EVALUATION OF THE EFFECTS OF COMBINE-RESIDUE MANAGEMENT ON SUGARCANE PRODUCTION AND WATER QUALITY

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Summary:

The majority of Louisiana sugarcane acreage is located in watersheds that contain water bodies designated as impaired and are included on the EPA 303-d list of water bodies not meeting water quality standards or not supporting their designated uses. Efforts are presently being made to reduce non-point source discharge from agriculture by developing and implementing Best Management Practices (BMPs) in all the sugarcane producing parishes. Methods to reduce runoff of nutrients, sediments, organic residue and pesticides from sugarcane fields are necessary to improve water quality in the impaired waterways. The allowable level of pollution for a specific water body is called a total maximum daily load (TMDL). It is the upper limit of contaminates a body of water can contain which would result in impairment. At present, state water standards must be achieved around the end of the decade.

Two sites in the Vermilion-Teche watershed were selected to evaluate the effects of combine-residue management on sugarcane production and water quality. These locations are the Iberia Research Station (Baldwin silty clay loam) and a site near Youngsville (Memphis silt loam). Residue management treatments include two treatments designed to mitigate the adverse effects of retained residue on sugarcane: 1) the application of stabilized urea (containing a urease inhibitor) plus composted biologicals and 2) the shredding of the residue for accelerated decomposition; and two treatments currently employed by the industry, 3) ground burning of the residue and 4) full post-harvest retention of the residue.

Runoff is being captured and sampled for quality parameters, including sediment, dissolved oxygen, nutrients and biological oxygen demand. Changes in soil nutrient levels and pest populations are also being monitored. The principal objective is to measure the relative differences among the residue management treatments for water and soil quality parameters. A secondary objective is to measure the response of sugarcane productivity to the imposed treatments.

Findings will serve as a basis for possibly revising sugarcane BMPs for residue management and sediment control. Research has demonstrated the value of removing the residue from row tops, with the succeeding crop sustaining loses as high as 25%. Burning, therefore, will remain an essential tool for sugarcane growers until alternatives are proven to be both economically and environmentally viable.

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EFFECT OF SALT WATER STRESS ON SUGARCANE SHOOT EMERGENCE AFTER PLANTING

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Twenty-seven sugarcane varieties (including the L04 series) were planted on September 14, 2005 in 15-ft plots in a randomized complete block design near Burns Point in St. Mary Parish. The field was flooded during Hurricane Rita tidal surge (September 24) and remained under water for at least eight days. The numbers of emerging shoots in each plot were counted during the first week of October, and again in the middle of December. At this time ten soil sample probes for the top and bottom three inch layers (0-3", 3-6") from each quadrant in the field were taken using a soil augar. Data on numbers of seedlings (per 15-ft plot) were analyzed using Proc Glimmix (SAS Institute 2004).

Soil sample analysis indicated a pronounced increase in all of the nutrients in upper soil layer compared to the lower layer (Table 1). There were highly significant differences in numbers of emerging shoots among varieties ($P<0.0001$). L 04-417 showed the maximum (23.0) and HoCP 03-757 the least (3.0) number of emerged shoots (Table 2). Among the five commercial cultivars included in the test, LCP 85-384 depicted maximum tolerance as indicated by higher number of emerged shoots (17.8). However, Ho 95-988 was able to germinate only 4.0 shoots per 15-ft test plots.

Table 1. Amount of salt/nutrients in upper and lower layers of flooded field soil.

Salt/Nutrient	Upper Layer (ppm)*	Lower Layer (ppm)**
Calcium	2051.4	1655.1
Copper	2.2	1.9
Magnesium	798.6	579.6
Phosphorus	69.5	57.3
Potassium	264.2	163.4
Sodium	595.1	279.0
Sulfur	51.4	37.6
Zinc	2.5	1.5

* 0-3 inches soil depth on top of row
** 3-6 inches depth

Table 2. Number of emerged sugarcane shoots following hurricane tidal surge flooding, Burns Point, LA, 2005.

Variety	Number of Shoots
L 04-417	23.0a
HoCP 03-743	19.0ab
LCP 85-384	**17.8abc**
HoCP 00-950	17.5abc
HoCP 85-845	**17.3abc**
L 04-434	17.3abc
L 04-431	15.8abcd
HoCP 03-708	14.3abcde
L 04-409	14.0abcde
L 04-423	14.8abcde
L 04-410	13.0abcde
HoCP 96-540	**12.8abcde**
HoCP 91-555	**12.3abcde**
L 04-407	11.5bcdef
L 04-403	11.3bcdef
L 04-408	11.3bcdef
L 04-429	10.5bcdefg
HoCP 03-704	10.3bcdefg
L 04-404	9.3bcdefg
L 04-400	8.3cdefg
L 99-226	8.0cdefg
L 04-425	7.3defg
L 04-430	7.0defg
HoCP 03-716	6.8defg
CP 89-2143	6.3efg
Ho 95-988	**4.0fg**
HoCP 03-757	3.0g
F[a]	7.21
$P > F$	< 0.0001

Means within the same column followed by the same letter are not significantly different ($P > 0.05$; Tukey's HSD).

[a] df = 26, 78

A SURVEY OF SOIL SALT CONTENT RESULTING FROM HURRICANES KATRINA AND RITA

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Hurricanes Katrina and Rita caused tidal surges along with concerns about salt deposition in soil. The unprecedented flooding inundated almost 40,000 acres of sugarcane in the coastal parishes of the state. While a considerable acreage of sugarcane was damaged or killed by the direct effects of the flood waters, the extent of the effects on sugarcane from the salt content of sea water is not completely known.

Representatives of several state and federal agencies met in October to discuss the hurricanes and their aftermath. A decision was made to develop a soil sampling protocol to be used to survey the soils in the flood zone for salinity. Initial sampling was limited in scope and specifically sought information on the enormity of the salt contamination problem. Seven sites across Iberia, St. Mary and Vermilion Parishes were chosen for the initial round of sampling. The sites were selected based on soil texture, depth and duration of the flood waters and distance from the coast. Soil cores were taken at depths of 0 - 3, 3 – 6 and 6 – 12 inches to determine the distribution of salt within the soil profile. The amounts of salt measured in the first samples varied widely as anticipated. The highest concentration was found at the 0 – 3 inch depth, ranging from 268 to 4,329 ppm. Though salt levels decreased with depth of sampling, the saltiest site contained almost 2,000 ppm in the 6 – 12 inch core. The level of salinity across sites was not predictable and did not appear to be associated with texture or any other variable.

Published reports suggest sugarcane is moderately sensitive to salt, with a saturated-extract electrical conductivity (EC) threshold for yield reduction at 1.7 dS m^{-1} (multiplying dS m^{-1} times 640 equals ppm). Research in Texas measured reductions in Brix, pol and purity and increases in fiber with each dS m^{-1} increase in EC. Because salt levels for most sites in the survey exceeded that of the salinity damage threshold of approximately 1,100 ppm, an additional 20 sites were sampled across a four-parish area in early November. A couple of the new sites contained levels of over 6,000 ppm in the surface three inches of soil.

Twelve of the original sites were re-sampled in early February to find out if sufficient leaching had occurred to reduce the salinity. Surprisingly, despite over 14 inches of rain at several sites, salinity levels increased at 5 of the 12 sites. At the time of the February re-sampling, a majority of the sampling sites contained salt at levels which exceeded that of the damage threshold of 1,100 ppm.

Flooding of agricultural land by hurricane storm surges can have both short and long-term effects on both crops and soil structure. While most of the ‘salt’ in seawater is sodium chloride (table salt), it also contains appreciable amounts of magnesium sulfate (Epson's salts) and other elements. After heavy rains, sodium and chloride will be preferentially lost in runoff and leachate. Therefore, within the next two years, much of the agricultural land flooded by last season's storm surges should naturally recover and return to previous levels of productivity. Recovery will occur more quickly in fields that received lower amounts of salt. A few areas that accumulated very high levels of salt are possibly at risk of becoming 'sodic', and may not recover without help.

The 'storm surge' analysis offered by the LSU AgCenter's Soil Testing Lab reports both salinity (ppm) and SAR (sodium absorption ratio). Salinity (ppm) is the better indicator of the salt impact on crops; however, if the SAR is greater than 15, this site should be carefully monitored. Not only will it take considerable time for salinity levels to drop, but this field is at risk of 'collapsing' during the process. Water will not infiltrate a collapsed soil, the pH will rise above 8, and toxic amounts of sodium will remain. Reclaiming such soils is costly and requires addition of large amounts of gypsum plus mechanical drainage.

None of the sites in our initial monitoring studies is currently in need of gypsum, but some would benefit from the addition of lime. If a field has an SAR >15 and low pH, application of agricultural lime will ensure that sodium is leached and sodic conditions avoided. Even where the SAR is <15, if soil pH is below 6.0 the addition of lime can help offset the effects of excessive salt and accelerate the leaching process.

Monitoring of soil salt levels will continue until sugarcane harvest, at which time a yield impact assessment will be made in an attempt to confirm the applicability of the salinity damage threshold for sugarcane in Louisiana.

IMPACT OF SUGARCANE MULCH MANAGEMENT STRATEGIES ON WATER QUALITY AND CROP YIELD

A Four Year Study

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INTRODUCTION

Since 1995, the sugarcane industry in Louisiana has been using a new harvesting system which involves the use of a combine harvester that cuts the cane stalks into billets, which are directly loaded into wagons for transport to the mill. Extractor fans in the combine harvester separate leaf-material from the billets and the plant residue is deposited on the soil surface. Historically, this sugarcane residue has been removed by burning. In recent years this burning of the residue has become objectionable to the general public because of health issues related to inhalation of the smoke. Increasingly, it is difficult to justify burning as a Best Management Practice of residue management. Environmental concerns about burning and public concerns for clean air, especially in newly developed suburban areas adjacent to sugarcane plantations, has moved the sugar industry toward green harvesting that leaves the residue on the surface. Because of these concerns, there is a need to find economical alternatives for residue management to identify benefits from residue with respect to reducing soil erosion and improving surface water quality. The primary purpose of this project was to evaluate the effect of post-harvest residue (mulch cover) on the field with respect to surface water quality. This project evaluated three management strategies with primary focus on mulch residue and its effect on soil erosion, surface water quality, and crop yields. The treatments include (1) burning the mulch after harvest and cultivating in the spring; (2) sweeping the mulch off of the top of the row after harvest and cultivating in the spring; and (3) leaving the mulch on the field after harvest and cultivating in the spring. Treatment 1 is the traditional method by which sugarcane mulch is managed in Louisiana. Treatments 2 and 3 are proposed sugarcane residue management practices for use by Louisiana sugarcane farmers. Sugarcane plant population, yields, and quality of surface runoff water were measured for each treatment.

MATERIALS AND METHODS

The experimental site was at the Louisiana Agricultural Experiments Station's St. Gabriel Research Station located 20 km south of Baton Rouge. Six leveed plots 0.25 ha in size (nine rows spaced 1.8 m apart and 140 m long) and sloped 0.1% were located on a Commerce silt loam soil (Aeric Fluvaquent, fine-silty, mixed, non-acid, thermic) (Camp 1976 and Rogers et al. 1985). The sugarcane cultivar HoCP91-555 was planted on September 19, 2001.

To measure and sample surface runoff, a sump was installed on the low side of each plot. A float-controlled electric sump pump was installed in each sump to discharge the runoff through a water meter and into a surface drainage ditch. An automatic water sampler at each sump was used to collect runoff samples. Runoff samples were analyzed by the Department of Agricultural Chemistry for total solids, nitrogen, phosphorus, and potassium. Nitrogen was determined by an automated colorimetric procedure developed by Wall and Gehrke (1979). Phosphorus and potassium were determined by EPA Method 200.2. (Martin et al., 1991). These analyses determined the total concentration in both solution and solids. Using the amount of surface runoff that was measured with the water meters and concentrations provided by the Department of Agricultural Chemistry, total loadings were calculated.

RESULTS AND DISCUSSION

The sugarcane was planted in September 19, 2001 and was harvested December 9, 2002, October 30, 2003, October 19, 2004, and October 25, 2005. Table 1 shows the sugarcane (biomass) yields for each treatment for 2002 to 2005. The biomass yields for the burned, swept, and mulch treatments were 64,947, 61753, and 60,240 kg/ha, respectively. The burned treatment increased biomass yields 7.8% over the mulch treatment. Table 2 shows the sugar yields for each treatment for 2002 to 2005. The sugar yields for the burned, swept, and mulch treatments were 7010, 6495, and 6386 kg/ha, respectively. The burned treatment increased sugar yields 9.8% over the mulch treatment.

Table 1. Annual Sugarcane (Biomass) Yields (kg/ha).

Treatment	Year 2002	Year 2003	Year 2004	Year 2005	Average
Burned	74180	71284	50213	64111	64947
Mulch	74180	67698	39677	59404	60240
Swept	74180	64784	43712	64335	61753

Table 2. Annual Sugar Yields (kg/ha).

Treatment	Year 2002	Year 2003	Year 2004	Year 2005	Average
Burned	8400	7377	5148	7113	7010
Mulch	8400	6457	4325	6363	6386
Swept	8400	6586	4180	6814	6495

During the period from September 1, 2001, to December 31, 2005, the average annual rainfall was 1472 mm (97% normal) (Table 3). The runoff for the burned, swept, and mulch treatments were 504, 514, and 530 mm, respectively. Table 4 shows the monthly rainfall and runoff values. There were no significant differences among the runoff values.

Table 3. Annual Rainfall and Runoff for St. Gabriel, Louisiana.

Year	Rain (mm)	Runoff (mm)		
		Mulch	Swept	Burned
2002	1697	582	559	546
2003	1306	472	456	444
2004	1581	687	645	643
2005	1302	377	388	380
Average	1472	530	512	503

Rain 97% Normal

The average annual soil losses for the period from September 1, 2001, to December 31, 2005, for the burned, swept, and mulch treatments were 7280, 7412, and 7252 kg/ha, respectively. (Table 5). A large portion of the soil erosion (41%) occurs during the first year of the sugarcane cycle. During this period, the rows are bare and the soil is loose following the fallow period. Soil erosion during the second crop year was reduced 64%. This was because the rows were covered with vegetation and the soil had consolidated. Table 6 shows the monthly values. There were no significant differences in soil loss.

Table 4. Average Monthly Rainfall and Runoff for 2002-2005 at St. Gabriel, Louisiana.

Month	Rain (mm)	Runoff (mm)		
		Mulch	Swept	Burned
Jan	85	37	34	35
Feb	131	82	72	75
Mar	93	32	32	27
Apr	123	55	52	52
May	113	38	35	38
Jun	221	68	67	69
Jul	109	13	12	10
Aug	90	8	7	7
Sep	164	49	48	42
Oct	135	53	55	54
Nov	118	50	53	50
Dec	90	45	47	45
Total	1472	530	514	504

Rain 97% Normal

The average annual nitrogen losses for the period from September 1, 2001, to December 31, 2005, for the burned, swept, and mulch treatments were 15.9, 17.0, and 16.0 kg/ha, respectively (Table 7). The monthly values are shown in Table 8. There were no significant differences in nitrogen losses.

The average annual phosphorus losses for the period from September 1, 2001, to December 31, 2005, for the burned, swept, and mulch treatments were 8.6, 9.9, and 8.8 kg/ha, respectively (Table 9). The monthly values are shown in Table 10. There were no significant differences in phosphorus losses.

The average annual potassium losses for the period from September 1, 2001, to December 31, 2005, for the burned, swept, and mulch treatments were 73.1, 77.5, and 77.3 kg/ha, respectively

(Table 11). The monthly values are shown in Table 12. There were no significant differences in potassium losses.

Table 5. Annual Soil Loss for St. Gabriel, Louisiana.

Year	Soil Loss (kg/ha)		
	Mulch	Swept	Burned
2002	11865	11865	11865
2003	4294	4182	3465
2004	7032	6955	7107
2005	5816	6646	6681
Average	7252	7412	7280

Table 6. Average Monthly Soil Loss for 2002-2005 at St. Gabriel, Louisiana.

Month	Soil Loss (kg/ha)		
	Mulch	Swept	Burned
Jan	597	656	606
Feb	301	456	469
Mar	627	625	592
Apr	1482	1206	1177
May	834	964	820
Jun	1512	1486	1500
Jul	110	110	96
Aug	102	88	90
Sep	366	465	435
Oct	450	460	473
Nov	272	290	416
Dec	608	617	617
Total	7261	7422	7289

CONCLUSIONS

The burned treatment increased biomass yields by 7.8% and sugar yields by 9.8%. There was 11,865 kg/ha soil erosion from the plots during the first year. The soil erosion for the second year was 64% smaller. There were no significant differences among the soil, nitrogen, phosphorus, and potassium losses.

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Table 7. Annual Nitrogen Losses for St. Gabriel, Louisiana.

Year	Nitrogen Loss (kg/ha)		
	Mulch	Swept	Burned
2002	8.1	8.1	8.1
2003	11.3	8.7	8.2
2004	26.7	29.6	28.8
2005	17.8	21.4	18.5
Average	16.0	17.0	15.9

Table 8. Average Monthly Nitrogen Losses for 2002-2005 at St. Gabriel, Louisiana.

Month	Nitrogen Loss (kg/ha)		
	Mulch	Swept	Burned
Jan	0.5	0.5	0.5
Feb	1.1	1.0	1.0
Mar	1.0	1.4	0.9
Apr	3.7	4.0	3.6
May	3.5	3.6	3.5
Jun	3.1	3.1	3.5
Jul	0.4	0.5	0.4
Aug	0.2	0.2	0.2
Sep	0.6	0.7	0.6
Oct	0.9	0.9	0.8
Nov	0.5	0.6	0.5
Dec	0.5	0.5	0.4
Total	16.0	17.0	15.9

Table 9. Annual Phosphorus Losses for St. Gabriel, Louisiana.

Year	Phosphorus Loss (kg/ha)		
	Mulch	Swept	Burned
2002	12.5	12.5	12.5
2003	9.1	9.5	7.6
2004	6.8	9.8	7.4
2005	6.8	7.8	6.7
Average	8.8	9.9	8.6

Table 10. Average Monthly Phosphorus Losses for 2002-2005 at St. Gabriel, Louisiana.

Month	Phosphorus Loss (kg/ha)		
	Mulch	Swept	Burned
Jan	0.5	0.6	0.5
Feb	0.7	0.7	0.6
Mar	0.5	0.7	0.7
Apr	1.6	1.8	1.2
May	0.3	0.9	0.5
Jun	1.4	1.5	1.6
Jul	0.1	0.1	0.1
Aug	0.1	0.1	0.1
Sep	0.8	0.6	0.4
Oct	1.0	1.2	1.1
Nov	1.3	1.1	1.2
Dec	0.5	0.6	0.6
Total	8.8	9.9	8.6

Table 11. Annual Potassium Losses for St. Gabriel, Louisiana.

Year	Potassium Loss (kg/ha)		
	Mulch	Swept	Burned
2002	107.4	107.4	107.4
2003	74.8	65.3	64.5
2004	74.5	78.4	70.7
2005	52.4	59.0	49.8
Average	77.3	77.5	73.1

Table 12. Average Monthly Potassium Losses for 2002-2005 at St. Gabriel, Louisiana.

Month	Potassium Loss (kg/ha)		
	Mulch	Swept	Burned
Jan	4.6	5.0	4.6
Feb	4.8	5.4	5.1
Mar	3.3	3.6	3.6
Apr	9.7	8.6	6.6
May	4.0	4.5	3.7
Jun	8.7	9.6	9.2
Jul	1.0	1.0	0.9
Aug	0.9	0.8	1.1
Sep	7.0	6.3	6.0
Oct	7.9	8.6	8.0
Nov	16.9	15.2	15.6
Dec	8.5	8.9	8.7
Total	77.3	77.5	73.1