PATHOLOGY RESEARCH

Jeffrey W. Hoy, Carolyn F. Savario, Raghuwinder Singh, Jancee Rice, and Jose David Cortes
Department of Plant Pathology and Crop Physiology

Pathology research addresses the important diseases affecting sugarcane in Louisiana. The overall program goal is to provide farmers with practices to minimize losses to diseases in a cost-effective manner. Projects receiving emphasis during 2018 included determining the increase, recovery, yield impact, and resistance to mosaic; providing support for healthy seedcane programs to manage systemic diseases; evaluating disease resistance in the variety selection program; and billet planting. Research results on billet planting are reported separately.

Mosaic Increase, Recovery, Yield Impact, and Resistance Evaluations

A project addressing mosaic, a historically important disease for the Louisiana sugarcane industry, was continued during 2018. The impetus for the project was the detection of virus-infected plants of multiple clones in breeding program variety tests and in experimental variety increase plots at multiple locations during 2016 suggesting a possible re-emergence of the disease. The research during 2018 was focused on determining the rates of mosaic increase in infected fields of HoCP 09-804, the recovery from symptoms and possibly from virus infection in two varieties, the impact of infection on yield, and screening the current commercial and basic breeding program parent populations for resistance by mechanical inoculation. In addition, surveys were conducted for 2016 series clones to be introduced to the breeding program outfield tests and American Sugar Cane League Primary Increase Stations. All surveys were based on visual observation of mosaic symptoms, and a subsample of symptomatic and asymptomatic leaves were collected to test for infection by *Sorghum mosaic virus* (SrMV) by reverse-transcriptase polymerase chain reaction (RT-PCR).

To determine rates of mosaic increase, follow-up surveys were conducted during May in seven second ratoon fields of HoCP 09-804. Incidence in plant cane ranged from 0.9-6.8% (Table 1). Disease incidence was higher in first ratoon compared to plant cane for three fields and lower for four fields (Table 1). In second ratoon, mosaic incidence decreased in all fields and was lower than was detected in plant cane for all seven fields (Table 1). The results indicate disease increase due to aphid transmission was minimal under prevailing conditions.

The lack of disease increase over two seasons and the continued failure to detect mosaic in fields of current commercial cultivars indicate that, under the current conditions, mosaic is not rapidly re-emerging as a problem disease. However, the past history of the disease in Louisiana; the existing known genetic variation in the virus; the recent detection of virus isolates not matching known strains in Louisiana; the seasonal variation in aphid species and abundance; and moderate susceptibility in two newly released varieties, HoCP 09-804 and L 11-183, are all reasons for continued careful disease monitoring and on-going breeding for host plant resistance.

The results from RT-PCR testing indicated that the mosaic symptoms recorded during the surveys were due to infection by SrMV and demonstrated that virus was present in leaves showing symptoms but not in leaves without symptoms. Over three seasons, SrMV was detected in all mosaic symptomatic leaf samples collected from multiple varieties collected from different locations, including 193 HoCP 09-804 samples and 24 L 10-147, 15 L 11-183, 21 Ho 11-532, one Ho 11-573, one Ho 12-626, three Ho 12-671, two L 13-242, and four L 13-269 samples. Only one of 250 (0.4%) HoCP 09-804 asymptomatic leaf samples tested positive for SrMV, and all samples of other varieties tested negative for SrMV, including 14 L 10-147, 13 L 11-183, 23 Ho 11-532, one Ho 11-573, one Ho 12-626, four Ho 12-671, and two L 13-242 samples. These results demonstrate that surveys based on observation of visual symptoms can provide an accurate assessment of mosaic incidence in a field.

Table 1. Change in incidence of mosaic symptomatic plants in fields of HoCP 09-804 from plant cane to first and second ratoon.

Parish (location)	Initial 2016 infection incidence in plant cane[a]	Infection incidence and percent change in first ratoon	Infection incidence and percent change in second ratoon[b]
Assumption (Cedar Grove)	1.0%	1.6% (+60%)	0.3% (-70%)
Assumption (Glenwood)	1.0%	0.7% (-30%)	0.0% (-100%)
Assumption (Little Texas)	6.8%	4.1% (-39%)	1.0% (-85%)
Lafourche (Raceland)	4.0%	7.9% (+98%)	2.0% (-50%)
Pointe Coupee (Alma)	6.8%	6.2% (-9%)	2.6% (-62%)
St. James (Blackberry)	0.9%	0.4% (-56%)	0.5% (-44%)
St. John (Glendale)	1.6%	1.2% (-25%)	0.2% (-88%)

[a] Initial infection percentages calculated only from rows that were resurveyed.
[b] Percent change in second ratoon is calculated as the change in incidence from plant cane to second ratoon.

'Recovery' defined as the loss of disease symptoms and possibly virus accumulation within an infected plant was evaluated for plants growing from buds on planted stalks that had mosaic symptoms of two varieties, HoCP 09-804 and L 10-147. The initial experiment was in first ratoon during 2018 and a second experiment was in plant cane during 2018. Single stalk plots were planted to establish the second experiment with individual stalks of each variety that were showing leaf symptoms of mosaic (symptomatic) or not showing symptoms (asymptomatic) at the Sugar Research Station. During May 2018, the single stalk plots in both experiments were evaluated to determine whether any asymptomatic plants had developed from buds on symptomatic stalks. The extent of recovery varied between the two varieties, and the 2018 results were similar to the 2017 results. Plots (from individual stalks) that had asymptomatic plants were again higher in first ratoon for L 10-147 (30%) than for HoCP 09-804 (1.9%); however, there was no increase in the frequency of recovered plants for either variety compared to plant cane (Table 2). The total frequency of asymptomatic plants was 16.3% for L 10-147 compared to 0.6% for HoCP 09-804, and the percentage of asymptomatic plants per plot was higher in L 10-147 (Table 2). There was variability in the extent of recovery within plots containing asymptomatic plants with some exhibiting complete recovery (100% asymptomatic plants) and some exhibiting partial recovery (containing a mixture of asymptomatic and symptomatic plants). Complete recovery occurred in one of 2 (50%) HoCP 09-804 plots and five of 19 (20.8%) L 10-147 plots (Table 3). In the plant cane of experiment two, the percentage of plots with asymptomatic plants was lower for both varieties compared to plant cane in 2017 with 15.7% for L 10-147 compared to 2.9% for HoCP 09-804 (Table 2). Total frequencies of asymptomatic plants were 9.9 and 0.7%, respectively, and the percentage of asymptomatic plants per plot was again higher in L 10-147 (Table 2). Partial recovery occurred in two of two HoCP 09-804 plots and 9 of 11 (81.8%) L 10-147 plots with asymptomatic plants (Table 3).

Table 2. Comparison of mosaic recovery evaluated as asymptomatic plants developing from plots of HoCP 09-804 and L 10-147 planted with individual mosaic symptomatic stalks.

Crop cycle year and experiment [a]	Variety	Plots with asymptomatic plants	Total number of asymptomatic plants	Percent asymptomatic plants per plot[b]
Plant cane Exp 1	HoCP 09-804	2/58 (3.4%)	3/152 (2.0%)	2.3 b
	L 10-147	26/81 (32.1%)	55/291 (18.9%)	19.8 a
First ratoon Exp 1	HoCP 09-804	1/54 (1.9%)	1/160 (0.6%)	0.9 b
	L 10-147	24/80 (30%)	48/294 (16.3%)	15.9 a
Plant cane Exp 2	HoCP 09-804	2/70 (2.9%)	2/291 (0.7%)	1.2 b
	L 10-147	11/70 (15.7%)	38/384 (9.9%)	9.4 a

[a] Two experiments (Exp) were conducted. Results in experiment one were determined in both plant cane and first ratoon. In experiment two, results were determined only in plant cane.
[b] Mean percentages of asymptomatic plants in plots containing asymptomatic plants were transformed with arcsin for statistical analyses separately comparing clones within each individual crop year and experiment. Means followed by different letters within experiments were significant at $p<0.05$.

Natural spread due to aphid transmission was monitored in plots of each variety planted with asymptomatic stalks. During 2018, the detection of symptomatic plants in plots planted with asymptomatic stalks was again low ranging from 0.2 to 6.3% across both varieties in the experiments in first ratoon and plant cane (Table 4). The results indicate that the rate of aphid transmission was low during the experiments.

As in 2017, testing by RT-PCR determined that SrMV was no longer detectable in the majority of recovered plants of both varieties (Table 5). The frequency of recovered plants in which SrMV could no longer be detected was lower for L 10-147 (5.5%) than for HoCP 09-804 (33.3%) in plant cane, but no virus was detected in recovered plant of either variety in first ratoon. In plant cane of the second experiment, no SrMV was detected in the two recovered plants of HoCP 09-804, and the detection rate for L 10-147 (5.1%) was similar to the first experiment. These results suggest that the phenomenon of recovery entails reversion from virus infection not only the loss of symptoms. In addition, the results with these two varieties demonstrate that recovery does occur for sugarcane plants with mosaic under Louisiana conditions, and this phenomenon could affect disease incidence in the field over time (and may have been involved in the reductions in mosaic incidence observed in the three annual surveys). However, the rate of recovery can vary considerably among varieties.

Table 3. Comparison of the extent of recovery from mosaic within plots of HoCP 09-804 and L10-147 that were planted with individual symptomatic stalks.

Crop cycle year and experiment [a]	Clone	Plots exhibiting 100% recovery from mosaic	Plots exhibiting less than 100% mosaic recovery	Mean percent recovery within plots	Range in percent recovery within plots
Plant cane Exp 1	HoCP 09-804	1	1	67%	33-100%
	L 10-147	10	16	62%	14-100%
First ratoon Exp 1	HoCP 09-804	0	1	50%	50%
	L 10-147	5	19	53%	20-100%
Plant cane Exp 2	HoCP 09-804	0	2	42%	33-50%
	L 10-147	2	9	60%	14-100%
Plant cane average	HoCP 09-804	0.5	1.5	55%	33-75%
	L 10-147	6	12.5	61%	14-100%

[a] Two experiments (Exp) were conducted. Results in experiment one were determined in both plant cane and first ratoon. In experiment two, results were determined only in plant cane. The average was determined for both plant cane experiments.

Table 4. Comparison of mosaic symptomatic plants resulting from aphid transmission occurring in plots of HoCP 09-804 and L 10-147 planted with individual asymptomatic stalks.

Crop cycle year and experiment [a]	Clone	Total plants	Number of symptomatic plants (%)	Total plots	Number of symptomatic plots (%)
Plant cane Exp 1	HoCP 09-804	204	7 (3.4)	46	5 (10.9)
	L 10-147	286	18 (6.3)	67	10 (14.9)
First ratoon Exp 1	HoCP 09-804	230	1 (1.3)	46	3 (6.5)
	L 10-147	338	21 (6.3)	67	11 (16.4)
Plant cane Exp 2	HoCP 09-804	400	5 (1.3)	70	2 (2.9)
	L 10-147	442	1 (0.2)	70	1 (1.4)

[a] Two experiments (Exp) were conducted. Results in experiment one were determined in both plant cane and first ratoon. In experiment two, results were determined only in plant cane.

Table 5. Detection of Sorghum mosaic virus (SrMV) by RT-PCR in recovered (asymptomatic) plants developing from plots of HoCP 09-804 and L 10-147 planted with individual mosaic symptomatic stalks.

Crop cycle year and experiment [a]	Clone	Total plants tested	Number of plants positive for SrMV
Plant cane Exp 1	HoCP 09-804	3	1 (33.3%)
	L 10-147	55	3 (5.5%)
First ratoon Exp 1	HoCP 09-804	1	0 (0%)
	L 10-147	49	0 (0%)
Plant cane Exp 2	HoCP 09-804	2	0 (0%)
	L 10-147	39	2 (5.1%)

[a] Two experiments (Exp) were conducted. Results in experiment one were determined in both plant cane and first ratoon, but results in experiment two were determined only in plant cane.

The recovery experiment also was used to estimate and compare the impact of mosaic on bud germination and yield of HoCP 09-804 and L 10-147. The number of buds was determined for each individual stalk planted in both experiments. The percent germination could then be determined from the number of primary shoots developing from each stalk. Bud germination was adversely affected by mosaic in HoCP 09-804 but was unaffected for L 10-147 in both experiments (Table 6). Shoot populations the following spring were lower in plots from symptomatic stalks compared to asymptomatic stalks for both varieties in the first experiment (Table 6). In contrast, in plant cane of the second experiment, shoots were lower in symptomatic stalk plots of HoCP 09-804 but higher in symptomatic stalk plots of L 10-147 (Table 6). The millable stalk population during August was then lower only for mosaic symptomatic stalk plots of HoCP 09-804 in plant cane of both experiments. However, the stalk population was lower for symptomatic plots of both varieties in first ratoon of the first experiment (Table 6).

The yield components stalk weight, sucrose per ton of cane (commercially recoverable sugar), cane tonnage, and total sucrose per acre were estimated and compared to evaluate the impact of mosaic on the yield of HoCP 09-804 and L 10-147. Stalk weight was similar for plots planted with symptomatic compared to asymptomatic stalks within each variety, except stalk weight was lower for symptomatic stalk plots of L 10-147 in first ratoon, suggesting only a minor effect of mosaic on this yield component (Table 7). The effect of mosaic on sucrose content of stalks also was similar for plots planted with symptomatic compared to asymptomatic stalks within each variety, except sucrose content was higher for symptomatic plots of HoCP 09-804 in plant cane of the first experiment. Both cane tonnage and total sucrose yield estimates were lower for symptomatic stalk plots of HoCP 09-804 compared to asymptomatic stalk plots but were similar for L 10-147 in both experiments (Table 7). These results demonstrate the variable effect of mosaic on yield in different varieties and indicate that mosaic can cause significant yield loss in HoCP 09-804, while L 10-147 appears to have some tolerance to the disease. The reduction in yield for HoCP 09-804 was mainly due to a reduction in stalk population.

Table 6. Comparison of bud germination, spring shoot populations, and stalk populations for plots of HoCP 09-804 and L 10-147 that were planted with individual mosaic asymptomatic or symptomatic stalks.

Crop cycle year and experiment [a]	Clone [b]	Bud germination [c]	Spring shoots per hectare [d]	Stalks per hectare [e]
Plant cane Exp 1	HoCP 09-804 A	28% a	57,363 a	83,630 a
	HoCP 09-804 S	15% b	22,346 c	53,822 c
	L 10-147 A	33% a	63,430 a	80,956 ab
	L 10-147 S	33% a	45,101 b	74,748 b
First ratoon Exp 1	HoCP 09-804 A	na	-	90,699 a
	HoCP 09-804 S	na	-	61,728 b
	L 10-147 A	na	-	82,319 a
	L 10-147 S	na	-	66,146 b
Plant cane Exp 2	HoCP 09-804 A	38% b	31,607 ab	86,385 a
	HoCP 09-804 S	30% c	18,489 c	75,773 c
	L 10-147 A	46% a	29,304 b	83,010 ab
	L 10-147 S	46% a	33,040 a	79,047 bc

[a] Two experiments (Exp) were conducted. Results in experiment one were determined in both plant cane and first ratoon. In experiment two, results were determined only in plant cane.
[b] Asymptomatic (A) and symptomatic (S) stalks were planted for each clone.
[c] The percentage of buds that germinated out of the total number of buds on a single stalk was estimated from primary shoot emergence. Means within an experiment followed by different letters were significantly different at p<0.05. Na = not applicable.
[d] Shoot populations were counted during the following spring. Means within an experiment followed by different letters were significantly different at p<0.05. Spring shoot counts were not determined in first ratoon of experiment one.
[e] Stalk populations were determined during late summer. Means within an experiment and crop year followed by different letters were significantly different at p<0.05.

Resistance to mosaic was evaluated for breeding program parents and selections in two different ways. To evaluate resistance to natural infection, stalks with symptoms of mosaic were planted in border rows and a row through the middle of the variety selection program inoculated test to evaluate resistance to smut and leaf scald. This approach utilizing virus “spreader rows” attempts to detect mosaic susceptible clones by controlled exposure to natural infection due to aphid transmission. A survey of the three replicate plots of all clones detected plants with mosaic symptoms in nine experimental varieties (Table 8).

Table 7. Comparison of stalk weight, sucrose content, cane yield, and total sucrose yield estimated for plots of HoCP 09-804 and L 10-147 that were planted with individual mosaic symptomatic or symptomatic stalks in two experiments.

Crop cycle year and experiment [a]	Clone [b]	Stalk weight (kg)[c]	Sucrose content (kg/ton of cane) [c]	Cane yield (tons/ha) [c]	Sucrose yield (kg/ha) [c]
Plant cane Exp 1	HoCP 09-804 A	1.03 ab	90.5 b	103.1 a	9,368.8 a
	HoCP 09-804 S	0.96 b	94.8 a	55.8 b	5,335.7 b
	L 10-147 A	1.18 a	88.5 b	116.5 a	10,325.3 a
	L 10-147 S	1.16 a	87.4 b	107.2 a	9,347.5 a
First ratoon Exp 1	HoCP 09-804 A	0.91 b	87.1 a	100.0 a	8,596.1 a
	HoCP 09-804 S	0.76 c	90.6 a	57.1 b	5,097.2 c
	L 10-147 A	1.04 ab	79.6 b	104.8 a	8,321.5 ab
	L 10-147 S	1.08 a	79.2 b	86.1 a	6,877.7 b
Plant cane Exp 2	HoCP 09-804 A	1.03 b	80.6 a	107.7 ab	8,696.7 a
	HoCP 09-804 S	0.93 b	82.7 a	86.7 b	7,119.6 b
	L 10-147 A	1.23 a	73.6 b	124.5 a	9,086.1 a
	L 10-147 S	1.27 a	70.4 b	121.3 a	8,460.5 ab

[a] Two experiments (Exp) were conducted. Results in experiment one were determined in both plant cane and first ratoon. In experiment two, results were determined only in plant cane.
[b] Mosaic asymptomatic (A) and symptomatic (S) stalks were planted for each clone.
[c] Means within an experiment and crop year followed by different letters were significantly different at $p < 0.05$.

Table 8. Detection of mosaic symptomatic plants in a field experiment evaluating mosaic resistance via natural infection at the Sugar Research Station during May 2018.[a]

Clone	No. mosaic infected plants in 3 replicates	Clone	No. mosaic infected plants in 3 replicates
L 14-267	1,0,0	L 15-317	1,0,0
Ho 14-836	5,0,0	L 16-350	4,1,1
HoL 14-841	3,1,0	L 16-354	1,0,0
Ho 14-864	8,2,0	L 16-380	1,0,0
HoCP 14-878	1,0,0		

[a]Stalks from mosaic symptomatic plants were planted in every fourth row and across the ends of the field to provide a source of inoculum to be spread by aphids into the experimental plots.

A second approach utilized mechanical inoculation of young plants grown in the greenhouse to evaluate resistance to mosaic. The first inoculations were conducted during 2017. Two inoculations were then conducted during 2018 with USDA-ARS Sugarcane Research Unit commercial and basic breeding program potential parents and accessions from the basic germplasm collection, and one inoculation was conducted with parents of the LSU AgCenter breeding program. In the first USDA inoculation, 67 potential parents from the 2016 and 2017 basic series and 115 commercial parents from the 2011 – 2017 series were inoculated along with

56 accessions. Each clone had a minimum of four plants (six single-node cuttings planted) with 4-5 leaves grown in Speedling trays. Two highly susceptible checks, L 08-088 and Rio sorghum, one moderately susceptible check, HoCP 09-804, and one resistant check, HoCP 96-540, were included with three replicates of six plants inoculated and one replicate non-inoculated. Inoculum consisted of sugarcane leaves from multiple clones infected with SrMV. Infection levels were determined by visual observation of systemic mosaic symptoms in leaves of the six inoculated plants 5 weeks after inoculation. Assigned ratings were HR = highly resistant (0% mosaic infection), MR = moderately resistant (1-24%), MS = moderately susceptible (25-49%), S = susceptible (50-74%), and HS = highly susceptible (75-100%). The infection intervals were based on a percentage range because of some variability in the number of surviving plants per clone.

No symptomatic plants were observed for 91% of the basic parents and 69% of the commercial parents in the first inoculation (Table 9). There was variability in the first inoculation for percentage of parent clones with a highly resistant reaction among the different series of commercial parents with averages ranging from 35.7 to 100% (Table 9). The 56 accessions in the first inoculation had 48 (86%) rated HR, 2 MR, 0 MS, 4 S, and 2 HS. Some mosaic susceptibility was detected in the commercial parent population, but the basic germplasm continues to provide a source of resistance for future breeding efforts. However, the second inoculation of 2018 series basic and commercial parents exhibited a highly resistant reaction for only 67 and 42% of the clones, respectively (Table 9). In addition, more susceptibility was detected in the repeat inoculation of the 53 accessions with 34 (64%) HR, 2 MR, 3 MS, 2 S, and 12 HS reactions. The reasons for the higher levels of infection observed in the second inoculation are not certain. No symptomatic plants were observed for 95% of the commercial parents from the LSU AgCenter Breeding Program (Table 10).

Inoculation of the checks produced the expected results with 100% infection for L 08-088 and Rio sorghum and no infection for HoCP 96-540, but no infection was detected in HoCP 09-804. Testing for SrMV by RT-PCR was conducted for a subset of symptomatic and asymptomatic plants, and virus was detected in symptomatic but not asymptomatic plants. SrMV was detected in a portion but not all of a small subset of samples collected from plants with what were deemed questionable symptoms.

The detection of mosaic susceptibility in multiple advanced selections in the variety selection program indicated that some level of susceptibility was going undetected in the crossing and selection programs. The recent reliance only on natural infection to detect susceptibility was apparently not adequate to detect susceptible clones due to insufficient inoculum pressure. The addition of a mosaic spread component to the smut and leaf scald inoculated test is now detecting susceptibility through natural infection resulting from more uniform exposure to mosaic infected plants. Valuable information on mosaic susceptibility has been obtained from the inoculated tests. Susceptible clones were detected at all levels of the breeding program. Susceptibility was traced to common parentage in some cases. The sources of susceptibility can now be eliminated or used with appropriate caution in future crossing. Annual mechanical inoculation of mosaic will need to be reinstituted as a component of the breeding program. The goal of all of the mosaic research is to prevent this important disease from re-emerging as a problem for the Louisiana sugarcane industry.

Table 9. Mosaic mechanical inoculation results for experiments conducted at the USDA-ARS Sugarcane Research Unit during 2018.

Experiment and parent population [a]	Series [b]	Number of clones	Number of clones categorized by resistance rating [c]				
			HR	MR	MS	S	HS
2018 USDA 1							
Basic	2016	29	25	3	0	0	1
	2017	38	36	1	1	0	0
	B total	67	61	4	1	0	1
Commercial	2011	1	1	0	0	0	0
	2013	1	1	0	0	0	0
	2014	14	5	2	2	2	3
	2015	28	19	2	1	2	4
	2016	39	27	2	1	3	6
	2017	32	26	2	2	2	0
	C total	115	79	8	6	9	13
	Total	182	140	12	7	9	14
2018 USDA 2							
Basic	2018	57	38	2	2	5	10
Commercial	2018	40	17	1	2	3	17
	Total	97	55	3	4	8	27

[a] Two experiments were conducted with clones from the USDA-ARS basic breeding and commercial parent populations.
[b] Series refers to clone groupings by year of assignment of permanent identification number. B = basic parent population and C = commercial parent population.
[c] Results are reported for clones that had at least four inoculated plants. Assigned ratings were HR = highly resistant (0% mosaic infection), MR = moderately resistant (1-24%), MS = moderately susceptible (25-49%), S = susceptible (50-74%), and HS = highly susceptible (75-100%).

Table 10. Mosaic mechanical inoculation results from 2018 for LSU AgCenter Breeding Program parents.

Experiment and parent population [a]	Series [b]	Number of clones	Number of clones (percentage) categorized by resistance rating [c]				
			HR	MR	MS	S	HS
2018 LSU							
Basic	2009	1	1	0	0	0	0
Commercial	1981	2	2	0	0	0	0
	1985	2	2	0	0	0	0
	1991	1	1	0	0	0	0
	1992	2	2	0	0	0	0
	1994	3	3	0	0	0	0
	1995	1	1	0	0	0	0
	1996	1	1	0	0	0	0
	1997	2	2	0	0	0	0
	1999	2	2	0	0	0	0
	2000	1	1	0	0	0	0
	2001	5	5	0	0	0	0
	2002	1	1	0	0	0	0
	2003	1	0	0	1	0	0
	2004	2	2	0	0	0	0
	2005	3	3	0	0	0	0
	2006	4	4	0	0	0	0
	2007	1	1	0	0	0	0
	2008	3	3	0	0	0	0
	2009	7	7	0	0	0	0
	2010	2	2	0	0	0	0
	2011	2	2	0	0	0	0
	2012	4	4	0	0	0	0
	2013	4	4	0	0	0	0
	2014	14	13	1	0	0	0
	2015	24	21	0	2	0	1
	C total	94	89	1	3	0	1
	Total	95	90	1	3	0	1

[a] One experiment was conducted with clones from the LSU AgCenter Breeding Program basic and commercial parent populations.

[b] Series refers to clone groupings by year of assignment of permanent identification number. B = basic parent population and C = commercial parent population.

[c] Results are reported for clones that had at least four inoculated plants. Assigned ratings were HR = highly resistant (0% mosaic infection), MR = moderately resistant (1-24%), MS = moderately susceptible (25-49%), S = susceptible (50-74%), and HS = highly susceptible (75-100%).

Healthy Seedcane Program Support

Disease testing was conducted by the Sugarcane Disease Detection Lab for the 23rd year during 2018. Kleentek and SugarTech seedcane production was monitored for ratoon stunt disease (RSD), and no disease was detected (Tables 11 and 12). A total of 1,520 stalk samples from research farms, variety increase plots, and grower fields were tested for RSD with no positives detected. The Local Quarantine supplied healthy plant material of 10 active experimental varieties from the 2014 series to the two seedcane companies to establish Foundation Stock plants that will provide apical meristems for tissue culture. Limited testing was conducted on commercial farms, and no RSD was detected in 23 sampled fields. A total of 8,127 leaf samples were tested for *Sugarcane yellow leaf virus* (Table 13). Commercial tissue-culture seedcane sources were tested as part of the LDAF seedcane certification program. No field failed to certify due to virus infection.

Table 11. RSD testing summary for 2018.

Source	Location	No. of fields	No. of varieties	No. of samples
Louisiana growers	State-wide	23	8	553
Variety Release Program	1° & 2° stations	-	20	217
Helena SugarTech®	Foundation stock	-	-	-
Kleentek®	Foundation stock	-	-	57
Kleentek®	Other than foundation	-	-	240
Local Quarantine	LSUAC	-		76
Research	LSUAC	-	-	377
Total				1,520

Table 12. RSD field and stalk infection frequencies in different crop cycle years for all varieties combined during 2018.

Crop Year	Total number of fields	Average field infection (%)	Total number of stalks	Average stalk infection (%)
Plant cane	4	0	122	0
First stubble	1	0	23	0
Second stubble	2	0	59	0
Older stubble	16	0	349	0
Totals/Averages	23	0	553	0

Table 13. Sugarcane yellow leaf virus testing summary for 2018.

Source	Location	No. of fields	No. of varieties	No. of samples
LDAF	Seed Certification	207		6770
Helena SugarTech®	Foundation stock	-	-	-
Kleentek®	Foundation stock	-	-	45
Kleentek®	Other than foundation	-	-	797
Local Quarantine	LSUAC	-	10	76
Research	LSUAC	-	-	439
Totals		207	10	8,127

Disease Resistance Studies

Research was conducted to develop molecular markers to brown rust, smut, and mosaic in cooperation with Dr. Niranjan Baisakh. Ongoing research has been focused on determining markers associated with the quantitative expression of resistance in L 99-233 to brown rust, caused by *Puccinia melanocephala*. Cold winter weather conditions resulted in no brown rust epidemic during the spring of 2018 limiting the field component of the research effort. Progeny (approximately 250) from a bi-parental cross between L 99-233 and HoCP 96-540 (rust susceptible) intended for a molecular marker validation study and the L 99-233 self population were planted at the Sugar Research Station to evaluate resistance to natural infection during 2019. Results of molecular genetics research for resistance to diseases are reported separately.

A study to develop molecular markers for resistance to smut, caused by *Sporisorium scitamineum*, was initiated. The same L 99-233 (susceptible) x HoCP 96-540 (resistant) bi-parental population is being utilized for smut resistance marker association. Clones of the population were dip-inoculated and planted at the Sugar Research Station. Resistance phenotypes will be determined during June, 2019.

The results from the screening of the commercial and basic parent populations for mosaic resistance by mechanical inoculation will be used to identify a population for resistance marker association. In addition, a bi-parental population from cross between mosaic resistant and mosaic susceptible parents will be identified for a marker validation population and inoculated and planted during 2019.

Resistance reactions to multiple diseases were evaluated as part of the Variety Selection Program in inoculated and natural infection experiments. Resistance to smut and leaf scald is evaluated annually for experimental varieties in an inoculated test at the Sugar Research Station. Resistance to spread of mosaic by aphid vectors is then evaluated in the same planting.

From the smut test, 25 (62%) were rated resistant, 10 (25%) moderately susceptible, and five (13%) highly susceptible (Table 14). In the leaf scald test, 23 (57%) rated resistant, 15 (38%)

moderately susceptible, and two (5%) highly susceptible (5%) (Table 15). The mosaic spread test results were provided above (Table 8).

An ongoing study to identify new potential parents with multiple disease resistance to smut, leaf scald (caused by *Xanthomonas albilineans*) and mosaic was completed. One hundred sixty clones from the increase stage of the variety selection program were dip-inoculated with smut at planting in a non-replicated test for the second time. The population was then inoculated in the same planting with the leaf scald pathogen during May, 2018. Mosaic susceptibility was evaluated as natural infection resulting from aphid transmission from surrounding rows planted with virus infected stalks. Eight clones did not develop any smut, systemic leaf scald or mosaic, and an additional six clones did not develop any smut or mosaic and had a moderately resistant leaf scald rating. These clones will be evaluated as potential parents for future crossing.

Table 4. Smut infection means and resistance ratings from 2018 inoculated test.

Variety	Mean percent	Rating[a]	Variety	Mean percent	Rating[a]
CP 73-351	27	6	HoCP14-878	4	2
LCP 85-384	4	2	HoCP 14-885	2	2
HoCP 89-846	2	2	L 15-306	3	2
HoCP 96-540	8	3	L 15-317	15	4
L 99-226	3	2	L 15-320	32	7
L 01-283	3	2	L 15-338	1	2
L 01-299	14	4	L 15-343	0	1
HoCP 04-838	18	5	L 16-348	55	9
HoCP 09-804	16	5	L 16-350	20	5
L 11-183	3	2	L 16-352	13	4
L 12-201	1	2	L 16-353	2	2
Ho 12-615	1	2	L 16-354	33	7
L 13-251	0	1	L 16-355	25	6
Ho 13-708	9	4	L 16-358	52	9
Ho 13-739	0	1	L 16-360	17	5
HoCP 13-740	0	1	L 16-372	7	3
HoCP 13-758	15	4	L 16-373	2	2
L 14-267	0	1	L 16-375	2	2
L 14-282	34	7	L 16-376	0	1
HoCP 14-802	8	3	L 16-377	0	1
HoCP 14-826	2	2	L 16-380	0	1
Ho 14-836	0	1	L 16-381	9	4
HoL 14-841	8	3	L 16-386	13	4
Ho 14-864	13	4	L 16-388	1	2
HoCP 14-867	2	2	L 16-391	0	1

[a]Resistance ratings assigned on a 1-9 scale in which 1-3 = resistant, 4-6 = moderately susceptible, and 7-9 = highly susceptible.

Table 5. Leaf scald resistance ratings determined in an inoculated test for commercial and experimental sugarcane varieties during 2018.

Variety	Visual rating[a]	Variety	Visual rating[a]
CP 73-351	5	HoCP14-878	2
LCP 85-384	2	HoCP 14-885	2
HoCP 89-846	2	L 15-306	2
HoCP 96-540	3	L 15-317	3
L 99-226	5	L 15-320	5
L 01-283	1	L 15-338	3
L 01-299	4	L 15-343	1
HoCP 04-838	3	L 16-348	1
HoCP 09-804	3	L 16-350	4
L 11-183	2	L 16-352	5
L 12-201	1	L 16-353	4
Ho 12-615	4	L 16-354	2
L 13-251	3	L 16-355	2
Ho 13-708	2	L 16-358	4
Ho 13-739	2	L 16-360	1
HoCP 13-740	2	L 16-372	5
HoCP 13-758	5	L 16-373	2
L 14-267	2	L 16-375	6
L 14-282	7	L 16-376	2
HoCP 14-802	4	L 16-377	3
HoCP 14-826	4	L 16-380	6
Ho 14-836	2	L 16-381	3
HoL 14-841	4	L 16-386	7
Ho 14-864	3	L 16-388	4
HoCP 14-867	2	L 16-391	4

[a]Resistance ratings assigned on a 1-9 scale in which 1-3 = resistant, 4-6 = moderately susceptible, and 7-9 = highly susceptible.