer fallow period, glyphosate in conjunction with tillage is used to reduce bermudagrass infestations. Etheredge et al. (2009) reported 86% bermudagrass control 40 days after glyphosate was applied at 23.25 oz ai/A and control increased to 98% when the same rate was applied sequentially. When glyphosate was applied as a substitute for a tillage operation, bermudagrass control was increased compared with tillage alone. Costs associated with fallow weed control programs are dependent on herbicide cost and tillage cost. Elimination of a single tillage operation reduced cost $44.37/A and addition of glyphosate (58.12 oz/A plus application cost) increased cost $117.37/A (Etheredge et al. 2009). Total cost for the conventional tillage alone program was $299.53/A and where herbicide was used in reduced tillage or no-tillage programs, total cost was $52.56 to $208.93/A more.

Several preemergence control options are available for seedling johnsongrass, where rhizome johnsongrass is difficult to control (Anonymous 2010). No more than 50% rhizome johnsongrass control can be expected with soil incorporation of pendimethalin or trifluralin. Johnsongrass control during the fallow period is addressed through combinations of tillage and glyphosate application (Etheredge et al. 2009).

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 during the summer fallow period (Anonymous 2010). Halosulfuron, trifloxysulfuron, and sulfentrazone have activity on nutsedge and can be used both in the sugarcane crop and during the fallow period (Anonymous 2010). Control of purple nutsedge in newly planted sugarcane is critical because of its ability to reestablish and compete with the crop.

Glyphosate applied during the fallow period has not adequately controlled bermudagrass and purple nutsedge, interest has increased in the evaluation of herbicide alternatives. One herbicide that could be used in a program with glyphosate is EPTC. EPTC was widely used as a preemergence treatment in corn (*Zea mays L.*). EPTC applied at 70.5 oz ai/A and incorporated 5 cm deep controlled johnsongrass 4 weeks after treatment 65%, but when incorporated 10 cm deep, control was 94% (Roeth 1973). Hauser (1963) suggested that purple nutsedge control could be increased when fields were disked several weeks before EPTC was applied.

Trifluralin herbicide, which requires incorporation, was used extensively in corn. A common incorporation implement is a rolling cultivator equipped with six independent gangs which incorporated trifluralin on the row top and sides. The implement is set to operate 5 to 8 cm deep so as to not injure sugarcane buds. Many growers still have rolling cultivators that could be used for incorporation of EPTC and trifluralin. A hipper/bedder is often used in fallowed sugarcane fields to eliminate weeds after beds have been established. This implement has a sweep centered on the top of the bed which opens the bed followed by 3-disk gangs that re-hip the beds in a single operation.

A fallow program in sugarcane that includes one or two timely applications of glyphosate in combination with a reduced tillage or a no tillage program can be effective in controlling both perennial weeds and sugarcane stubble. Preemergence herbicides in fallow program can be important in reducing tillage operations. Conservation of soil moisture with reduce tillage could benefit emergence, growth and yield of planted sugarcane. No tillage fallow program is more likely to be consider for conservation program that government support (Anonymous 2005). Sugarcane producers heavily use 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 no-tillage or reduced tillage system may be practical.

MATERIALS AND METHODS

Fallow Sugarcane Weed Control Cost

This research was conducted to present estimates of costs per acres associated with fallow sugarcane weed control programs for Louisiana in 2010. The 2010 projected costs is associated with the various phases of sugarcane fallow using different machinery, implements, and weed control practices followed by most growers in the main sugarcane production area in Louisiana. This research evaluated 14 fallow sugarcane weed control practices for bermudagrass, johnsongrass, and purple nutsedge (Table 2.1-2.2). The fallow activities were determined with combination of tillage operation and herbicides application in dollars per acre. Fixed costs were not included in this research for the short-run analysis of the fallow sugarcane operations.

In tillage operations, machinery cost data for implements were obtained from production cost reports based on annual surveys of machinery dealers. In addition, these data were supplemented with data from a recent issue of the official guide, tractors, and farms equipment[1]. Machinery performance rates (hours per acre) for selected tillage and field operations were calculated using implement size, tractor size, and typical field speed and field efficiency based on ASABE Standards (2009). Performance rate related time required to cover a field distance based upon factors including the speed of the machinery traveling across the field, the width of the machine or implement being used and the field efficiency of operation being conducted. Field efficiency is a percentage value which specifies, of the total time a tractor is running, what percentage of that time is being spent actually in tillage or herbicide application. The field efficiency value is generally less than 100%, including idling time, traveling or waiting to upload new implement or time spent traveling to another field. The field efficiency was dependent on the implement used with typical values in the 65% to 85% range (ASABE 2009).

[Eq. 1] $$\textit{Acres per Hour} = \frac{\textit{Field Speed x Machine Width x Field Efficiency}}{8.25}$$

[Eq. 2] $$\textit{Hours per Acre} = 1 / \textit{Acres per Hour}$$

Operating or variable cost for the tractor included charges for fuel, labor, and inputs. Diesel fuel consumption of the tractor used for a tillage operation or herbicide application is primarily a function of horsepower. Diesel engines consume, on average, 0.044 gallons of diesel per horsepower-hour (gal/hp-hr) per PTO horsepower. Fallow fuel operation cost per acre was

[1] Guide Tractors and Farm Equipment. St. Louis: National Farm and Power Services, Inc., Fall 1993

Table 2.1. Fallow sugarcane weed control programs for bermudagrass and johnsongrass problems[1].

Treatment 1 & 8	Treatment 2 & 9	Treatment 3 & 10	Treatment 4 & 11	Treatment 5 & 12	Treatment 6 & 13	Treatment 7 & 14
Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)
Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)
Bottom Plow	Chisel Plow	Chisel Plow	Chisel Plow	Chisel Plow	Chisel Plow	Chisel Plow
Chisel Plow	Disk	Disk	Disk	Bed up (2)	Disk	Disk
Disk	Bed up (2)	Bed up (2)	Chisel Plow	Packer	Bed up	Bed up
Bed up (2)	Boom Sprayer[3]	Re-Hip	Disk	Boom Sprayer[6]	Boom Sprayer[8]	Boom Sprayer[10]
Boom Sprayer[2]	Boom Sprayer[3]	Boom Sprayer[4]	Bed up (2)	Boom Sprayer[7]	Bed up	Re-Hip
Boom Sprayer[2]			Boom Sprayer[5]		Boom Sprayer[9]	Boom Sprayer[11]

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), re-hip (18 ft.) and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up, and re-hip) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Treatment 1 application of Roundup Original Max (46 oz); treatment 8 application of generic glyphosate (64 oz).

[3] Treatment 2 application of Roundup Original Max (46 oz); treatment 9 application of generic glyphosate (64 oz).

[4] Treatment 3 application of Roundup Original Max (46 oz); treatment 10 application of generic glyphosate (64 oz).

[5] Treatment 4 application of Roundup Original Max (46 oz); treatment 11 application of generic glyphosate (64 oz).

[6] Treatment 5 application of DuPont K4 60DG (4 lb); treatment 12 application of DuPont K4 60DG (4 lb).

[7] Treatment 5 application of Roundup Original Max (46 oz); treatment 12 application of generic glyphosate (64 oz).

[8] Treatment 6 application of trifluralin 4EC (4 qt); treatment 13 application of trifluralin 4EC (4 qt).

[9] Treatment 6 application of Roundup Original Max (46 oz); treatment 13 application of generic glyphosate (64 oz).

[10] Treatment 7 application of EPTC (3.5 pt); treatment 14 application of EPTC (3.5 pt).

[11] Treatment 7 application of Roundup Original Max (46 oz); treatment 14 application of generic glyphosate (64 oz).

Table 2.2. Fallow sugarcane weed control programs for the purple nutsedge problems[1].

Treatment 1 & 8	Treatment 2 & 9	Treatment 3 & 10	Treatment 4 & 11	Treatment 5 & 12	Treatment 6 & 13	Treatment 7 & 14
Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)
Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)	Disk (2)
Bottom Plow	Chisel Plow	Chisel Plow	Chisel Plow	Chisel Plow	Chisel Plow	Chisel Plow
Chisel Plow	Disk	Disk	Disk	Disk	Disk	Disk
Disk	Bed up (2)	Bed up (2)	Chisel Plow	Bed up (2)	Bed up (2)	Bed up
Bed up (2)	Boom Sprayer[3]	Re-Hip	Disk	Boom Sprayer[6]	Boom Sprayer[8]	Boom Sprayer[10]
Boom Sprayer[2]	Boom Sprayer[3]	Boom Sprayer[4]	Bed up (2)	Boom Sprayer[7]	Boom Sprayer[9]	Re-Hip
Boom Sprayer[2]			Boom Sprayer[5]			Boom Sprayer[11]

[1]Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, bottom plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Treatment 1 application of Roundup Original Max (46 oz); treatment 8 application of generic glyphosate (64 oz).

[3] Treatment 2 application of Roundup Original Max (46 oz); treatment 9 application of generic glyphosate (64 oz).

[4] Treatment 3 application of Roundup Original Max (46 oz); treatment 10 application of generic glyphosate (64 oz).

[5] Treatment 4 application of Roundup Original Max (46 oz); treatment 11 application of generic glyphosate (64 oz).

[6] Treatment 5 application of Permit 75DG (1 oz) plus Roundup Original Max (46 oz); treatment 12 application of Permit 75DF (1 oz) plus generic glyphosate (64 oz).

[7] Treatment 5 application of Roundup Original Max (46 oz); treatment 12 application of generic glyphosate (64 oz).

[8] Treatment 6 application of Yukon 67.5 WG (6 oz) plus Roundup Original Max (46 oz); treatment 13 application of Yukon 67.5 WG (6 oz) plus generic glyphosate (64 oz).

[9] Treatment 6 application of Roundup Original Max (46 oz); treatment 13 application of generic glyphosate (64 oz).

[10] Treatment 7 application of EPTC (4 pt); treatment 14 application of EPTC (4 pt).

[11] Treatment 7 application of Roundup Original Max (46 oz); treatment 14 application of generic glyphosate (64 oz).

calculated by multiplying the fuel consumption rate per hour times the estimates machinery performance rate (hours per acre), multiplied by the price of diesel fuel ($2.30).

[Eq. 3] *Fuel Consumption per Hour (gal/hr) = 0.044 gal/hp-hr x Machine Horsepower*

[Eq. 4] *Fuel Cost per Acre = Diesel Price x Gallons per Hour x Hours per Acre*

Labor cost was a function of the hourly labor rate charged and the machinery performance rate. Actual hours of labor quantity usually exceeded the machine hours by 10% to 20% due to travel time, time required to lubricate and service the machine and other factors. The labor cost was estimated using a labor multiplier of 1.1 (10%) as shown below:

[Eq. 5] *Labor Cost per Acre = Labor Rate ($/hr) x Performance Rate (hrs/acre) x 1.1*

Regular hired farm labor was charged at $9.60 per hour. This wage rate includes a $7.50 per hour basic wage rate plus additional cost (27.65%) for social security, Medicare, and workman's compensation (6.2%, 1.45%, and 20%). It is recognized that full-time labor is not generally available on an hourly basis. However, for a single farm operation, the hourly charge represents a practical approach for charging the farm operation for labor necessary to achieve the sugarcane weed control.

Input price data were based from suppliers of agricultural chemicals and services in Louisiana. These prices were used as a basis for estimating sugarcane production input costs for 2010. Chemical weed control practices were identified as individual operations within sugarcane fallow activities. Materials were designated by common name and reflect the recommended rate (Anonymous 2010). For bermudagrass and johnsongrass weed control treatments, the herbicides applied were Roundup Original Max[2] at 46 oz/A, generic glyphosate[3] at 64 oz/A, DuPont K4

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[2] Roundup Original Max, a glyphosate N-(phosphonomethyl)glycine in the form of its potassium salt. Monsanto Company, 800 North Lindbergh Boulevard, St. Louis, MO 63167.

[3] Mad Dog Plus, a glyphosate N-(phosphonomethyl)glycine in the form of its isopropylamine salt. Loveland Products, Inc., P.O. Box 1286, Greeley, CO 80632-1286.

60DG[4], Trifluralin 4EC[5] at 4 qt/A, and EPTC[6] at 3.5 pt/A. Purple nutsedge weed control treatments included Roundup Original Max at 46 oz/A, generic glyphosate at 64 oz/A, Permit 75DF[7] at 1oz/A, EPTC at 3.5 pt/A, and Yukon 67.5WG[8] at 6 oz/A. The total variable cost associated with fallow operations and herbicide applications for weed control per acre was determined following this procedure:

[Eq. 6] *Variable Cost per Acre = Fuel Cost/Acre + Labor Cost/ Acre + Herbicide Cost/Acre*

Spreadsheet-based Producer Decision Aid Tool Cost

The fallow weed control option is a spreadsheet model that was designed as a tool to be used in the cost analysis for farmers during the fallow sugarcane period. The spreadsheet model was designed in Excel for Windows (© Microsoft). The information entered in the spreadsheet was used in the calculation of fallow sugarcane weed control costs. The user has the option to describe his fallow operation using a drop down menu for various categories. From this menu, the user can choose which fallow operation activity is more related to his own farm operation such as month, day, type of operation, machinery operation (machinery, implement size, tractor size, field speed, and number of passes), and herbicide applied. The user will need to add his own herbicide application rates according to his fallow activities that will be followed for the recommended herbicide rate and unit chosen for the user. Each category covers a different set of information described fallow sugarcane weed control cost.

Economically Optimal Fallow Weed Control Programs

The goal of this research was to identify optimal weed control programs which minimize the

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[4] DuPont K4 60DG. Diuron 3-[3,4-Dichlorophenyl]-1,1-dimethylurea-Hexazinone. Dupont. Wilmintong, DE.
[5] Trifluralin 4EC. a,a,a-trifluoro-2,6-dinitro-N, N-diproyl-p-toluidine. ALBAUGH, Inc company. Ankeny, Iowa.
[6] Eptam 7EC, EPTC, S-ethyl dipropylthiocarbamate. Helena Chemical Co., 225 Schilling Blvd., Collierville, TN 38017.
[7] Permit 75DF. Halosulfuron-methyl (75%). Gowan company. Yuma, Arizona 85366-5569.
8 Yukon 67.5WG. Halosulfuron-methyl-sodium salt of diacamba. Gowan company. Yuma, Arizona 85366-5569.

control for bermudagrass, johnsongrass, and purple nutsedge problems while meeting specified minimum weed control levels. The research evaluated fourteen fallow sugarcane weed control programs for each weed problem. Specific weed control decision problems addressed were: (1) the less expensive sugarcane fallow weed control activity in combination of tillage operation and herbicide application; and (2) the sugarcane fallow weed control treatment had to achieve at least 87% control for bermudagrass and johnsongrass, and 78% control for purple nutsedge. For all weed control treatments, bermudagrass, johnsongrass, and purple nutsedge control was determined using a scale of 0 to 100% with 0 = no control and 100 = all plants dead. Percentage control for each treatment was basically estimated according to Mite (2010).

A linear programming (LP) model of the following form was used as an analytical tool to identify the economically optimal fallow weed control program. The research used binary and non-binary LP models to optimize the chosen treatment cost and percentage weed control level. The general mathematical programming model was defined as follows:

Objective function:

$$MIN\ C = c_L\ QLABOR + c_F\ QFUEL + c_1\ QHERB1 + \ldots + c_5\ QHERB5$$

Subject to the following constraints:

Sugarcane Fallow weed control program treatments:

(1) $\sum_{t=1}^{14} T_t = 1$

Quantity for each treatment of labor ($QLBT_t$), fuel ($QFLT_t$), and herbicides applied (QH_nT_t):

(2) $a_{L-t}\, T_t = QLBT_t \quad for\ t = 1, 2, \ldots, 14$

(3) $a_{F-t}\, T_t = QFLT_t \quad for\ t = 1, 2, \ldots, 14$

(4) $a_{H1-t}\, T_t = QH1T_t \quad for\ t = 1, 2, \ldots, 14$

(5) $a_{H2-t}\, T_t = QH2T_t \quad for\ t = 1, 2, \ldots, 14$

(6) $$a_{H3-t}\, T_t \;=\; QH3T_t \quad for\ t = 1, 2, \dots, 14$$

(7) $$a_{H4-t}\, T_t \;=\; QH4T_t \quad for\ t = 1, 2, \dots, 14$$

(8) $$a_{H5-t}\, T_t \;=\; QH5T_t \quad for\ t = 1, 2, \dots, 14$$

Minimum required weed control percentage achieved for each weed problem:

(9) $$\sum_{t=1}^{14} a_{CT-t}\ T_t \;\geq\; CT$$

Total quantity of weed control inputs used for the fallow sugarcane weed control program:

(10) $$\sum_{t=1}^{14} \mathrm{QLBT_t} \;=\; \mathrm{QLABOR}$$

(11) $$\sum_{t=1}^{14} \mathrm{QFLT_t} \;=\; \mathrm{QFUEL}$$

(12) $$\sum_{t=1}^{14} \mathrm{QH1T_t} \;=\; \mathrm{QHERB1}$$

(13) $$\sum_{t=1}^{14} \mathrm{QH2T_t} \;=\; \mathrm{QHERB2}$$

(14) $$\sum_{t=1}^{14} \mathrm{QH3T_t} \;=\; \mathrm{QHERB3}$$

(15) $$\sum_{t=1}^{14} \mathrm{QH4T_t} \;=\; \mathrm{QHERB4}$$

(16) $$\sum_{t=1}^{14} \mathrm{QH5T_t} \;=\; \mathrm{QHERB5}$$

Binary variable specification for binary linear programming decision model:

(17) $$T_1, T_2, \dots, T_{14}\ are\ binary$$

where: *QLABOR* = quantity of labor per acre (hours/A), *QFUEL* = quantity of fuel per acre (gal/A), *QHERB1*…,*QHERB5* = the quantity of herbicides applied to control bermudagrass, johnsongrass and purple nutsedge (units/A), c_L = the labor wage rate ($/hour), c_F = the fuel price ($/gal), $c_1 \dots c_5$ = cost per unit for herbicide applied, $T_1 \dots T_{14}$ = treatments, a_{L-t} = the hours of labor required for treatment T_t, , a_{F-t} = the gallons of fuel required for treatment T_t, $a_{H1-t} – a_{H5-t}$ = the units of herbicides (1-5) required for treatment T_t, and a_{CT-t} = minimum % weed control.

The objective function is a cost function of the decision variables that is minimized subject to the constraints where labor, fuel, and herbicides (Roundup Original Max, generic glyphosate, DuPont K4 60DG, Trifluralin 4EC, EPTC, Permit 75DF, and Yukon 67.5WG) were the decision variables quantities under control of the decision maker for which optimal values were to be determined, and c_n are the objective function input price coefficients.

The constraints are the restrictions on the optimal solution that limit the values the decision variables may take. The fourteen treatments for bermudagrass, johnsongrass, and purple nutsedge were determined for T_t (1). The technical coefficients ($a_{(L,\,F,\,H1\ldots H5)-t}\,T_t$) for each decision variable were determined to reach the input quantity for each treatment of labor, fuel, and herbicides in every weed problem. Weed control constraint (CT) was represented as a minimum percentage weed control for every weed problem that all fourteen treatments had to achieve to get the best weed control ($a_{CT-t}\,T_t$). Total quantity for each decision variable (QLABOR, QFUEL, and QHERB1...QHERB5) was determined with the sum of fourteen individual decision variables in each treatment for each weed problem.

CHAPTER 3

RESULTS AND DISCUSSION

INTRODUCTION

Sugarcane fallow weed control cost programs were associated with various tillage operations and herbicide applications using three row machinery and the fallow practices followed by most growers in the main sugarcane producing area from Louisiana. Tillage operations and weed control are intimately linked, and the ability to control weeds, herbicide cost and benefits of tillage were considered when farmers need to determine the feasibility of a sugarcane fallow weed control program. The fallow period is one of the most critical times for perennial weed management because once the sugarcane crop is planted, the row top will not be mechanically disturbed for the remainder of 5 to 6 years crop cycle (Etheredge et al. 2009). The cost of sugarcane fallow operations cost were reflected in costs per acre of land, and herbicides rates were based on recommendations of the Weed Management Guide by the LSU AgCenter.

Farmers have different considerations in developing their sugarcane fallow weed control programs in Louisiana. An optimized sugarcane fallow plan is a fundamental activity in business profitability because it can increase the returns in the first year of production from an operation with low costs. The use of operations research adapted to sugarcane weed management is still limited, resulting in decision-making at management level being primarily empirical. However, linear programming models could be a useful tool for decision-making for farmers or consultants in the sugarcane production sector of the sugar industry.

Sugarcane Fallow Weed Control Cost Programs

The sugarcane fallow weed control cost programs for bermudagrass and johnsongrass had the same total cost for each treatment due to each treatment of tillage operations and herbicide applications the same for both weeds. For these treatments, sugarcane fallow operations had the same response to control bermudagrass and johnsongrass. On the contrary, purple nutsedge programs used a different fallow operation arrangement to achieve a desired level of weed control. Fallow weed control cost programs were estimated based on typical farmer's practices employed in sugarcane production in Louisiana.

The sugarcane fallow operations for the control of perennial weeds call for first destroying older crop stubble using disking operations in two field passes twice in May. Tillage operations were also conducted during June and July where the most common implements used in Louisiana were chisel plow, bottom plow, disk, re-hip, and bed up. For purple nutsedge treatments, packer implements were used after the DuPont K4 herbicide was applied. Herbicide applications were applied in late July and the beginning of August because the combinations of tillage and herbicide application gave a better weed control before planting. EPTC and trifluralin were applied and immediately incorporated due to volatilization using bed up and re-hip tillage operations. In the appendixes A4 to A31 are described specifically the machinery operations, efficiency, fuel, labor, herbicides cost for each treatment used for the perennial weeds during sugarcane fallow period. Seven fallow operations were duplicated for each perennial weed problems where seven included Roundup Original Max and the other seven treatments applied generic glyphosate using the cost of the herbicide Mad Dog Plus as input price. Treatments 5, 6, 7, 12, 13, and 14 (Appendixes A4 to A17) for bermudagrass and johnsongrass control programs included the herbicides DuPont K4, Trifluralin, and EPTC with a total cost of $81.73, $73.00, $75.14, $66.53, $57.80, and $59.94 per acre, respectively (Table 3.1). Treatments for purple nutsedge applied the herbicides Permit, Yukon, and EPTC (Appendixes A18 to A31) in combination with glyphosate for a total cost of $95.83, $97.67, $75.14, $65.43, $67.27, and

Table 3.1. Sugarcane fallow total cost of operations for bermudagrass and johnsongrass control

Treatments	Passes[2]	Cost			
	(#)	Fuel	Labor	Herbicide[3]	Total
		($/A)			
1	11	25.30	14.52	41.40	81.22
2	10	22.54	13.01	41.40	76.95
3	10	22.48	12.66	20.70	55.83
4	11	24.60	13.82	20.70	59.12
5	10	22.31	13.12	46.30	81.73
6	10	22.04	12.66	38.33	73.00
7	10	22.04	12.66	40.44	75.14
8	11	25.30	14.52	11.00	50.82
9	10	22.54	13.01	11.00	46.55
10	10	22.48	12.66	5.50	40.63
11	11	24.60	13.82	5.50	43.92
12	10	22.31	13.12	31.10	66.53
13	10	22.04	12.66	23.10	57.80
14	10	22.04	12.66	23.24	59.94

[1] Fuel and labor price in sugarcane fallow operations was $2.30 and $9.60, respectively.
[2] Total numbers of passes for machinery operations for each treatment (disk, bottom plow, chisel plow, bed up, re-hip, packer, and boom sprayer)
[3] The herbicides applied were Roundup Original Max (46 oz), generic glyphosate (64 oz), DuPont K4 60DG (4 lb), trifluralin 4EC (4 qt), and EPTC (3.5 pt).

$59.94 per acre, respectively (Table 3.2).

Roundup Original Max at 46 oz/A applied for bermudagrass and johnsongrass treatments was more expensive by $30.40 for treatments 1 and 2 compared with treatments 8 and 9, by $15.20 for treatments 3, 4, 5, 6, and 7 compared with treatments 10, 11, 12, 13, and 14 when was applied generic glyphosate at 64 oz/A, respectively (Appendixes A4 to A17). Generic glyphosate applied for bermudagrass control in combination with tillage operations was less expensive because its price is 80% less compared with the price of Roundup Original Max. Treatments 1 and 8 had a fuel cost of $25.30 per acre and a labor cost of $14.52 per acre, more expensive than the other treatments due to more tillage operations. Treatments 1 and 2 had the most expensive herbicide application cost of $41.40 when Roundup Original Max was applied twice compared when Roundup Original Max or generic glyphosate were applied once or generic glyphosate were applied twice, and when DuPont, Trifluralin, and EPTC were applied followed by Roundup Original Max or generic glyphosate (Table 3.1).

For purple nutsedge, treatments applied with Roundup Original Max at 46 oz/A were more expensive by $30.40 for treatments 1 and 2 compared with treatments 8 and 9, by $15.20 for treatments 3, 4, 5, 6 and 7 compared with treatments 10, 11, 12, 13 and 14 when generic glyphosate at 64 oz/A was applied, respectively. Treatments 1 and 8 had the same cost for fuel and labor for bermudagrass and johnsongrass control programs, being that these treatments were more expensive than the other treatments. For treatments 5 and 6, herbicide costs were $60.78 and $62.12 per acre, being the most expensive when Permit and Yukon were applied once followed by Roundup Original Max applied twice for each treatment (Table 3.2).

Treatments that included Roundup Original Max were more costly for all perennial weed problems compared with treatments applied with including generic glyphosate, when the prices

Table 3.2. Sugarcane fallow total cost operations for purple nutsedge control[1].

Treatments	Passes[2]	Cost			
	(#)	Fuel	Labor	Herbicide[3]	Total
		---------------------------- ($/A) ----------------------------			
1	11	25.30	14.52	41.40	81.22
2	10	22.54	13.01	41.40	76.95
3	10	22.48	12.66	20.70	55.83
4	11	24.60	13.82	20.70	59.12
5	10	22.54	13.01	60.28	71.50
6	10	22.54	13.01	62.12	73.34
7	10	22.04	12.66	40.44	75.14
8	11	25.30	14.52	11.00	50.82
9	10	22.54	13.01	11.00	46.55
10	10	22.48	12.66	5.50	40.63
11	11	24.60	13.82	5.50	43.92
12	10	22.54	13.01	29.88	56.30
13	10	22.54	13.01	31.72	58.14
14	10	22.04	12.66	25.24	59.94

[1] Fuel and labor price in sugarcane fallow operations was $2.30 and $9.60, respectively.
[2] Total numbers of passes for machinery operations for each treatment (disk, bottom plow, chisel plow, bed up, re-hip, and boom sprayer)
[3] The herbicides applied were Roundup Original Max (46 oz), generic glyphosate (64 oz), Permit 75DF (1 oz), Yukon 67.5WG (6 oz), and EPTC (3.5 pt).

of fuel, labor, Roundup Original Max, and generic glyphosate were $2.30 (Gal.), $9.60 (hour), $0.45 (oz/A), and $0.09 (oz/A), respectively. Etheredge et al. (2009) reported an increase of 98% bermudagrass control when glyphosate was applied twice. In this research, the costs associated with fallow weed control programs were dependent on herbicide cost and tillage cost. Elimination of a single tillage operation reduced cost $45.47/A, and addition of glyphosate (47.3 oz/A plus application cost) increased cost $107.37/A. Cost of treatments 3, 4, 10, and 11 (Appendixes A4 to A31) for bermudagrass, johnsongrass, and purple nutsedge was less compared with the others treatment, when glyphosate was applied twice or in combination the DuPont, trifluralin, EPTC, Permit, and Yukon.

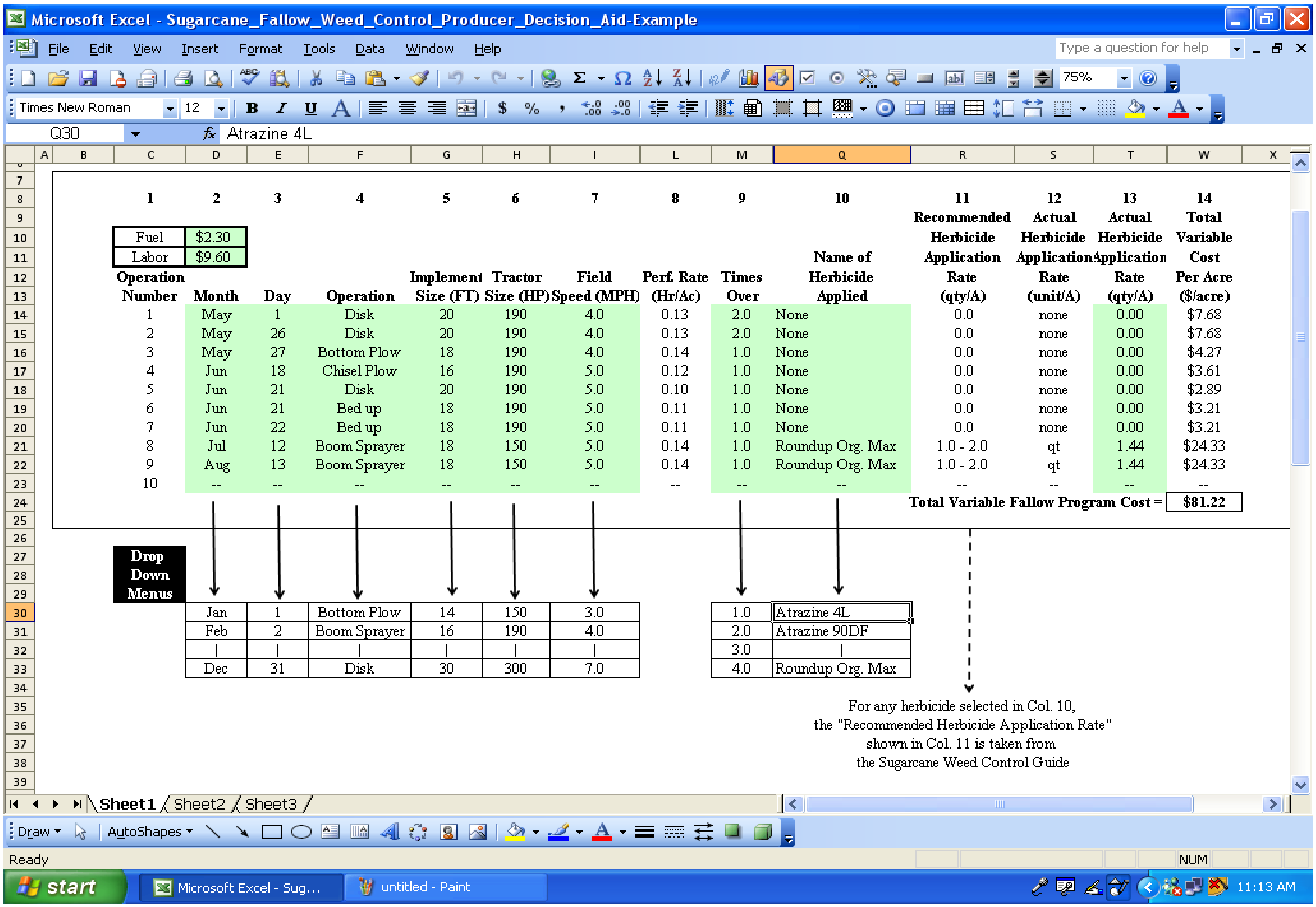
Spreadsheet-based Producer Decision Aid Tool Cost

The sugarcane fallow weed control cost report generated by the spreadsheet-based producer decision aid model summarizes the sugarcane fallow operations and weed control costs, equipment used, performance rates, and herbicides applied in dollars per acre. Farm field operation specifications are listed in terms of day and month on which a farmer would conduct field operations during the sugarcane fallow period. These data are entered by the model user and are for specific farm situations. Fuel and labor prices and actual herbicide application rates are data entered by the model user. Daily fallow operations that include implements, implement size, tractor size, field speed, and times over were listed in a drop down menu that user chooses according his specific fallow field practices.

Performance rates are calculated automatically when the user already has described the operation in a particular day. When the fallow operation selected is an application implement such as a boom sprayer, the user can select the herbicide that he wants to apply through a prepared herbicide list using a drop down menu. The herbicide selected by the user will automatically have the recommended herbicide application rate (qty/A) suggested by the LSU AgCenter, and the user could fill the actual herbicide application rate that he usually applies during his fallow operation. The herbicide price is already linked with the recommended and actual herbicide application rate spreadsheet cells. The final column summarizes the total variable costs per acre associated with every operation for sugarcane weed control in dollars per acre that will provide an estimate of the total variable cost per acre of the specific fallow program entered in the model. Fixed costs are not included in this research because the study's objective is to evaluate the cost of alternative fallow field operations during a short-run period of three to six months during a single crop year. An example is shown in Fig. 3.1, the user described between May and August each operation procedure to achieve a desired level of weed control during the fallow period. Disk is an operation used twice every time during sugarcane fallow, which was estimated to be $7.68/A compared with bottom plow, chisel plow, and bed up with $4.27, $3.61, $3.21/A, respectively. Field speeds for the implements used for tillage operations are usually in the range of 4 to 5 mph. The herbicide application operation is a combined cost estimate associated with a boom sprayer application cost and a herbicide material cost. In this example, Roundup Original Max was applied twice with an individual application cost of $24.33/A, and the total variable treatment program cost was estimated to be $81.22/A.

Economically Optimal Fallow Weed Control Programs

The optimal sugarcane fallow weed control program had two different objective functions when the utilized LP procedure was binary and non-binary for bermudagrass and purple nutsedge. The non-binary LP model selected two treatments to achieve an optimal minimum 87% control for bermudagrass and johnsongrass and a minimum 78% control for purple nutsedge, because the non-binary LP model did not specify that the solution had to select only



Microsoft Excel - Sugarcane_Fallow_Weed_Control_Producer_Decision_Aid-Example

Fuel	$2.30
Labor	$9.60

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Operation Number	Month	Day	Operation	Implement Size (FT)	Tractor Size (HP)	Field Speed (MPH)	Perf. Rate (Hr/Ac)	Times Over	Name of Herbicide Applied	Recommended Herbicide Application Rate (qty/A)	Actual Herbicide Application Rate (unit/A)	Actual Herbicide Application Rate (qty/A)	Total Variable Cost Per Acre ($/acre)
1	May	1	Disk	20	190	4.0	0.13	2.0	None	0.0	none	0.00	$7.68
2	May	26	Disk	20	190	4.0	0.13	2.0	None	0.0	none	0.00	$7.68
3	May	27	Bottom Plow	18	190	4.0	0.14	1.0	None	0.0	none	0.00	$4.27
4	Jun	18	Chisel Plow	16	190	5.0	0.12	1.0	None	0.0	none	0.00	$3.61
5	Jun	21	Disk	20	190	5.0	0.10	1.0	None	0.0	none	0.00	$2.89
6	Jun	21	Bed up	18	190	5.0	0.11	1.0	None	0.0	none	0.00	$3.21
7	Jun	22	Bed up	18	190	5.0	0.11	1.0	None	0.0	none	0.00	$3.21
8	Jul	12	Boom Sprayer	18	150	5.0	0.14	1.0	Roundup Org. Max	1.0 - 2.0	qt	1.44	$24.33
9	Aug	13	Boom Sprayer	18	150	5.0	0.14	1.0	Roundup Org. Max	1.0 - 2.0	qt	1.44	$24.33
10	--	--	--	--	--	--	--	--	--	--	--	--	--

Total Variable Fallow Program Cost = $81.22

Drop Down Menus

Month	Day	Operation	Implement Size (FT)	Tractor Size (HP)	Field Speed (MPH)	Times Over	Name of Herbicide Applied
Jan	1	Bottom Plow	14	150	3.0	1.0	Atrazine 4L
Feb	2	Boom Sprayer	16	190	4.0	2.0	Atrazine 90DF
|	|	|	|	|	|	3.0	|
Dec	31	Disk	30	300	7.0	4.0	Roundup Org. Max

For any herbicide selected in Col. 10,
the "Recommended Herbicide Application Rate"
shown in Col. 11 is taken from
the Sugarcane Weed Control Guide

Figure 3.1. Sugarcane Fallow Weed Control Program – Producer Decision Aid

one treatment with minimum cost and minimum weed percentage control established. In comparison, the binary LP model selected only one treatment that had minimum fallow operation costs while also achieving a minimum 87% control for bermudagrass and johnsongrass or 78% control for purple nutsedge described in the constraint equation from the model.

For bermudagrass, the objective function using the non-binary LP procedure for fallow weed control was $43.38/A total cost using treatment 9 (46%) with 95% control and treatment 10 (53%) using 87% control. The binary LP model selected treatment 9 (100%) with $46.55/A as treatment solution and 95% control. In this case, the LP model took the less expensive treatment within the group of 14 treatments, and also LP model forced to achieve at least 87% control being treatment 9 with a 95% control. For johnsongrass control, the non-binary LP model selected the same treatments for the binary LP model where the objective function value was $40.63/A of treatment 10 (100%) as the optimal solution with 95% control. In purple nutsedge control treatments, the non-binary LP model had the same procedure to take two treatments with the difference being that it selected 80% from T12 and 27% for T9. The objective function for purple nutsedge control in fallow was $61.6/A with at least 78% control compared with the binary LP model solution that selected treatment 12 with $65.43/A as objective function and 80% control. Linear programming models are a useful tool for decision-making when there are different fallow operations in combination of tillage and herbicide applications that farmers have to consider to decrease their variables cost and get also a good perennial weed control (Table 3.3).

All treatments could be sensitive to any price changes in their decision variables that can affect total variable cost for each treatment. The linear programming procedure conducted a price range analysis in only binary models for each fallow weed control program. When generic glyphosate (Mad Dog Plus) price was equal or more than \$0.27 oz/A for bermudagrass, and \$0.33 oz/A for johnsongrass and purple nutsedge a new treatment came up as solution where the objective functions (sugarcane fallow program cost) changes and become more expensive than initial generic glyphosate price (Table 3.4). Generic glyphosate was the most sensitive decision variable price that can have an effect directly over herbicide application cost; however, generic glyphosate was cheaper with 80% less than Roundup Original Max price, where the option that generic glyphosate price could increases 80% without Roundup Original Max price increases at the same time is not a practical scenario.

Table 3.3. Linear programming solution for sugarcane fallow weed control programs with 14 treatment options[1].

Weed problem	LP model[2]	Objective function	Basis variables	Control
		------ (\$) ------	(treatments)	(%)
Bermudagrass	Non-binary	43.38	T9 (0.46) T10 (0.53)	87
	Binary	46.55	T9 (0.1)	95
Johnsongrass	Non-binary	40.63	T10 (0.1)	95
	Binary	40.63	T10 (0.1)	95
Purple nutsedge	Non-binary	61.6	T12 (0.8) T9 (0.27)	78
	Binary	65.38	T12 (0.1)	80

[1] Sugarcane fallow operation cost and Weed control were conducted using simplex method linear programming algorithm in SAS (Saxton 1998). For bermudagrass, johnsongrass, and purple nutsedge were fourteen treatments with different fallow sugarcane operation.
[2] LP procedures were conducted binary (one treatment for an objective function) and non-binary (more than one treatment for an objective function).

For bermudagrass control programs, fuel and generic glyphosate were the decision variables that can affect the objective function of \$46.55/A for treatment 9 (Table 3.5). Fuel price was found to not be a sensitive parameter, as the tradeoff between tillage operations and herbicide

Table 3.4. Price sensitivity analysis of generic glyphosate (Mad Dog Plus) for sugarcane fallow operations and weed control [1].

	Bermudagrass prices			Johnsongrass price			Purple nutsedge price		
Treatments	Control [2]	(\$0.09)	(\$0.27)	Control	(\$0.09)	(\$0.33)	Control	(\$0.09)	(\$0.33)
	%	------------ \$ ------------		%	------------ \$ -------------		%	------------ \$ -------------	
1	95	81.22	81.22	100	81.22	81.22	70	81.22	81.22
2	95	76.95	76.95	100	76.95	76.95	70	76.95	76.95
3	80	55.83	55.83	95	55.83	55.83	60	55.83	55.83
4	80	59.12	59.12	95	59.12	59.12	60	59.12	59.12
5	95	81.73	81.73	95	81.73	81.73	80	95.83	95.83
6	95	73.00	73.00	95	73.00	73.00	80	97.67	97.67
7	95	75.14	75.14	95	75.14	75.14	50	75.14	75.14
8	95	50.82	74.38	100	50.82	82.06	70	50.82	82.06
9	95	46.55	70.11	100	46.55	77.79	70	46.55	77.79
10	80	40.63	52.41	95	40.63	56.25	60	40.63	56.25
11	80	43.92	55.70	95	43.92	59.54	60	43.92	59.54
12	95	66.53	78.31	95	66.53	82.15	80	65.43	96.67
13	95	57.80	69.58	95	57.80	73.42	80	67.27	98.51
14	95	59.94	71.72	95	59.94	75.56	50	59.94	75.56
Min. cost		46.55	69.58		40.63	73.42		65.43	95.83

[1] The price of Roundup Original Max (\$ 0.45), DuPont k4 (\$ 6.40), trifluralin (\$ 4.40), and EPTC (\$ 5.64) maintained constant.
[2] Bermudagrass, johnsongrass, and purple nutsedge at least percentage control to achieve optimal minimum cost treatment was 87%, 87%, and 78%, respectively.

applications were not flexible enough within the group of treatments evaluated. Labor and herbicide (Roundup Original Max, DuPont, trifluralin, and EPTC) prices did not have any effect over treatment 9 for bermudagrass control programs. Generic glyphosate price is sensitive when its price reaches $0.27/A, and treatment 13 becomes the new solution when Roundup Original Max price is $0.40 or $0.45/A. Table 3.6 shows if the price fluctuation for generic glyphosate is $0.20 to $0.33/A, and Roundup Original Max is $0.25 to $0.35/A, treatment 12 become the new solution. When Roundup Original and generic glyphosate prices are more or equal than $0.40 and $0.27/A, treatment 13 will be the new solution for linear programming model.

Table 3.5. Sensitivity price analysis for decision variable in bermudagrass control

			Sensitivity price range[1]	
Variable	Code	Model Coeff.	Min.	Max.
		-------------------	$	--------------------
Fuel	Qfuel	2.30	-1.23	92.63
Labor	Qlabor	9.60	-17.82	infinity
Roundup Original Max	H1	0.45	0.11	infinity
DuPont K4 60DG	H2	6.40	-0.07	infinity
Trifluralin 4EC	H3	4.40	0.10	infinity
EPTC	H4	5.64	0.12	infinity
Generic glyphosate	H5	0.09	-0.005	0.27[*]

[1] Price range analysis was conducted using simplex method linear programming algorithm in SAS (2003). All treatments had to achieve at least 87% control before to take minimum total sugarcane fallow cost.
[*] Sensitive parameter

For johnsongrass control programs, fuel and generic glyphosate were the decision variables that can affect the objective function of $40.63/A for treatment 10 (Table 3.7). Fuel price was not sensitive in the bermudagrass control programs when its price increases more than $92.63/A. Labor and herbicide (Roundup Original Max, DuPont, trifluralin, and EPTC) prices did not have any effect over treatment 10. Generic glyphosate price is sensitive when its price reaches $0.33/A, and treatment 3 becomes the new solution when Roundup Original Max price is

Table 3.6. Bermudagrass treatment price sensitivity analysis for generic glyphosate and Roundup Original Max[1].

	Roundup Original Max								
	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
Generic Glyphosate	$								
0.09	T9 (46.55)	T9 (46.55)	T9 (46.55)	T9 (46.55)	T9 (46.55)	T9 (46.55)	T9 (46.55)	T9 (46.55)	T9 (46.55)
0.10	T9 (48.35)	T9 (48.35)	T9 (48.35)	T9 (48.35)	T9 (48.35)	T9 (48.35)	T9 (48.35)	T9 (48.35)	T9 (48.35)
0.15	T9 (54.75)	T9 (54.75)	T9 (54.75)	T9 (54.75)	T9 (54.75)	T9 (54.75)	T9 (54.75)	T9 (54.75)	T9 (54.75)
0.20	T2 (58.55)	T9 (61.15)	T9 (61.15)	T9 (61.15)	T9 (61.15)	T9 (61.15)	T9 (61.15)	T9 (61.15)	T9 (61.15)
0.25 $	T2 (58.55)	T2 (63.15)	T9 (67.55)	T9 (67.55)	T9 (67.55)	T9 (67.55)	T9 (67.55)	T9 (67.55)	T9 (67.55)
0.27	T2 (58.55)	T2 (63.15)	T2 (67.75)	T13 (69.58)	T13 (69.58)	T13 (69.58)	T13 (69.58)	T13 (69.58)	T13 (69.58)
0.30	T2 (58.55)	T2 (63.15)	T2 (67.75)	T6 (70.70)	T13 (71.50)	T13 (71.50)	T13 (71.50)	T13 (71.50)	T13 (71.50)
0.32	T2 (58.55)	T2 (63.15)	T2 (67.75)	T6 (70.70)	T13 (72.78)	T13 (72.78)	T13 (72.78)	T13 (72.78)	T13 (72.78)
0.33	T2 (58.55)	T2 (63.15)	T2 (67.75)	T6 (73.70)	T6 (73.00)	T13 (72.42)	T13 (72.42)	T13 (72.42)	T13 (72.42)

[1] Bermudagrass percentage control was at least 87% for all treatments (T_n).

$0.45/A. Table 3.8 shows if the price fluctuation for generic glyphosate is $0.20 to $0.33/A, and Roundup Original Max is $0.25 to $0.45/A, treatment 3 become the new solution for linear programming model.

Table 3.7. Sensitivity price analysis for decision variables in johnsongrass control

Variable	Code	Model Coeff.	Sensitivity price range[1]	
			Min.	Max.
		------------------	$	------------------
Fuel	Qfuel	2.30	-1.23	92.63
Labor	Qlabor	9.60	-17.82	infinity
Roundup Original Max	H1	0.45	0.11	infinity
DuPont K4 60DG	H2	6.40	-0.07	infinity
Trifluralin 4EC	H3	4.40	0.10	infinity
EPTC	H4	5.64	0.12	infinity
Generic glyphosate	H5	0.09	-0.05	0.33*

[1] Price range analysis was conducted using simplex method linear programming algorithm in SAS (2003). All treatments had to achieve at least 87% control before to take minimum total sugarcane fallow cost.

* Sensitive parameter

For purple nutsedge control programs, fuel, labor, and EPTC prices were not sensitive, their prices did not respond to any increased or decreased prices given as result the same $65.43/A as objective function for treatment 12. Generic glyphosate price is sensitive when its price reaches $0.33/A, and treatment 5 becomes the new solution with $95.83/A as objective function when Roundup Original Max price is $0.45/A. When Roundup Original Max and Yukon 67.5WG is lower or equal than $0.12 and $3.45/A, and Permit 75DF is more or equal than $20.7/A, respectively, a new treatment becomes solutions and objective function changes (Table 3.9).

In the table 3.10, the price fluctuation for generic glyphosate is $0.20 to $0.33/A, and Roundup Original Max is $0.25 to $0.35/A, and $0.45 to $0.65/A, treatment 5 become the new solution for linear programming model.

Generic glyphosate (Mad Dog Plus) was observed more sensitive whether their prices

Table 3.8.Johnsongrass treatment price sensitivity analysis for generic glyphosate and Roundup Original Max[1].

	Roundup Original Max								
	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
Generic Glyphosate	------ $ ------								
0.09	T10 (40.63)	T10 (40.63)	T10 (40.63)	T10 (40.63)	T10 (40.63)	T10 (40.63)	T10 (40.63)	T10 (40.63)	T10 (40.63)
0.10	T10 (41.53)	T10 (41.53)	T10 (41.53)	T10 (41.53)	T10 (41.53)	T10 (41.53)	T10 (41.53)	T10 (41.53)	T10 (41.53)
0.15	T10 (44.73)	T10 (44.73)	T10 (44.73)	T10 (44.73)	T10 (44.73)	T10 (44.73)	T10 (44.73)	T10 (44.73)	T10 (44.73)
0.20	T3 (46.63)	T10 (47.93)	T10 (47.93)	T10 (47.93)	T10 (47.93)	T10 (47.93)	T10 (47.93)	T10 (47.93)	T10 (47.93)
0.25	T3 (46.63)	T3 (48.93)	T10 (51.13)	T10 (51.13)	T10 (51.13)	T10 (51.13)	T10 (51.13)	T10 (51.13)	T10 (51.13)
0.27	T3 (46.63)	T3 (48.93)	T3 (51.23)	T10 (52.41)	T10 (52.41)	T10 (52.41)	T10 (52.41)	T10 (52.41)	T10 (52.41)
0.30	T3 (46.63)	T3 (48.93)	T3 (51.23)	T3 (53.53)	T10 (54.33)	T10 (54.33)	T10 (54.33)	T10 (54.33)	T10 (54.33)
0.32	T3 (46.63)	T3 (48.93)	T3 (51.23)	T6 (70.70)	T10 (55.61)	T10 (55.61)	T10 (55.61)	T10 (55.61)	T10 (55.61)
0.33	T3 (46.63)	T3 (48.93)	T3 (51.23)	T3 (51.53)	T3 (55.83)	T10 (56.25)	T10 (56.25)	T10 (56.25)	T10 (56.25)

[1] Johnsongrass percentage control was at least 87% for all treatments (T_n).

Table 3.9. Sensitivity price analysis for decision variables in purple nutsedge control

Variable	Code	Model Coeff.	Sensitivity price range[1]	
			Min.	Max.
			------------------- $ --------------------	
Fuel	Qfuel	2.30	-10.88	Infinity
Labor	Qlabor	9.60	-89.25	infinity
Roundup Original Max	H1	0.45	0.12*	infinity
EPTC	H4	5.64	infinity	infinity
Generic glyphosate	H5	0.09	0.03*	0.33*
Permit 75DF	H6	18.88	infinity	20.7*
Yukon 67.5WG	H7	3.45	3.14*	infinity

[1] Price range analysis was conducted using simplex method linear programming algorithm in SAS (2003). All treatments had to achieve at least 78% control before to take minimum total sugarcane fallow cost.
* Sensitive parameter

increased or decreased in each fallow weed control program. In bermudagrass and purple nutsedge control, when generic glyphosate has a price of $0.20, $0.25, and $0.27/A vs. Roundup Original Max with $0.25, $0.30, and $0.35, treatment 9 for bermudagrass control program and treatment 5 for purple nutsedge control program become the new sugarcane fallow weed control solution. For johnsongrass control program, when generic glyphosate has a price of $0.20, $0.25, $0.27, $0.30, and 0.33/A vs. Roundup Original Max with $0.25, $0.30, $0.35, $0.40, and $0.45, treatment 3 becomes solution. Glyphosate price has strong influence in the costs for weed control programs being an important input within of the farmer decision during sugarcane fallow.

Table 3.10. Purple nutsedge treatment price sensitivity analysis for generic glyphosate and Roundup Original Max[1].

Generic Glyphosate	Roundup Original Max 0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
$	----------	----------	----------	----------	$	----------	----------	----------	----------
0.09	T12 (65.38)	T12 (65.38)	T12 (65.38)	T12 (65.38)	T12 (65.38)	T12 (65.38)	T12 (65.38)	T12 (65.38)	T12 (65.38)
0.10	T12 (67.19	T12 (67.20	T12 (67.21	T12 (67.22	T12 (67.23	T12 (67.24	T12 (67.25	T12 (67.26	T12 (67.27
0.15	T12 (73.63)	T12 (73.63)	T12 (73.63)	T12 (73.63)	T12 (73.63)	T12 (73.63)	T12 (73.63)	T12 (73.63)	T12 (73.63)
0.20	T5 (77.43)	T12 (80.03)	T12 (80.03)	T12 (80.03)	T12 (80.03)	T12 (80.03)	T12 (80.03)	T12 (80.03)	T12 (80.03)
0.25	T5 (77.43)	T5 (82.03)	T12 (86.43)	T12 (86.43)	T12 (86.43)	T12 (86.43)	T12 (86.43)	T12 (86.43)	T12 (86.43)
0.27	T5 (77.43)	T5 (82.03)	T5 (86.63)	T12 (88.99)	T12 (88.99)	T12 (88.99)	T12 (88.99)	T12 (88.99)	T12 (88.99)
0.30	T5 (77.43)	T5 (82.03)	T5 (86.63)	T12 (91.23)	T12 (92.83)	T12 (92.83)	T12 (92.83)	T12 (92.83)	T12 (92.83)
0.32	T5 (77.43)	T5 (82.03)	T5 (86.63)	T12 (91.23)	T12 (95.39)	T12 (95.39)	T12 (95.39)	T12 (95.39)	T12 (95.39)
0.33	T5 (72.43)	T5 (82.03)	T5 (86.63)	T12 (91.23)	T5 (95.83)	T5 (95.83)	T5 (95.83)	T5 (95.83)	T5 (95.83)

[1] Purple nutsedge percentage control was at least 78% for all treatments (T_n).

CHAPTER 4

SUMMARY AND CONCLUSIONS

Roundup Original Max at 46 oz/A applied for bermudagrass and johnsongrass treatments was more expensive by $30.40 per acre for treatments 1 and 2 compared with treatments 8 and 9, by $15.20 per acre for treatments 3, 4, 5, 6, and 7 compared with treatments 10, 11, 12, 13, and 14 when compared with treatments which applied generic glyphosate (Mad Dog Plus) applied at 64 oz/A, respectively. For purple nutsedge, Roundup Original Max at 46 oz/A applied was more expensive by $30.40 per acre for treatments 1 and 2 compared with treatments 8 and 9, by $15.20 acre for treatments 3, 4, 5, 6and 7 compared with treatments 10, 11, 12, 13 and 14 when was applied generic glyphosate at 64 oz/A, respectively. In general, the treatments applied with Roundup Original Max had an increased cost of fallow sugarcane weed control compared with treatments applied with generic glyphosate, when the prices of fuel, labor, Roundup Original Max, and generic glyphosate were $2.30 (Gal.), $9.60 (hour), $0.45 (oz/A), and $0.09 (oz/A), respectively.

Treatments 3, 4, 10, 11 for bermudagrass, johnsongrass, and purple nutsedge had a reduced cost compared with the other treatments, when glyphosate was applied twice or in combination the DuPont, trifluralin, EPTC, Permit, and Yukon. Fuel and Labor cost for treatments 1 and 8 in each weed control program in sugarcane fallow was $25.30 and $14.50 per acre higher than other treatments, respectively. Treatments 5, 6, 12, and 13 in purple nutsedge had a lower cost in fuel and labor compared with bermudagrass and johnsongrass control program.

The fallow period weed control cost report generated by the spreadsheet-based producer decision aid model summarizes the sugarcane fallow operations and weed control cost, equipment used, performance rates, and herbicide applied in dollars per acre. Farm specifications are listed in terms of day and month that generally the farmers conduct during sugarcane fallow. These data are entered by the model user and are for specific farm situations. Fuel – labor prices and actual herbicide application rate are data entered for the user. Daily fallow operations that include implements, implement size, tractor size, field speed, and times over are listed in a drop down menu that user chooses according his fallow practices. Performance rate is calculated automatically when the user already has described the operation in a particular day. When the fallow operation is boom sprayer, the user can select the herbicide that he wants to apply through a listed using a drop down menu. The herbicide selected for the user will have automatically the recommended herbicide application rate (qty/A), and the user could fill the actual herbicide application rate that usually applied during his fallow operation. The herbicide price is already linked with recommended and actual herbicide application rate cell. The final column summarizes the total variable costs per acre associated to every operation for sugarcane weed control in dollars per acre that will give the total fallow program cost.

The optimal sugarcane fallow weed control program had two different objective functions when LP procedure was binary and non-binary for bermudagrass and purple nutsedge. The non-binary LP model took two treatments to achieve at least 87% control for bermudagrass and johnsongrass because of LP model did not describe specifically that solution has to be one treatment with minimum cost and at least percentage control established. In comparison, binary LP model took only one treatment that has minimum fallow operation cost and also more or equal than 87% control described in the constraint equation from the model.

For bermudagrass control programs, the objective function of the LP non-binary model was \$43.38/A total cost using treatment 9 (46%) with 95% control and treatment 10 (53%) with 80% control to reach 87% total control. LP binary model took treatment 9 (100%) with \$46.5/A as treatment solution and 95% control. At this case, the LP model took the cheapest treatment within of the 14 treatments, and also LP model forced to achieve at least 87% control being treatment 9 with 95% control. In johnsongrass LP model, the non-binary and binary models had $40.63/A as objective function of treatment 10 with 95%control. Purple nutsedge control LP model, the non-binary LP model had the same procedure to take two treatments with the different that used 80% from T12 and 27% for T9. The objective function was $61.6/A with at least 78% control compared with binary LP model that took treatment 12 with $65.43/A as objective function and 80% control.

The linear programming procedure conducted a price range analysis for each fallow weed control program. Generic glyphosate (Mad Dog Plus) was sensitive when its price increases or it is equal to $0.27 oz/A for bermudagrass, and $0.33 oz/A for johnsongrass and purple nutsedge. When the price is over this level new treatment is coming up with new objective function in LP model. Fuel price was not sensitive when its price increases more than $92.63/A. Labor; DuPont, trifluralin, and EPTC prices did not have any effect over treatment 9 for bermudagrass and johnsongrass control programs. Fallow weed control programs applied with Roundup Original Max had a higher cost in general for all perennial weed problems compared with treatments applied with generic glyphosate. Spreadsheet-based producer decision aid tool cost can be useful tool to farmer’s decision making on weed control during sugarcane fallow. Fuel and labor were not sensitive prices on sugarcane fallow programs and generic glyphosate price was observed to be more sensitive than the prices of other herbicides used in each fallow weed control program

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APPENDIX: SUPPLEMENTARY DATA

Table A1. Specific mathematical programming model for bermudagrass

$$MIN\ C = \$9.60\ QLABOR + \$2.30\ QFUEL + \$0.45\ QHERB1 + \$6.40\ QHERB2 + \$4.40\ QHERB3 + \$5.64\ QHERB4 + \$0.09\ QHERB5$$

s.t.

(1) $\sum_{t=1}^{14} T_t = 1$

(2-1)	$1.51\ T_1 = QLBT_1$	(2-8)	$1.51\ T_8 = QLBT_8$
(3-1)	$11.00\ T_1 = QFLT_1$	(3-8)	$11.00\ T_8 = QFLT_8$
(4-1)	$92.00\ T_1 = QH1T_1$	(8-8)	$128.00\ T_8 = QH5T_8$
(2-2)	$1.35\ T_2 = QLBT_2$	(2-9)	$1.35\ T_9 = QLBT_9$
(3-2)	$9.80\ T_2 = QFLT_2$	(3-9)	$9.80\ T_9 = QFLT_9$
(4-2)	$92.00\ T_2 = QH1T_2$	(8-9)	$128.00\ T_9 = QH5T_9$
(2-3)	$1.32\ T_3 = QLBT_3$	(2-10)	$1.32\ T_{10} = QLBT_{10}$
(3-3)	$9.77\ T_3 = QFLT_3$	(3-10)	$9.77\ T_{10} = QFLT_{10}$
(4-3)	$46.00\ T_3 = QH1T_3$	(8-10)	$64.00\ T_{10} = QH5T_{10}$
(2-4)	$1.44\ T_4 = QLBT_4$	(2-11)	$1.44\ T_{11} = QLBT_{11}$
(3-4)	$10.70\ T_4 = QFLT_4$	(3-11)	$10.70\ T_{11} = QFLT_{11}$
(4-4)	$46.00\ T_4 = QH1T_4$	(8-11)	$64.00\ T_{11} = QH5T_{11}$
(2-5)	$1.37\ T_5 = QLBT_5$	(2-12)	$1.37\ T_{12} = QLBT_{12}$
(3-5)	$9.70\ T_5 = QFLT_5$	(3-12)	$9.70\ T_{12} = QFLT_{12}$
(4-5)	$46.00\ T_5 = QH1T_5$	(8-12)	$64.00\ T_{12} = QH5T_{12}$
(5-5)	$4.00\ T_5 = QH2T_5$	(5-12)	$4.00\ T_{12} = QH2T_{12}$
(2-6)	$1.32\ T_6 = QLBT_6$	(2-13)	$1.32\ T_{13} = QLBT_{13}$
(3-6)	$9.58\ T_6 = QFLT_6$	(3-13)	$9.58\ T_{13} = QFLT_{13}$
(4-6)	$46.00\ T_6 = QH1T_6$	(8-13)	$64.00\ T_{13} = QH5T_{13}$
(6-6)	$4.00\ T_6 = QH3T_6$	(6-13)	$4.00\ T_{13} = QH3T_{13}$
(2-7)	$1.32\ T_7 = QLBT_7$	(2-14)	$1.32\ T_{14} = QLBT_{14}$
(3-7)	$9.58\ T_7 = QFLT_7$	(3-14)	$9.58\ T_{14} = QFLT_{14}$
(4-7)	$46.00\ T_7 = QH1T_7$	(8-14)	$64.00\ T_{14} = QH5T_{14}$
(7-7)	$3.50\ T_7 = QH4T_7$	(7-14)	$3.50\ T_{14} = QH4T_{14}$

(9) $95\ T_1 + 95\ T_2 + 80\ T_3 + 80\ T_4 + 95\ T_5 + 95\ T_6 + 95\ T_7 + 95\ T_8 + 95\ T_9 + 80\ T_{10} + 80\ T_{11} + 95\ T_{12} + 95\ T_{13} + 95\ T_{14} \geq 87$

(10) $\sum_{t=1}^{14} \mathrm{QLBT_t} = \mathrm{QLABOR}$

(11) $\sum_{t=1}^{14} \mathrm{QFLT_t} = \mathrm{QFUEL}$

Table A1. Continued

(12)	$\sum_{t=1}^{14} \mathrm{QH1T_t} = \mathrm{QHERB1}$
(13)	$\sum_{t=1}^{14} \mathrm{QH2T_t} = \mathrm{QHERB2}$
(14)	$\sum_{t=1}^{14} \mathrm{QH3T_t} = \mathrm{QHERB3}$
(15)	$\sum_{t=1}^{14} \mathrm{QH4T_t} = \mathrm{QHERB4}$
(16)	$\sum_{t=1}^{14} \mathrm{QH5T_t} = \mathrm{QHERB5}$
and	$T_1, T_2, \ldots, T_{14}$ *are binary*

Table A2. Specific mathematical programming model for johnsongrass

$$MIN\ C = \$9.60\ QLABOR + \$2.30\ QFUEL + \$0.45\ QHERB1 + \$6.40\ QHERB2 + \$4.40\ QHERB3 + \$5.64\ QHERB4 + \$0.09\ QHERB5$$

s.t.

(1) $\sum_{t=1}^{14} T_t = 1$

(2-1) $1.51\ T_1 = QLBT_1$
(3-1) $11.00\ T_1 = QFLT_1$
(4-1) $92.00\ T_1 = QH1T_1$

(2-2) $1.35\ T_2 = QLBT_2$
(3-2) $9.80\ T_2 = QFLT_2$
(4-2) $92.00\ T_2 = QH1T_2$

(2-3) $1.32\ T_3 = QLBT_3$
(3-3) $9.77\ T_3 = QFLT_3$
(4-3) $46.00\ T_3 = QH1T_3$

(2-4) $1.44\ T_4 = QLBT_4$
(3-4) $10.70\ T_4 = QFLT_4$
(4-4) $46.00\ T_4 = QH1T_4$

(2-5) $1.37\ T_5 = QLBT_5$
(3-5) $9.70\ T_5 = QFLT_5$
(4-5) $46.00\ T_5 = QH1T_5$
(5-5) $4.00\ T_5 = QH2T_5$

(2-6) $1.32\ T_6 = QLBT_6$
(3-6) $9.58\ T_6 = QFLT_6$
(4-6) $46.00\ T_6 = QH1T_6$
(6-6) $4.00\ T_6 = QH3T_6$

(2-7) $1.32\ T_7 = QLBT_7$
(3-7) $9.58\ T_7 = QFLT_7$
(4-7) $46.00\ T_7 = QH1T_7$
(7-7) $3.50\ T_7 = QH4T_7$

(2-8) $1.51\ T_8 = QLBT_8$
(3-8) $11.00\ T_8 = QFLT_8$
(8-8) $128.00\ T_8 = QH5T_8$

(2-9) $1.35\ T_9 = QLBT_9$
(3-9) $9.80\ T_9 = QFLT_9$
(8-9) $128.00\ T_9 = QH5T_9$

(2-10) $1.32\ T_{10} = QLBT_{10}$
(3-10) $9.77\ T_{10} = QFLT_{10}$
(8-10) $64.00\ T_{10} = QH5T_{10}$

(2-11) $1.44\ T_{11} = QLBT_{11}$
(3-11) $10.70\ T_{11} = QFLT_{11}$
(8-11) $64.00\ T_{11} = QH5T_{11}$

(2-12) $1.37\ T_{12} = QLBT_{12}$
(3-12) $9.70\ T_{12} = QFLT_{12}$
(8-12) $64.00\ T_{12} = QH5T_{12}$
(5-12) $4.00\ T_{12} = QH2T_{12}$

(2-13) $1.32\ T_{13} = QLBT_{13}$
(3-13) $9.58\ T_{13} = QFLT_{13}$
(8-13) $64.00\ T_{13} = QH5T_{13}$
(6-13) $4.00\ T_{13} = QH3T_{13}$

(2-14) $1.32\ T_{14} = QLBT_{14}$
(3-14) $9.58\ T_{14} = QFLT_{14}$
(8-14) $64.00\ T_{14} = QH5T_{14}$
(7-14) $3.50\ T_{14} = QH4T_{14}$

(9) $100\ T_1 + 100\ T_2 + 95\ T_3 + 95\ T_4 + 95\ T_5 + 95\ T_6 + 95\ T_7 + 100\ T_8 + 100\ T_9 + 5\ T_{10} + 95\ T_{11} + 95\ T_{12} + 95\ T_{13} + 95\ T_{14} \geq 87$

(10) $\sum_{t=1}^{14} \mathrm{QLBT_t} = \mathrm{QLABOR}$

(11) $\sum_{t=1}^{14} \mathrm{QFLT_t} = \mathrm{QFUEL}$

(12) $\sum_{t=1}^{14} \mathrm{QH1T_t} = \mathrm{QHERB1}$

Table A2. Continued

(13)	$\sum_{t=1}^{14} \mathrm{QH2T_t} = \mathrm{QHERB2}$
(14)	$\sum_{t=1}^{14} \mathrm{QH3T_t} = \mathrm{QHERB3}$
(15)	$\sum_{t=1}^{14} \mathrm{QH4T_t} = \mathrm{QHERB4}$
(16)	$\sum_{t=1}^{14} \mathrm{QH5T_t} = \mathrm{QHERB5}$
and	$T_1, T_2, \ldots, T_{14}$ *are binary*

Table A3. Specific mathematical programming model for purple nutsedge

$$MIN\ C = \$9.60\ QLABOR + \$2.30\ QFUEL + \$0.45\ QHERB1 + \$5.64\ QHERB4 + \$0.09\ QHERB5 + \$18.88\ QHERB6 + \$3.45\ QHERB7$$

s.t.

(1) $\sum_{t=1}^{14} T_t = 1$

(2-1)	$1.51\ T_1 = QLBT_1$	(2-8)	$1.51\ T_8 = QLBT_8$
(3-1)	$11.00\ T_1 = QFLT_1$	(3-8)	$11.00\ T_8 = QFLT_8$
(4-1)	$92.00\ T_1 = QH1T_1$	(8-8)	$128.00\ T_8 = QH5T_8$
(2-2)	$1.35\ T_2 = QLBT_2$	(2-9)	$1.35\ T_9 = QLBT_9$
(3-2)	$9.80\ T_2 = QFLT_2$	(3-9)	$9.80\ T_9 = QFLT_9$
(4-2)	$92.00\ T_2 = QH1T_2$	(8-9)	$128.00\ T_9 = QH5T_9$
(2-3)	$1.32\ T_3 = QLBT_3$	(2-10)	$1.32\ T_{10} = QLBT_{10}$
(3-3)	$9.77\ T_3 = QFLT_3$	(3-10)	$9.77\ T_{10} = QFLT_{10}$
(4-3)	$46.00\ T_3 = QH1T_3$	(8-10)	$64.00\ T_{10} = QH5T_{10}$
(2-4)	$1.44\ T_4 = QLBT_4$	(2-11)	$1.44\ T_{11} = QLBT_{11}$
(3-4)	$10.70\ T_4 = QFLT_4$	(3-11)	$10.70\ T_{11} = QFLT_{11}$
(4-4)	$46.00\ T_4 = QH1T_4$	(8-11)	$64.00\ T_{11} = QH5T_{11}$
(2-5)	$1.35\ T_5 = QLBT_5$	(2-12)	$1.35\ T_{12} = QLBT_{12}$
(3-5)	$9.80\ T_5 = QFLT_5$	(3-12)	$9.80\ T_{12} = QFLT_{12}$
(4-5)	$92.00\ T_5 = QH1T_5$	(8-12)	$128.00\ T_{12} = QH5T_{12}$
(5-5)	$1.00\ T_5 = QH6T_5$	(5-12)	$1.00\ T_{12} = QH6T_{12}$
(2-6)	$1.35\ T_6 = QLBT_6$	(2-13)	$1.35\ T_{13} = QLBT_{13}$
(3-6)	$9.80\ T_6 = QFLT_6$	(3-13)	$9.80\ T_{13} = QFLT_{13}$
(4-6)	$92.00\ T_6 = QH1T_6$	(8-13)	$128.00\ T_{13} = QH5T_{13}$
(6-6)	$6.00\ T_6 = QH7T_6$	(6-13)	$6.00\ T_{13} = QH7T_{13}$
(2-7)	$1.32\ T_7 = QLBT_7$	(2-14)	$1.32\ T_{14} = QLBT_{14}$
(3-7)	$9.58\ T_7 = QFLT_7$	(3-14)	$9.58\ T_{14} = QFLT_{14}$
(4-7)	$46.00\ T_7 = QH1T_7$	(8-14)	$64.00\ T_{14} = QH5T_{14}$
(7-7)	$3.50\ T_7 = QH4T_7$	(7-14)	$3.50\ T_{14} = QH4T_{14}$

(9) $70\ T_1 + 70\ T_2 + 60\ T_3 + 60\ T_4 + 80\ T_5 + 80\ T_6 + 50\ T_7 + 70\ T_8 + 70\ T_9 + 60\ T_{10} + 60\ T_{11} + 80\ T_{12} + 80\ T_{13} + 50\ T_{14} \geq 78$

(10) $\sum_{t=1}^{14} \mathrm{QLBT_t} = \mathrm{QLABOR}$

(11) $\sum_{t=1}^{14} \mathrm{QFLT_t} = \mathrm{QFUEL}$

(12) $\sum_{t=1}^{14} \mathrm{QH1T_t} = \mathrm{QHERB1}$

Table A3. Continued

(13)	$\sum_{t=1}^{14}\ \mathrm{QH4T_t} = \mathrm{QHERB4}$
(14)	$\sum_{t=1}^{14}\ \mathrm{QH5T_t} = \mathrm{QHERB5}$
(15)	$\sum_{t=1}^{14}\ \mathrm{QH6T_t} = \mathrm{QHERB6}$
(16)	$\sum_{t=1}^{14}\ \mathrm{QH7T_t} = \mathrm{QHERB7}$
and	$T_1, T_2, \ldots, T_{14}\ are\ binary$

Table A4. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 1.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	Total Var. Cost
			(hr/Ac)	(gal/A)	------ ($/A) ----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	27	Bottom Plow	0.14	1.20	2.75	1.51	-	-	-	-	4.27
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jul	12	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											81.22

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bottom plow (18 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, bottom plow, chisel plow, and bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A5. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 2.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	--------- ($/A)	---------		(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jul	12	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											76.95

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A6. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 3.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	Total Var. Cost
			(hr/Ac)	(gal/A)	--------- ($/A)	---------		(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jul	12	Re-Hip	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											55.83

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A7. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 4.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	----- ($/A) -----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jul	16	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jul	16	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jul	16	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											59.12

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A8. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 5.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A)	-----		(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jun	21	Packer	0.11	0.71	1.64	1.14	-	-	-	-	2.78
Jun	21	Boom Sprayer	0.14	0.93	2.14	1.49	DuPont K4 60DG	4	lb	6.40	29.23
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											81.73

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), Packer (18 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer, packer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A9. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 6.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	----- ($/A) -----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Jun	21	Boom Sprayer	0.11	0.71	1.64	1.14	Trifluralin 4EC	4	qt	$4.40	20.38
Jun	21	Bed up	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	$0.45	24.33
Total cost											73.00

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A10. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 7.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	----- ($/A)	-----		(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Jun	21	Boom Sprayer	0.11	0.71	1.64	1.14	EPTC	4	pt	5.64	22.52
Jun	21	Re-Hip	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											75.14

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), re-hip (18 ft.) and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up, and re-hip) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A11. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 8.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A)	---		(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	27	Bottom Plow	0.14	1.20	2.75	1.51	-	-	-	-	4.27
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jul	12	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											50.82

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bottom plow (18 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, bottom plow, chisel plow, and bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A12. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 9.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ---			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jun	21	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											$46.55

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, bottom plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A13. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 10.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ---			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jul	12	Re-Hip	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											40.63

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A14. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 11.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A)	---		(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jul	16	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jul	16	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jul	16	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											43.92

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A15. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 12.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ---			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jun	21	Packer	0.11	0.71	1.64	1.14	-	-	-	-	2.78
Jun	21	Boom Sprayer	0.14	0.93	2.14	1.49	DuPont K4 60DG	4	lb	6.40	29.23
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											66.53

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), Packer (18 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer, packer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A16. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 13.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ---			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Jun	21	Boom Sprayer	0.11	0.71	1.64	1.14	Trifluralin 4EC	4	qt	4.40	20.38
Jun	21	Bed up	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											57.80

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A17. Fallow sugarcane operations and weed control costs for bermudagrass and johnsongrass – treatment 14.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ---			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Jun	21	Boom Sprayer	0.11	0.71	1.64	1.14	EPTC	4	pt	5.64	22.52
Jun	21	Re-Hip	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											59.94

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), re-hip (18 ft.) and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up, and re-hip) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A18. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 1.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	27	Bottom Plow	0.14	1.20	2.75	1.51	-	-	-	-	4.27
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jul	12	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											81.22

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bottom plow (18 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, bottom plow, bed up, and chisel plow) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A19. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 2.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ---			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jul	12	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											76.95

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, bottom plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A20. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 3.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	--- ($/A)---			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jul	12	Re-Hip	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											55.83

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), re-hip (18 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, re-hip, chisel plow, and bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A21. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 4.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	($/A) -			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jul	16	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jul	16	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jul	16	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											59.12

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A22. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 5.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	----- ($/A)	-----		(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jun	21	Boom Sprayer					Permit 75DF	1	oz	18.88	18.88
Jun	21	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Aug	31	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											95.83

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A23. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 6.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	22	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jun	22	Boom Sprayer					Yukon 67.5 WG	6	oz	3.45	20.72
Jun	22	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Aug	31	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											97.67

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A24. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 7.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	Var. Cost
			(hr/Ac)	(gal/A)	---- ($/A) ----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jul	16	Bed up	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Jul	16	Boom Sprayer	0.11	0.71	1.64	1.14	EPTC	4	pt	5.64	22.52
Jul	16	Re-Hip	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Roundup Org. Max	46	oz	0.45	24.33
Total cost											75.14

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), re-hip (18ft.) and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up, and re-hip) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A25. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 8.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	27	Bottom Plow	0.14	1.20	2.75	1.51	-	-	-	-	4.27
Jun	17	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jul	12	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											50.82

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bottom plow (18 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, bottom plow, bed up, and chisel plow) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A26. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 9.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jul	12	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											46.55

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A27. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 10.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	21	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jul	12	Re-Hip	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											40.63

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), re-hip (18 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up, and re-hip) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A28. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 11.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jul	16	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jul	16	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jul	16	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											43.92

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A29. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 12.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	22	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jun	22	Boom Sprayer					Permit 75DF	1	oz	18.88	18.88
Jun	22	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Aug	31	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											65.43

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A30. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 13.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jun	22	Bed up (2)	0.11	1.80	4.15	2.28	-	-	-	-	6.42
Jun	22	Boom Sprayer					Yukon 67.5 WG	6	oz	3.45	20.72
Jun	22	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Aug	31	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											67.27

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

Table A31. Fallow sugarcane operations and weed control costs for purple nutsedge – treatment 14.

Machinery Operation - Efficiency				Fuel - Labor			Herbicide				Total Var. Cost
Month	Day	Machinery Operation[1]	Perf. Rate[2]	Fuel Use	Fuel Cost	Labor Cost	Name	Qty.	Unit	Price	
			(hr/Ac)	(gal/A)	---- ($/A) ----			(units/A)		($/unit)	($/A)
May	1	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
May	26	Disk (2)	0.13	2.16	4.96	2.72	-	-	-	-	7.68
Jun	18	Chisel Plow	0.12	1.01	2.33	1.28	-	-	-	-	3.61
Jun	21	Disk	0.10	0.81	1.87	1.02	-	-	-	-	2.89
Jul	16	Bed up	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Jul	16	Boom Sprayer	0.11	0.71	1.64	1.14	EPTC	4	pt	5.64	22.52
Jul	16	Re-Hip	0.11	0.90	2.07	1.14	-	-	-	-	3.21
Aug	13	Boom Sprayer	0.14	0.93	2.14	1.49	Generic Glyphosate	64	oz	0.09	9.13
Total cost											59.94

[1] Implement size: disk (20 ft.), chisel plow (16 ft.), re-hip (18 ft.), bed up (18 ft.), and boom sprayer (18ft.). Tractor size was 190 hp for tillage operations (disk, chisel plow, bed up, and re-hip) and 150 hp for herbicide application operations (boom sprayer). Number of passes over the field greater than one indicated in parentheses.

[2] Operation performance rate (hours per acre) were calculated using implement size, tractor size, typical field speed and field efficiency according to ASABE Standards (2009).

VITA

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