TIMING OF GLYPHOSATE APPLICATIONS, ALTERNATIVES TO THE USE OF GLYPHOSATE AND RESPONSE OF NEW VARIETIES TO GLYPHOSATE IN MAXIMIZING THE YIELD OF SUGAR PER ACRE OF LOUISIANA SUGARCANE IN 2005

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SUMMARY

In the first of three field experiments planned for 2005, 13 ripener treatments were applied on August 18, 2005 to the first-stubble crop of the sugarcane variety LCP 85-384. Ripener treatments included three or four rates of three glyphosate products, Polado-L, Roundup WeatherMAX and Touchdown Total and three rates of Palisade. All ripener treatments were compared to non treated plots as control. These same treatments had been superimposed to the same plots in the plantcane crop in 2004. The second field experiment was scheduled for treatment on September 15; however, because of Hurricane Katrina and the lodged condition of the crop, the treatments could not be applied as scheduled. Data were still obtained for the second experiment to measure the residual effect, if any, of the 13 ripener treatments on cane and sugar yield in the subsequent stubble crop following the application of the treatments in 2004. A third field experiment was scheduled for 2005 to test the efficacy of glyphosate on eight new varieties, Ho 95-988, HoCP 96-540, L 97-128, L 99-226, L 99-233, L 00-266, CP 89-2143 and TucCP 77-42 as well as LCP 85-384; however, it too was scrapped because of lodged conditions of the cane caused by Hurricanes Katrina and Rita.

In the first experiment, all ripener treatments with the exception of Palisade and Polado-L at the lowest rates studied tended to increase the yield of theoretical recoverable sugar per ton of cane (TRS/TC) at 28 and 42 days after treatment (DAT) when compared to control. Because of the lodged condition of the crop, it was not possible to count the number of millable stalks in each plot; therefore, estimated yield of cane or sugar per acre could not be calculated. There was a general trend for lower mean stalk weight (MSW) and reduced mean stalk length (MSL) as a result of all glyphosate treatments where the rates were equivalent to the 6-oz/A rate of Polado-L (0.1875 lb ae/A) or higher, regardless of product used. Accordingly, it would be anticipated that yield of cane per acre (TC/A) would also be reduced as a result of the higher glyphosate rates. It appeared that Palisade at the rates studied caused little or no reduction in MSW or MSL.

At 56 DAT, where plots were harvested by combine and weighed, there were no significant differences amongst treatments in TC/A or yield of theoretical recoverable sugar per acre (TRS/A). In general, there were significant increases in TRS/TC for many of the glyphosate as well as the Palisade treatments. There were no differences amongst treatments for MSW or MSL with the exception of one rate of Palisade (0.267 lb/A) where the MSW was significantly higher than control. However, because of the lodged condition of the crop, there was considerable variability in the data for all criteria measured which made interpretation of the data

more difficult.

It appeared that there was little or no residual effect on the subsequent stubble crop from the 13 ripener treatments applied on September 14, 2005 and harvested on November 17, 2005 for any of the parameters measured, TC/A, TRS/TC, TRS/A, MSW and MSL. However, there was a trend towards a lower TC/A for the Roundup WeatherMAX and Touchdown iQ treatments at the highest rate tested (equivalent to the 8-oz/A Polado-L rate or 0.2500 lb ae/A).

INTRODUCTION

In Louisiana, a sugarcane crop cycle usually consists of a fall-planted crop (plantcane), which grows very little during winter and is harvested about one year after planting, and two or more stubble (ratoon) crops. The region has a 7- to 9-month growing season that extends from late February/early March to late November or until the first freeze of the winter season causes a cessation of growth. The harvest generally occurs from late September through early January. Consequently, sugarcane is relatively immature at the beginning of harvest and sucrose levels are usually low, generally increasing as the harvest season advances, depending upon the variety and the environmental conditions. Sucrose levels in juice and yield of sugar per ton of cane and per acre are affected greatly by variety and weather conditions during the growing season and harvest. A combination of high incident light, cool nights and drying soil prior to and during the harvest period retards vegetative growth and promotes sucrose accumulation (natural ripening) (Legendre 1975).

Artificial ripening of sugarcane has been made possible by the development of plant growth regulators use as chemical ripeners that hasten sugarcane maturation and increase sugar yield (Nickell 1984). Glyphosate [N-(phosphonomethyl)glycine], one of the most effective chemical ripeners used on a world-wide basis, apparently influences the way dry matter is partitioned, increasing the ratio of sucrose to fiber (Osgood et al. 1981). However, glyphosate treatment usually decreases cane yield in the crop by slowing cane growth after treatment, thus reducing stalk weight. In Louisiana, the effectiveness of glyphosate for ripening sugarcane is strongly dependent upon variety, treatment-harvest interval and growing season.

Until the 2003 harvest season, the only glyphosate formulation labeled for use in Louisiana was Polado-L® (Monsanto Company) which was also labeled for sucrose enhancement in Florida, Hawaii, Texas and Puerto Rico. Its use was and still is restricted to the stubble crops only. The label stipulates a use rate of 4 to 14 ounces per acre of the formulated product (contains 4 lb of glyphosate acid in each gallon in the isopropyl amine salt form) and a treatment-harvest interval of 35 to 49 days. For the 2003 harvest, a second formulation of glyphosate, Touchdown iQ® (Syngenta) was labeled for use in Louisiana. The Touchdown iQ label also stipulates use only in stubble crops at a rate of 8 to 10 ounces per acre of the formulated product (contains 3 lb of glyphosate acid in each gallon in the diammonium salt form) and a treatment harvest interval of 21 to 35 days. A third glyphosate formulation, Roundup WeatherMAX® (Monsanto Company) was labeled for the 2004 crop year. In Louisiana, WeatherMAX is labeled at 3.5 to 12 ounces per acre of the formulated product (contains 4.5 lb of glyphosate acid in each gallon in the potassium salt form). In 2005, Syngenta discontinued the Touchdown iQ formulation and replaced it with the Touchdown Total® (with

iQ technology) formulation (contains 4.17 lb of glyphosate acid in each gallon in the diammonium salt form) although there was still some Touchdown iQ left in some dealer's inventory for commercial use. Touchdown Total is labeled at 3.8 to 13.3 ounces per acre of the formulated product. Syntenta also had labeled another glyphosate formulation for use as a ripener, Touchdown Hi-Tech®, although none was used commercially in 2005. None of these products are labeled for plantcane crops because of possible phytotoxicity to crown buds which could adversely affect regrowth (stubbling), thus having the potential to reduce plant stands and yields in the subsequent stubble crop.

Slow stand development in spring is commonly observed in glyphosate-treated sugarcane in Louisiana. Millhollon and Legendre (1996) found that annual glyphosate (Polado-L) ripener treatments will usually increase mean annual sugar yield, but the magnitude of the increase will depend on variety tolerance to the treatments. They found that CP 70-321 appeared to have adequate tolerance to annual treatments, whereas LCP 85-384 can show extreme sensitivity. This prompted a reduction in the rate of Polado-L from 8 oz/A to 6 oz/A for LCP 85-384.

Polado-L and Touchdown Hi-Tech are currently formulated without added surfactant. Research has demonstrated that a quality non-ionic surfactant can improve the efficacy of these products. All other products mentioned above are formulated with a surfactant and no additional surfactant is recommended.

Currently, glyphosate is used on approximately 250-300,000 acres in Louisiana each crop year, netting the state's sugarcane growers, processors and landlords an estimated $132/acre in increased revenue. This amounts to approximately $40 million in increased gross revenues each year. However, no current glyphosate formulations are labeled for plantcane use and can cause a loss of cane yield in the crop being treated. There is also the potential for these products to cause yield reduction in the subsequent stubble crop, especially when used at the higher rates. Therefore, additional research is needed to find alternative ripeners that can be used on the plantcane crop and be harvested at a reduced treatment-harvest interval. Additionally, alternative ripeners should be developed that have little or no impact on cane yield and will not affect the subsequent stubble crop.

The objectives of this study were: 1) to evaluate the timing of application of three formulations of glyphosate on yield of sugar per acre at various intervals after treatment; 2) to evaluate alternatives to the use of glyphosate as ripeners; and 3) to evaluate the efficacy of glyphosate on the yield of sugar per acre of eight new varieties, Ho 95-988, HoCP 96-540, L 97-128, L 99-226, L 99-233, L 00-266, CP 89-2143 and TucCP 77-42 as well as LCP 85-384.

PROCEDURES

In the first of two field experiments, the same 13 ripener treatments as were applied in the plantcane crop were superimposed to all plots in the first-stubble crop of LCP 85-384 on August 18, 2005 (Test I) in water at a broadcast rate of 8 gal/A with a CO_2 sprayer and hand-held boom. The fields had been cultivated and fertilized according to recommended practices; insecticides were applied as required to control the sugarcane borer (Legendre 2001). A nonionic surfactant, Induce® (0.25% v/v)(Helena), was added to all spray solutions of Polado-L only. Each experiment consisted of 13 ripener treatments: Polado-L at 4, 6 and 8 oz of the formulated product per acre (0.1250, 0.1875 and 0.2500 lb ae/A, respectively), Roundup WeaterMAX at 3.6, 5.3 and 7.1 oz of the formulated product per acre (0.1250, 0.1875 and 0.2500 lb ae/A, respectively), Touchdown Total at 5.30, 6.65, 8.00 and 10.70 oz of the formulated product per acre (0.1250, 0.1562, 0.1875 and 0.2500 lb ae/A, respectively), Palisade at 0.223, 0.267 and 0.312 lb ai/A and an untreated check serving as a control. A 36-inch band was sprayed over sugarcane foliage so that most of the leaves were wet by the spray. Plots were one-row (6 ft) by 50 ft long with a 5-foot alley and with buffer rows on either side of treated row, arranged in a randomized complete block design with three replications. All plots were sampled at 28 and 42 days after treatment (DAT) and harvested green by combine at 56 DAT and weighed. The mulch residue remained on the field after harvest.

From each plot, a 15-stalk sample was taken at random along the row at 28, 42 and 56 days after treatment (DAT). Stalks were stripped of all leaves and topped approximately 4-6 in below the apical meristem (bud). Following hand sampling at 56 DAT, each plot was harvested by a cane combine (Cameco Model 2500) operating at approximately 3.5 mph and an extractor fan speed of 950 rpm. All cane from each plot was weighed in the wagon equipped with load cells and the weights recorded. Data collected and/or calculated from each plot included mean stalk weight (MSW), mean stalk length (MSL), Brix by refractometer, sucrose by polarimetry, purity (the ratio of sucrose to Brix) and the yield of theoretical recoverable sugar per ton of cane (TRS/TC). From weighed plots, the yield of tons cane per acre (TC/A) was calculated adjusted to the plot size as well as the yield of theoretical recoverable sugar per acre (TRS/A).

For the second experiment (Test II), no ripener treatments were applied in 2005 because of the lodged condition of the crop; however, the same 13 ripener treatments as described in Test I had been applied on September 14, 2004. The configuration of the test field for Test II was similar to Test I; plots were one-row (6 ft) by 50 ft long with a 5-foot alley and with buffer rows on either side of treated row, arranged in a randomized complete block design with three replications.

In order to determine the residual effect of the 13 ripener treatments in the subsequent stubble crop, a 15-stalk sample was removed from each plot on November 17, 2005. The samples were handled in the same manner as described in the previous paragraph. Each plot was then harvested by cane combine and the weights recorded. Data collected and/or calculated were also the same as described in the previous paragraph.

Data were analyzed using the Proc Mixed Procedure of the SAS (v 8.2) software package. Data were balanced and least square means were calculated. Mean separation was accomplished by the PDIFF option ($P = 0.05$).

RESULTS AND DISCUSSION

In the first experiment (Test I), all ripener treatments with the exception of Palisade and Polado-L at the lowest rates studied [0.223 lb/A and 4 oz/A (0.1250 lb ae/A, respectively)] tended to increase the yield of theoretical recoverable sugar per ton of cane (TRS/TC) at 28 and 42 days after treatment (DAT) when compared to control (Tables 1-2). Because of the lodged condition of the crop, it was not possible to count the number of millable stalks in each plot; therefore, estimated yield of cane or sugar per acre could not be calculated. There was a general trend for lower mean stalk weight (MSW) and reduced stalk length (MSL) as a result of all glyphosate treatments where the rates were 6 oz/A (0.1875 lb ae/A) and higher, regardless of product used. On the other hand, it appeared that Palisade caused little or no reduction in MSW or MSL at 28 DAT (Table 1). However, there was a trend towards reduced MSW and MSL at 42 DAT, especially at the two higher rates of Palisade although the differences were not significant from control (Table 2). It would be anticipated that yield of cane per acre (TC/A) would also be reduced as a result of the higher rates of glyphosate. However, because of the increase in TRS/A, no reduction in TRS/A would be anticipated (Legendre et al. 2004).

At 56 DAT, where plots were harvested by combine and weighed, there were no significant differences amongst treatments in yield of tons of cane per acre (TC/A) or yield of theoretical recoverable sugar per acre (TRS/A)(Table 3). In general, there was a trend towards higher TRS/TC for many of the glyphosate as well as the Palisade treatments; however, the data are quite variable, undoubtedly, because of the lodged condition of the crop. This variability made interpretation of the data more difficult. There were no differences amongst treatments for MSW or MSL with the exception of one rate of Palisade (0.267 lb/A) where the MSW was significantly higher than control. These data are very significant in that there was a perception by many producers that glyphosate actually reduced TRS/A, especially when applied in August for early harvest in mid to late September. These data do show that early glyphosate treatments do generally reduce TC/A by negatively impacting MSW and MSL. However, the longer the treatment-to-harvest interval, the greater will be the measured reduction in MSW and possibly TC/A (Legendre and Finger 1987). The results of the current experiment are similar to those reported by Legendre et al. (2004, 2005) and Millhollon and Legendre (1996) where they indicated that glyphosate can reduce TC/A. They found that TRS/A was not significantly reduced due to the increase in TRS/TC. However, in Test I, the increase in TRS/TC more than compensated for any loss of TC/A (Table 3). Although glyphosate is classified as a herbicide, when used as a ripener at the lower rates, it acts as a plant growth regulator. In general, it still causes a reduction in MSW and MSL, regardless of the rate applied.

It appeared that Palisade which is classified as a growth regulator, not a herbicide, had a less dramatic effect on TC/A and MSW at 56 DAT. In the current study, there was no increase in TRS/A although there was a trend towards increased TRS/TC. This is similar to the response reported in 2004 when applied at the same rates to the plantcane crop (Legendre et al. 2005).

There was no residual effect of the 13 treatments on the expression of TC/A, TRS/TC, TRS/A, MSW and MSL in the subsequent stubble crop although there was a trend towards a lower TC/A for the high rates of Roundup WeatherMAX (7.1 oz/A or 0.2500 lb ae/A) and Touchdown iQ (10.7 oz/A or 0.2500 lb ae/A) when harvested approximately one year after the application of the original treatment (Table 4). These results are similar to those publicized by Millhollon and Legendre (1996); however, in their study they applied Polado-L to the same plots

in both the plantcane and first-stubble crops at 8 oz/A (0.2500 lb ae/A). They noted a significant reduction in TC/A in the second-stubble crop for the variety LCP 85-384 which they classified as very sensitive to glyphosate at the higher rates. It was from this study that the use rate for LCP 85-384 was reduced from 8 to 6 oz/A. In the current study, it appears that the 6-oz rate of Polado-L or the equivalent rate of the other formulations has little or no deleterious effects on the parameters studied.

ACKNOWLEDGMENTS

We acknowledge the assistance of Luke Etheredge, Curtis Jones and Gert Hawkins for their assistance in making this study possible. This research was supported in part by grants from the American Sugar Cane League of the U.S.A, Monsanto Company and Syngenta..

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Table 1. Effects of 13 ripener treatments on yield of theoretical recoverable sugar per ton of cane (TRS/TC), mean stalk weight (MSW) and mean stalk length (MSL) in the first-stubble crop of LCP 85-384 when sampled at 28 days after treatment 1/.

Treatment	TRS/TC (lbs)		MSW (lbs)		MSL (in)	
Control	156		1.48		79.4	
Palisade @ 0.223 lb/A	170		1.46		78.1	
Palisade @ 0.267 lb/A	176	+	1.37		74.8	
Palisade @ 0.312 lb/A	176	+	1.45		77.4	
Polado @ 4 oz/A	170		1.31		76.8	
Polado @ 6 oz/A	182	+	1.24	-	72.2	-
Polado @ 8 oz/A	174	+	1.37		76.1	
RdUp Weather Max @ 3.6 oz/A	175	+	1.46		72.8	-
RdUp Weather Max @ 5.3 oz/A	181	+	1.42		78.1	
RdUp Weather Max @ 7.1 oz/A	185	+	1.34		74.1	-
Touchdown Total @ 5.30 oz/A	177	+	1.43		76.1	
Touchdown Total @ 6.65 oz/A	183	+	1.42		76.8	
Touchdown Total @ 8.00 oz/A	182	+	1.28		70.9	-
Touchdown Total @ 10.70 oz/A	179	+	1.42		73.5	-

1/ Treated, August 18; sampled, September 13, 2005. (+) or (-) denotes values in a column are statistically higher or lower than control, respectively.

Table 2. Effects of 13 ripener treatments on yield of theoretical recoverable sugar per ton of cane (TRS/TC), mean stalk weight (MSW) and mean stalk length (MSL) in the first-stubble crop of LCP 85-384 when sampled at 42 days after treatment 1/.

Treatment	TRS/TC (lbs)		MSW (lbs)		MSL (in)	
Control	186		1.51		87.7	
Palisade @ 0.223 lb/A	180		1.48		85.0	
Palisade @ 0.267 lb/A	211	+	1.35		78.7	
Palisade @ 0.312 lb/A	201		1.38		79.3	
Polado @ 4 oz/A	201		1.48		84.6	
Polado @ 6 oz/A	205	+	1.49		81.1	
Polado @ 8 oz/A	210	+	1.37		80.2	
RdUp Weather Max @ 3.6 oz/A	206	+	1.43		76.6	-
RdUp Weather Max @ 5.3 oz/A	209	+	1.51		84.3	
RdUp Weather Max @ 7.1 oz/A	183		1.31		74.3	-
Touchdown Total @ 5.30 oz/A	202		1.30		78.0	-
Touchdown Total @ 6.65 oz/A	193		1.23	-	79.9	
Touchdown Total @ 8.00 oz/A	202		1.33		76.4	-
Touchdown Total @ 10.70 oz/A	202		1.35		76.6	-

1/ Treated, August 18; sampled, September 28, 2005. (+) or (-) denotes values in a column are statistically higher or lower than control, respectively.

Table 3. Effects of 13 ripener treatments on yield of theoretical recoverable sugar per acre (TRS/A), yield of cane per acre (TC/A), yield of theoretical recoverable sugar per ton cane (TRS/TC), mean stalk weight (MSW) and mean stalk length (MSL) in the first-stubble crop of LCP 85-384 when harvested at 56 days after treatment 1/.

Treatment	TRS/A (lbs)	TC/A (tons)	TRS/TC (lbs)		MSW (lbs)		MSL (in)
Control	5979	28.1	214		1.32		78.7
Palisade @ 0.223 lb/A	6273	27.1	231		1.40		79.3
Palisade @ 0.267 lb/A	5696	25.5	224		1.52	+	78.2
Palisade @ 0.312 lb/A	5856	26.5	220		1.48		76.2
Polado @ 4 oz/A	6027	26.3	230		1.40		83.2
Polado @ 6 oz/A	5565	23.5	235	+	1.36		79.8
Polado @ 8 oz/A	6138	27.1	227		1.35		79.5
RdUp Weather Max @ 3.6 oz/A	5995	25.8	232	+	1.37		76.1
RdUp Weather Max @ 5.3 oz/A	5700	23.6	241	+	1.43		80.8
RdUp Weather Max @ 7.1 oz/A	5633	26.0	216		1.46		73.8
Touchdown Total @ 5.30 oz/A	5224	23.1	224		1.35		75.6
Touchdown Total @ 6.65 oz/A	6661	28.6	232	+	1.41		78.0
Touchdown Total @ 8.00 oz/A	5924	25.1	236	+	1.26		73.9
Touchdown Total @ 10.70 oz/A	5752	26.0	223		1.28		74.0

1/ Treated, August 18; harvested, October 13, 2005. (+) or (-) denotes values in a column are statistically higher or lower than control, respectively.

Table 4. Effects of 13 ripener treatments on yield of theoretical recoverable sugar per acre (TRS/A), yield of cane per acre (TC/A), yield of theoretical recoverable sugar per ton cane (TRS/TC), mean stalk weight (MSW) and mean stalk length (MSL) in the first-stubble crop of LCP 85-384 when harvested at approximately one year after treatment1/.

Treatment	TRS/A (lbs)		TC/A (tons)		TRS/TC (lbs)	MSW (lbs)		MSL (in)	
Control	8624		31.9		269	1.50		81.1	
Palisade @ 0.223 lb/A	6325	-	24.9	-	252	1.51		86.4	
Palisade @ 0.267 lb/A	8650		32.9		264	1.50		86.6	
Palisade @ 0.312 lb/A	9604		36.1		266	1.58		88.2	
Polado @ 4 oz/A	8508		33.0		257	1.55		88.5	
Polado @ 6 oz/A	8803		32.4		272	1.62		87.7	
Polado @ 8 oz/A	8564		32.9		261	1.62		90.6	+
RdUp Weather Max @ 3.6 oz/A	8951		33.7		266	1.41		84.8	
RdUp Weather Max @ 5.3 oz/A	9303		34.4		270	1.84	+	94.5	+
RdUp Weather Max @ 7.1 oz/A	7845		29.0		271	1.54		90.0	+
Touchdown iQ @ 5.30 oz/A	9302		33.9		274	1.51		87.4	
Touchdown iQ @ 6.65 oz/A	8466		31.2		272	1.50		87.4	
Touchdown iQ @ 8.00 oz/A	8124		30.5		266	1.53		86.6	
Touchdown iQ @ 10.70 oz/A	7275		27.2		268	1.50		86.1	

1/ Treated, August 18, 2004; harvested, November 17, 2005. (+) or (-) denotes values in a column are statistically higher or lower than control, respectively.