ASSOCIATION OF SUGARCANE PITH, RIND HARDNESS, AND FIBER WITH RESISTANCE TO THE SUGARCANE BORER

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ABSTRACT

Varietal resistance is an important component of the integrated pest management program for controlling damaging infestations of the sugarcane borer in Louisiana sugarcane. Developing borer-resistant varieties is, however, hindered to some extent by a general lack of knowledge of resistance selection strategies. We investigated the association of sugarcane pith with sugarcane borer resistance within a population of progeny selected from a biparental cross. The population consisted of 15 clones selected with pith and 15 clones selected without pith. These selections were planted in a replicated experiment to evaluate their response to borer feeding. Damage was measured as percent bored internodes and damage ratings in both the plant-cane and first ratoon crop. We found that the subpopulation with pith sustained fewer damaged internodes (pith = 12.5 %; no pith = 15.6 %) and had lower damage ratings (pith = 3.7; no pith = 4.0) than the subpopulation without pith; however, these differences were not significant when selection was considered a random effect in our statistical model. Pith in the upper portion of the stalk was negatively correlated with damaged internodes and ratings in first ratoon. Within each subpopulation, there were individuals that were both resistant and susceptible suggesting that factors other than the presence or absence of pith were contributing to resistance. Two other factors that were investigated, target-internode rind hardness and fiber content, were more closely associated with resistance than pith. Fiber content was correlated with resistance in all cases. Pith was not correlated to rind hardness and fiber content. Phenotypic selection in the early stages of variety development for low insect damage may result in varieties with high fiber content and rind hardness, and possibly with higher levels of pith. Accumulating these traits through repetitive phenotypic selection during recurrent selection may account for the lower sugar yields often observed in borer resistant selections.

INTRODUCTION

The sugarcane borer, *Diatraea saccharalis* (F.), is the most important insect pest of sugarcane (*Saccharum* spp. hybrids) in Louisiana (Reagan and Martin, 1989). Currently, insecticides provide the most effective means of controlling damaging infestations of the borer in sugarcane fields in Louisiana (Rodriguez et al., 2001). However, high application costs, associated environmental concerns following insecticide applications, and concern for potential insecticide resistance compel a need for implementing alternative control strategies.

Plant resistance has long been recognized as an important component of pest management of the borer in Louisiana (Holloway, 1935). Resistant cultivars, when available to farmers for planting, express their resistance as complex contributions from several mechanisms. Coburn and Hensley (1972) reported that the tightness of leaf sheaths was partially responsible for the resistance of NCo 310 to the borer. Martin and Cochran (1975) and Martin et al. (1975) found a significant negative correlation between rind hardness of the internode first accessible to attack and mean percent internodes subsequently bored by larvae. White and Hensley (1987) reported that tolerance to larval feeding also could be an important mechanism of resistance.

Several researchers reported that the borer has no ovipositional preference among sugarcane varieties (Tucker, 1933; Fuchs and Harding, 1978; and Kyle and Hensley, 1970). However, Sosa (1988) compared oviposition on pubescent (*Saccharum robustum*) and glabrous sugarcane clones and showed that twice as many eggs were laid on leaves of the glabrous clones as on the pubescent clones. This trait has not yet been transferred to high-yielding commercial varieties.

Borer resistance is measured in sugarcane clones in numerous ways. Bessin et al. (1990) recorded the number of bored internodes per stalk and the number of the internodes with exit holes per stalk, indicating a successful pupation. Using stalk number per area and the number of moth exit holes, these researchers estimated the number of adult moths produced per area per year per variety. White (1993a) incorporated a damage rating in addition to using percentage of bored internodes in their assessment of damage.

Loss in yield due to borer injury is the ultimate measure of susceptibility, and absence of yield loss is a function of resistance mechanisms known and those not yet identified. It has been known for many years that comparing yields from insecticide-treated and non-treated plots is an effective way to differentiate between resistant and susceptible cultivars (Long et al., 1961). Milligan et al. (2003) calculated selection indices using five different measures (percent bored internodes, percent exited internodes, pupation success, moth production, and a damage rating) and found that the most effective single trait to indicate yield loss is percent bored internodes. If data collection costs were considered, then the subjectively assessed damage rating would be the most expeditious of the traits examined.

A damage rating has been used effectively in our current recurrent selection program for borer resistance to identify resistant selections in both seedlings and first clonal stage trials (Milligan, 1994; White et al., 1996). A low damage rating, as with the absence of yield loss, can be the cumulative effect of many resistance mechanisms. However, repetitive phenotypic selection for low borer damage ratings may result in the accumulation of traits in resistant varieties that could have an adverse effect on other important characters related to sucrose yield.

Pith is the white, low-density, low moisture-percentage volume tissue (dead parenchyma cells) sometimes present in stalks of some sugarcane varieties (Figure 1). During our routine evaluations of selections for borer resistance, we noted a high frequency of pith in our second-clonal stage trials. In our 1999 assignment series (planted in 2002), the pith ratings of the 15 most promising selections ranged from rating of P0 (= 0 % pith) to P7 (= 70 % pith) with a P2 (= 20 %) average. The question arose whether pith might in fact be contributing to borer resistance. However, Davidson (1966) reported little correlation between borer damage and stalk density. The objective of this study was to investigate the relationship of borer resistance with pith and other resistance traits, such as rind hardness and fiber content.

MATERIALS AND METHODS

During the fall of 2002, 30 progeny from the cross HoCP 94-839 X HoCP 90-941 were selected for planting in a replicated borer-evaluation experiment at the USDA, ARS Ardoyne Research Farm near Schriever, LA. This cross was chosen because it has a history of producing a high frequency of progeny with good agronomic phenotype and also a high frequency of progeny with pith. Selections for this experiment were identified in the first-ratoon seedling crop. These selections also were chosen on the basis of good stalk height, stalk diameter, and stalk number (= 8 stalks/stool). Presence of pith was determined by cutting a single stalk, mid-internode approximately half-way up the stalk. Clones to make the pith population were chosen on the basis of at least a P2 (20 % of stalk area containing pith) rating.

Eight stalks were taken from each selection for planting the borer-evaluation experiment. This experiment was planted as a randomized complete block design with four replications. Individual plots were a single, 1.8 m row with an inter-row spacing of 1.5 m. One row of maize (*Zea mays* L.) was planted on either side of the experiment the following spring to serve as a borer-inoculated host for increasing the intensity of borer pressure. Procedures for inoculation and plot maintenance, including those for controlling red-imported fire ant (*Solenopsis invecta* Buren) followed those of White et al. (1996).

In addition to the experimental clones, the male parent (HoCP 90-941) was included as well as two commercial borer-resistant standards (CP 70-321 and HoCP 85-845) and two commercial borer susceptible standards (LCP 85-384 and HoCP 91-555). Unfortunately, the female parent could not be included in the experiment. The resistant variety CP 70-321 was included in the experiment as it is characterized as having a large pipe (hollow tube) transversing the length of the stalk (Figure 1), whereas HoCP 85-845 is a variety characterized as having extensive pith (Figure 1). Although LCP 85-384 and HoCP 91-555 are both considered susceptible to the borer, LCP 85-384 expresses a level of tolerance to borer feeding that HoCP 91-555 does not. Pith is not associated with either of these two varieties (Figure 1).

We quantified borer damage by both plant damage response ratings and percent damaged internodes. Percent damage internodes (%) were determined for each plot from a 10-stalk sample by the ratio of bored internodes to total internodes. Damage response ratings were made for each plot and were based on a 1-9 scale, where 1 indicated none to little borer damage and 9 indicated heavy damage (White et al. 2001). Data for this experiment were collected in the plant-cane and first-ratoon crop.

Six additional stalks were used to plant a borer-free observation plot to provide stalks for collecting descriptive data. Stalks from these plots were used to describe selections for the following traits: pith, rind hardness, fiber content, stalk weight, and sucrose yield. Because we selected in single-stools, the number of stalks available for planting limited the availability of seed-cane. We thought that it was more appropriate to collect these descriptive data from plots that were essentially borer free than from the infested plots where the possibility heavy borer damage may mask the true phenotypic expression of a variety.

Figure 1. Cross-sections of three commercial sugarcane varieties and one clonal selection (US 93-15) from the recurrent selection program for borer resistance showing pipe and various degrees of stalk pith. The variety US 93-15 represents an extreme in pith expression. This variety was selected from the recurrent selection program for borer resistance and is highly resistant to both the sugarcane borer and Mexican rice borer (*Eoreuma loftini*). Stalk sections were taken mid-internode approximately half-way up the stalk.

Pith ratings were taken from three stalks randomly selected from the increase plots. A 0 – 9 visual rating (0 = no pith; 9 = 90 % pith) was taken near the top third or fourth internode below the growing-point and at the mid-point of the stalk at harvest [17 Nov. 2003 (plant-cane) and 3 Dec. 2004 (first ratoon)]. Also at this time, and from the increase plots, a random 10-stalk sample was taken from each plot, topped at the youngest fully elongated internode, and knife-stripped of all leaf and sheath material. The sample was weighed to determine average stalk weight. In addition, internode rind-hardness was determined from the third and fourth internodes below the youngest fully-expanded internode. These internodes are referred to as target internodes as they are sites of larval penetration into the stalk (White 1993b). We measured rind-hardness from both internodes separately rather than pool results because it is sometimes difficult to determine the youngest fully-expanded internode. Rind hardness measurements were made with a handheld durometer Model H 1000 (Rex Gauge Company, Bush Grove, IL). These 10-stalk samples were processed using a pre-breaker, and the resulting pulp was pressed to separate juice from bagasse. Brix, sucrose, and fiber content (percent cane) composition, as well as theoretical sugar recovery (TRS) levels (kg/mt), were determined using standard methods (Legendre 1992). The PROC MEANS procedure (SAS 2005) was used to test whether the mean difference between any two descriptive traits was significantly different from zero.

The data from the resistance-evaluation experiment were analyzed as a randomized complete block design with a split plot arrangement of treatments. The whole plots were the two populations, and 15 selections in each population and crop year were the subplots. The analysis was done using the PROC MIX procedure (SAS 2005). We conducted two analyses, one assuming selection as a fixed effect in the model and the other assuming selection as a random effect. Pearson Correlation Coefficients were determined using the PROC CORR procedure (SAS 2005). Summary statistics for the figure were generated by the PROC BOXPLOT procedure (SAS 2005).

Additionally, whorl tissue was collected from each increase plot for conducting molecular genotyping to determine the fidelity of the cross. We followed the molecular genotyping procedures of Pan et al. (2003) using the following six microsatellites: SMC334BS, SMC336BS, SMC597CS, SMC18SA, SMC1604SA, and SMC703BS. These microsatellites were used for all 30 selections plus the male parent (HoCP 90-941). The resulting PCR (polymerase chain reaction) products were sized on a Beckman Coulter CEQ 8000 (Beckman Coulter, Inc., Fullerton, CA) Genetic Analysis System. The data-file generated from the capillary electrophoresis system was analyzed with the CEQ 8000 Genetic Analysis System software version 9.0.

RESULTS

Although not having the DNA of the female parent (HoCP 94-839) available limited the inferences that could be drawn from a molecular genotyping evaluation, a review of the data indicated that all 30 progeny likely had HoCP 90-941 as their male parent. A comparative review of the data also suggested a conservative allelic pattern consistent with patterns observed in progeny of sugarcane crosses where only two parents are involved.

Phenotypic and yield data suggested that the pith and no-pith subpopulations were similar to one another, but neither group collectively appeared to have the sugar yield potential of the commercial varieties included in the experiment (Table 1). This was particularly evident for TRS where the two subject populations had TRS values roughly 10-20 % lower than the commercial varieties.

There were individual clones originally taken for the no-pith subpopulation that expressed pith in both the plant-cane and first-ratoon crop. The top stalk-section pith rating for this group ranged from 0.0 to 3.0 in the plant-cane crop and 0.0 to 6.7 in the first ratoon crop. The middle stalk-section pith rating for this group ranged in the plant-cane from 0.0 to 3.7 and 0.0 to 6.7 in the first ratoon crop. Only once did we rate a pith selection as having no pith and that was for a middle stalk-section rating in the plant-cane crop. However, in the plant-cane crop, the pith population had significantly higher pith ratings than the no-pith population at both the top ($Pr > |t| < 0.0001$) and middle stalk-height ($Pr > |t| < 0.0001$). While, in the first ratoon crop, there was no significant difference between the pith and no-pith populations for the top stalk pith rating ($Pr > |t| < 0.69$), but there was a significant difference between the two populations for the middle stalk rating ($Pr > |t| < 0.02$) (Table 1). When the data were averaged from all 30 selections, the plant-cane crop had significantly less pith than the first ratoon crop at both the top stalk-section ($Pr > |t| < 0.0001$) and middle stalk-section ($Pr > |t| = 0.0003$).

Rind hardness also varied among the selections, but there was no difference among subpopulation means of either durometer reading for the two populations in either the plant-cane [third internode ($Pr > |t| = 0.7643$) and fourth internode ($Pr > |t| = 0.54$)] or the first ratoon [third internode ($Pr > |t| = 0.4721$) and fourth internode ($Pr > |t| = 0.15$)]. Rind hardness was however significantly greater in the first ratoon crop than in the plant-cane crop for the third internode ($Pr > |t| < 0.01$) and also the fourth internode ($Pr > |t| < 0.01$).

Analysis of variance for percent damaged internodes and mean damage ratings with selection as a fixed effect is shown in Table 2. This analysis suggests that there was a significant difference in insect damage between the two pith subpopulations with the pith subpopulation sustaining less damage than the no-pith subpopulation. However, when selection was considered a random effect (Table 3), there was no difference in damage between the two subpopulations. The box and whisker plots in Figure 2 summarize the individual plot data from plant and first ratoon crops for both percent damaged internodes and damage rating. These data suggest that the random model is the more appropriate model, as there appears little difference between the two sub-populations for percent damaged internodes and damage ratings. Both subpopulations contained individuals that were resistant to borer feeding and others that were susceptible to feeding. The range of the data for both percent damaged internodes and mean damage ratings also were similar for the two subpopulations.

Both models showed that there was a significant difference between the plant-cane and first ratoon crop in the level of borer damage sustained. Damage was significantly higher in the plant-cane crop as measured by both mean percent damaged internodes (plant = 18.9 %; ratoon = 9.4 %) and mean damage rating (plant = 5.4; ratoon = 2.4). Mean damage ratings were low in both years. Use of the damage rating is limited to standing cane and must generally be collected no earlier than September to observe the full plant response to borer infestations (Milligan et al., 2003). Although plots were rated on 27 August 2003 and 10 September 2004, it appears that in neither year did we collect data at the time of optimum expression of damage among selections.

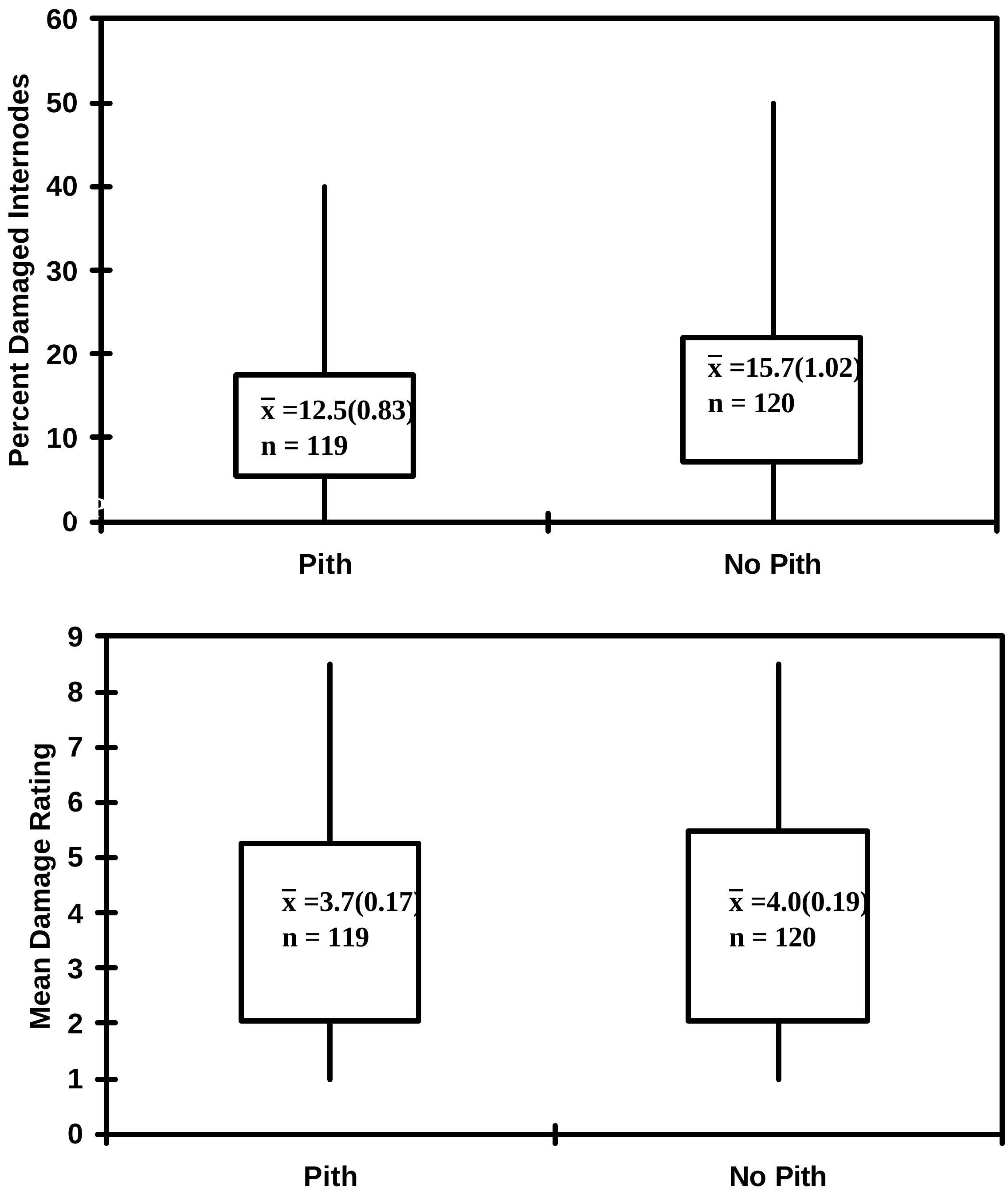

Figure 2. Box and whisker plots showing the data range for individual plots with the first and third quartiles being noted by the bottom and top of the boxes, respectively. The values inside the boxes are the mean, standard error of the mean and number of observations per response variable.

Table 1. Mean values of phenotypic and yield descriptors for the two pith subpopulations, HoCP 90-941 (Male Parent), and industry standards.

Group	Stalk wt.	3rd inter-node[1]	4th inter-node[1]	Pith top[2]	Pith mid[2]	Brix[3]	Sucrose[3]	Fiber[3]	TRS[3]	D.I.[4]	D.R.[5]
	(kg)	-(durometer[6])-		-----(rate)-----		-------------(%)------------			(kg/mt)	(%)	(rating)
					Plant-cane crop						
Pith	1.2	69.9	79.3	3.2	3.9	14.8	12.1	17.0	97.6	17.5	5.2
No pith	1.2	69.4	78.5	1.2	0.9	14.3	11.9	16.7	97.1	20.4	5.6
CP70-321	1.3	70.9	82.2	0.7	0.0	17.1	15.4	14.3	133.6	20.7	5.4
LCP85-384	1.1	75.2	82.5	0.3	0.0	16.8	14.7	14.6	125.1	20.7	5.6
HoCP85-845	1.5	66.0	75.2	5.0	3.3	15.4	13.2	15.1	110.4	11.5	4.3
HoCP90-941	1.3	76.8	90.5	4.7	0.3	16.9	14.6	13.2	124.7	21.8	5.1
HoCP91-555	1.1	72.6	79.6	0.0	0.0	17.3	14.8	16.8	121.9	29.1	6.5
					First ratoon crop						
Pith	1.0	74.5	82.7	5.8	5.8	14.9	12.4	19.5	98.8	7.4	2.4
No pith	1.1	75.4	83.7	3.5	1.7	14.7	12.6	18.7	101.6	11.4	2.5
CP70-321	1.5	82.2	86.3	0.0	0.0	17.4	15.8	18.9	131.4	9.3	1.8
LCP85-384	1.0	80.1	87.7	0.0	0.0	16.7	15.0	17.8	125.3	10.9	1.6
HoCP85-845	1.4	76.3	82.6	5.7	4.7	16.0	14.0	20.0	112.6	4.0	1.9
HoCP90-941	1.2	79.1	87.9	5.7	2.3	17.3	15.5	15.7	132.6	24.7	2.8
HoCP91-555	1.0	77.8	82.8	1.0	0.7	17.8	15.5	18.7	127.0	13.5	3.1

[1]Durometer reading taken from the 3rd and 4th internodes below the top fully expanded internode.
[2]Pith rating from 0 (no pith) to 9 (90% pith) taken from the top section and middle section of the stalk.
[3]Determined from a single 10-stalk sample.
[4]Percent damaged internode data were collected from 10-stalk samples taken from the replicated (reps=4) resistance evaluation.
[5]Damage rating scale from 0 (little damage) to 9 (heavy damage).
[6]A 100 durometer reading equals 822 grams of load and a 0 durometer equals 56 grams of load.

Table 2. Analysis of variance of insect damage for the two subpopulations with selection assumed to be a fixed effect.

		% Damage internodes		Mean damage rating	
Fixed effect	df	F Value	Prob.>F	F Value	Prob.>F
Population [Pop]	1	17.03	<0.0001	5.17	0.0255
Crop	1	136.82	<0.0001	500.57	<0.0001
Pop*Crop	1	0.59	0.444	0.41	0.5258
Selection(Pop)	28	8.25	<0.0001	3.70	<0.0001
Selection*Crop(Pop)	1	1.67	0.0225	1.38	0.1315
Variance components of random effects			Estimate		Estimate
Rep			2.85		0.05
Pop*Selection*Rep			0.00		0.14
Residual			40.62		1.09

Table 3. Analysis of variance of insect damage for the two subpopulations with selection assumed to be a random effect.

		% Damage internodes		Mean damage rating	
Fixed effect	df	F Value	Prob.>F	F Value	Prob.>F
Population [Pop]	1	1.97	0.1711	1.37	0.2517
Crop	1	81.41	<0.0001	360.39	<0.0001
Pop*Crop	1	0.37	0.5479	0.29	0.5930
Variance components of random effects			Estimate		Estimate
Rep			2.83		0.05
Selection(Pop)			35.07		0.42
Pop*Selection*Rep			0.00		0.14
Selection*Crop(Pop)			6.90		0.11
Residual			40.62		1.08

Pearson Correlation Coefficients are given in Table 4. All resistance traits measured were negatively correlated with percent damaged internodes and mean damage rating in some comparisons. Pith was only correlated with resistance traits in first ratoon. Pith in the upper portion of the stalk was negatively correlated with both percent damaged internodes and the damage rating. The greatest number of negative correlations between rind hardness and internode damage and ratings were obtained with hardness of the upper internode in plant cane. Fiber content was correlated with increased resistance in all comparisons. The low number of significant correlations of pith with both damage measures suggests that pith is less important in conferring resistance than either fiber content or target-internode rind hardness. The correlation data also indicate that pith is not associated with either fiber content or target internode rind hardness.

Table 4. Pearson correlation coefficients among resistance factors and insect damage from the two pith subpopulations.

	Hrd2Plt[1]	Hrd1Fr[2]	Hrd2Fr[2]	Pith1Plt[3]	Pith2Plt[3]	Pith1Fr[4]	Pith2Fr[4]	FiberPlt[5]	FiberFr[5]	DIPlt[6]	DIFr[6]	RatePlt[7]	RateFr[7]
Hrd1Plt[1]	0.78	0.63	0.33	0.13	0.09	0.09	0.03	0.46	0.35	-0.57	-0.39	-0.32	-0.41
	<0.01	<0.01	0.08	0.49	0.64	0.65	0.88	0.01	0.06	<0.01	0.03	0.08	0.02
Hrd2Plt[1]		0.39	0.30	0.24	0.11	0.21	0.09	0.17	0.21	-0.53	-0.27	-0.33	-0.29
		0.03	0.11	0.20	0.55	0.26	0.64	0.36	0.28	<0.01	0.15	0.07	0.13
Hrd1Fr[2]			0.58	-0.38	-0.11	-0.18	-0.17	0.52	0.29	-0.43	-0.23	-0.40	-0.30
			<0.01	0.04	0.58	0.35	0.36	<0.01	0.13	0.02	0.22	0.03	0.11
Hrd2Fr[2]				-0.36	-0.06	-0.10	-0.05	0.30	0.12	-0.24	-0.18	-0.20	-0.06
				0.05	0.74	0.60	0.77	0.10	0.52	0.20	0.35	0.30	0.75
Pith1Plt[3]					0.56	0.66	0.53	-0.11	0.18	-0.17	-0.27	-0.10	-0.29
					<0.01	<0.01	<0.01	0.57	0.35	0.37	0.16	0.58	0.12
Pith2Plt[3]						0.69	0.78	0.07	0.08	-0.15	-0.29	-0.23	-0.16
						<0.01	<0.01	0.72	0.69	0.43	0.12	0.22	0.39
Pith1Fr[4]							0.74	0.08	0.21	-0.37	-0.43	-0.27	-0.40
							<0.01	0.66	0.28	0.04	0.02	0.14	0.03
Pith2Fr[4]								0.18	0.15	-0.23	-0.41	-0.20	-0.19
								0.35	0.44	0.23	0.03	0.29	0.31
FiberPlt[5]									0.77	-0.48	-0.51	-0.52	-0.58
									<0.01	<0.01	<0.01	<0.01	<0.01
FiberFr[5]										-0.56	-0.59	-0.60	-0.72
										<0.01	<0.01	<0.01	<0.01
DIPlt[6]											0.70	0.75	0.69
											<0.01	<0.01	<0.01
DIFr[6]												0.46	0.83
												<0.01	<0.01
RatePlt[7]													0.57
													<0.01

[1]Plant-cane rind hardness from the 3rd (Hrd1Plt) and 4th (Hrd2Plt) internode below the top fully expanded internode.
[2]First ratoon crop rind hardness from the 3rd (Hrd1Fr) and 4th Hrd2Fr) internode below the top fully expanded internode.
[3]Plant-cane pith rating from the 3rd (Pith1Plt) and 4th (Pith2Plt) internode below the top fully expanded internode.
[4]First ratoon crop pith rating from the 3rd (Pith1Fr) and 4th (Pith2Fr) internode below the top fully expanded internode.
[5]Plant-cane fiber content (FiberPlt) and first ratoon crop fiber content (FiberFr).
[6]Percent damaged internodes from the plant (DIPlt) cane and first ratoon crop (DIFr).
[7]Mean damage rating in the plant cane (RatePlt) and first ratoon crop (RateFr).

DISCUSSION

Our study, like Davidson (1966), did not reveal a clear association of pith with resistance to sugarcane borer. This is in contrast to Agarwal (1959) who reported that varieties with pith suffered higher infestations of *Chilo tumidicostalis and C. infuscatellus* (old-world Lepidopteran stem borers). We did find negative correlations of pith with percent damaged internodes and damage ratings in the first ratoon crop. It is not known how pith might confer borer resistance. A more extensive study involving more individuals from a greater number of crosses and tested over more years is likely needed to determine with greater certainty the role that pith plays in determining resistance.

The weak association of pith and borer resistance, when compared to fiber and internode rind hardness with borer resistance, may be due to the large genotype x environment interaction reported for this trait (Gravois et al. 1990). This interaction suggests that certain genotypes (clones) may exhibit more pith associated resistance to the borer in some years than in other years. The large variation also makes it difficult to conduct a study, such as ours, as it is not always possible to assure that a selection with pith will express pith consistently and that one selected for not having pith will never express pith. As Lakshmikantham (1946) observed, we also found that ratoon crops have a higher incidence of pith than plant-cane crops, and this was the season in which there were negative correlations with internode damage and ratings. Perhaps pith is more important in conferring resistance in varieties like HoCP 85-845 that express pith consistently from year to year.

It was outside the scope of this study to calculate genotypic correlations for the resistance traits in this study with sugar yields. It has been well established, however, that pith and fiber are inversely related to yield (Gravois and Milligan 1992). This relationship has not been established with the target internode hardness, although our data suggest that target internode hardness and fiber content are moderately associated.

Results from our study suggest that repeated phenotypic clonal selection for borer resistance may result in genotypes of a similar phenotype. A typical borer resistant sugarcane plant would likely have high fiber content, high target internode rind hardness, and possibly higher levels of pith. This plant profile describes many of the selections coming out of our recurrent selection program for borer resistance. This may explain also why, as a group, our program produces clones with lower sugar yields than commercial levels. The goal is to use these borer-resistant clones in a crossing program with clones that are high yielding and borer-susceptible with the resulting progeny expressing both borer resistance and commercial yield potential. Otherwise, to obtain high levels of borer resistance without sacrificing yield may depend upon finding alternative sources of resistance not correlated with yield and to develop accompanying selection procedures to identify experimental clones with commercial value for these traits.

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