VARIETAL REACTION AND INHERITANCE TRENDS OF SUSCEPTIBILITY OF SUGARCANE TO RUST (*PUCCINIA MELANOCEPHALA* H. & P. SYD).[1]

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ABSTRACT

A total of 452 sugarcane clones were tested for their reaction to rust by field evaluation. These included introduced, locally-developed commercial and breeding varieties, the original clones of *Saccharum* species, and the *S. spontaneum* hybrids of F_1, BC_1, and BC_2 generations. The inheritance trends of susceptibility to rust were also studied.

It was found that nearly 54% of the clones tested were infected by the rust, and 15% were either susceptible or highly susceptible. In the genus *Saccharum*, most of *S. officinarum* clones were infected with the rust although the infection in most cases was mild. A clear inheritance trend of rust susceptibility was established from percent infection values of the original seedlings. These values were obtained from crosses with parental varieties having known reactions to the disease. In addition to variety, other factors affecting the incidence of the disease are discussed.

INTRODUCTION

Sugarcane rust was first detected in Puerto Rico in October, 1978. The causal organism was identified as *P. melanocephala* H. & P. Syd. (6, 7). The disease was also discovered recently in the Dominican Republic, Jamaica, Florida, and Louisiana[3] (1, 5, 8).

These are two rusts of sugarcane identified as *P. kuehnii* Bull and *P. erianthi* Padw & Khau (= *P. melanocephala* H. & P. Syd.) (2, 3). The former is widespread in South East Asia and Australia, and has a restricted distribution in Africa. The latter has a more limited occurrence in central East Africa, China, India, and Nepal (3). In India, *P. melanocephala* is reportedly confined to cultivated sugarcane, while *P. kuehnii* has been found on *S. spontaneum*, other wild canes, and certain related genera (4, 8).

Rust caused by *P. kuehnii* is of little economic importance in most countries. However, the disease caused by *P. melanocephala* has produced severe damage in India where the variety Co 475 was withdrawn from commercial use because of its high susceptibility (8). The recent outbreaks of this same rust in the Caribbean area are causing great

[1] Manuscript submitted to Editorial Board December 17, 1979.

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concern. Approximately 30% of the Dominican Republic crop and 12% of the Jamaica crop are now planted with variety B 4362, which has been found to be highly susceptible to the disease (5, 7).

In view of the extensive spread of this rust in Puerto Rico since October 1978, a series of natural infection trials was conducted to determine the impact of the disease on commercial cane varieties and the sugarcane breeding program. Efforts were also made to study inheritance trends toward rust susceptibility in sugarcane. The results obtained from these studies are briefly presented in this paper.

TABLE 1.—*Rating system employed in evaluating sugarcane susceptibility to rust*

Grade	Description of rust infection	Reaction (Apparent susceptibility)
1	No symptoms	
2	A few isolated lesions over the tips of a few older leaves	Highly resistant (HR)
3	Additional lesions over older leaves	
4	Lesions in aggregates over old leaves of a greater part of the plant and small pustules occurring in the center of necrotic lesions	Resistant (R)
5	Additional and larger aggregated lesions with pustules over nearly all old leaves	Intermediate (I)
6	Lesions with larger pustules over old leaves and some of the young leaves	Susceptible (S)
7	Additional young leaves having larger aggregated lesions and pustules	
8	Heavy pustules over aggregated lesions covering most of the young leaves. Portions of the old leaves severely desiccated	Highly susceptible (HS)
9	Plants severely infected appearing as if they were fired previously	

MATERIALS AND METHODS

A total of 452 clones were tested for rust susceptibility in field evaluations at the UPR-AES Gurabo Substation, Gurabo, Puerto Rico. These include original clones of *S. officinarum*, *S. spontaneum*, *S. robustum*, and *S. sinense*. Hybrids of F_1, BC_1, and BC_2 of *S. spontaneum*, as well as commercial varieties and clones used in the local breeding program, were also tested. Approximately 300 clones were planted in single-row plots, in 15-ft rows spaced 5 feet apart, during early February 1979. The remaining clones were ratooned in mid-February 1979. Each plot included two 30-ft rows spaced 5 feet apart. Three varieties having known susceptibility, including PR 67-1070 (HR)[4], PR 67-1355 (MR), and PR 67-3129 (HS),

[4] Abbreviations: HR (highly resistant); MR (moderately resistant); HS (highly susceptible).

TABLE 2.—*Rust reaction of Non-Puerto Rican sugarcane clones*

Clone	Rust rating	Clone	Rust rating
B 3439	2	B 60267	4
B 34104	2	BH 10 (12)	5
B 37161	6	BO 11	1
B 37172	1	BO 17	2
B 4098	6	BO 24	5
B 4145	6	CB 3822	1
B 41227	5	CB 4176	4
B 42231	3	CB 44105	6
B 4362	9	CB 4644	5
B 43337	2	CB 4812	1
B 44341	2	CB 4915	1
B 45151	3	Co 281	2
B 46136	3	Co 290	2
B 4744	6	Co 301	1
B 47258	1	Co 312	2
B 49119	1	Co 419	5
B 49198	1	Co 421	5
B 50112	6	Co 449	5
B 50377	1	Co 453	5
B 52107	6	Co 475	9
B 54172	2	Co 617	1
B 5744	1	Co 622	1
B 59233	1	Co 650	5
Co 658	1	H 41-3340	1
Co 740	1	H 44-3098	1
Co 775	5	H 48-4178	6
Co 997	5	H 49-5	9
CoK 32	1	H 49-134	1
CoL 9	1	H 49-3533	9
Co 6806	1	H 50-7209	1
Co 1148	1	H 51-760	5
CP 34-79	1	H 51-3346	5
CP 48-103	1	H 52-4610	4
CP 52-1	1	H 53-263	6
CP 52-43	1	H 53-1447	3
CP 52-68	5	H 54-775	5
CP 57-603	1	H 54-2508	3
CP 61-37	5	L 60-14	4
CP 65-357	5	L 60-25	1
Eros	4	Luna	1
F 134	2	M 134-32	1
F 141	1	M 213-40	5
F 144	1	M 147-44	6
F 146	1	M 149-44	6
F 160	1	M 202-46	3
H 32-8560	1	M 93-48	5
H 37-1933	1	M 253-48	2
H 39-3633	1	M 305-49	1
M 423-51	7	Q 59	2
M 115-58	2	Q 62	2

TABLE—*Continued*

Clone	Rust rating	Clone	Rust rating
Mex 52-17	5	Q 64	2
Mex 52-29	3	Q 66	2
Mex 53-142	4	Q 67	4
Mex 54-245	2	Q 68	2
MQ 657	3	Q 69	3
NCo 310	1	Q 70	4
NCo 334	1	Q 72	5
NCo 376	1	Q 73	2
Pindar	5	Q 75	1
POJ 2878	1	Q 76	5
POJ 2946	2	Q 79	5
POJ 3016	1	Q 90	8
POJ 3067	2	Q 94	4
PT 43-52	1	Trojan	5
Q 55	2	Tuc 2645	1
Q 58	5	Tuc 2638	1

were included in each of two experiments as reference varieties. The border rows of both experiments were planted with susceptible varieties in order to provide a high incidence of rust pathogen. To hasten plant growth and rust development, plots were irrigated at 15- to 20-day intervals.

The first ratings on rust reaction for each test clone were taken May 18, 1979. The ratoon plants were approximately 3 months old and the plant canes 3 1/3 months. The second and third ratings followed at intervals of approximately 1 month. Rust evaluations for unselected original seedlings were made in early November, approximately 5 months after the seedlings were transplanted to the field. Table 1 shows the rating system employed in evaluating rust susceptibility.

The percent infection for the original seedlings was computed from the total number of seedlings per cross inspected from three to four rows (around 100 to 150 stools). Samples were taken at random and the number of infected stools recorded.

RESULTS

Tables 2, 3 and 4 show the highest grade of susceptibility to rust of each clone. The results indicate that out of 133 introduced clones, 83 clones (63.9%) were infected with the rust. Seventeen clones (12.8%) were rated as susceptible or highly susceptible, and 26 clones (19.7%) were found to have intermediate susceptibility. Ninety clones were resistant or highly resistant. The highly susceptible varieties are B 4362, Co 475, H 49-5, H 49-3533, and Q 90. The varieties rated as susceptible are B 37161, B 4098, B 4145, H 53-263, M 147-44, M 149-44, and M 423-51 (table 2).

TABLE 3.—*Rust reaction of Puerto Rican commercial varieties and some important breeding clones*

Clone	Rust rating	Clone	Rust rating
M 336	6	PR 1117	1
PR 900	2	PR 1128	1
PR 975	1	PR 1132	8
PR 980	1	PR 1137	7
PR 1000	1	PR 1140	2
PR 1002	1	PR 1141	1
PR 1013	5	PR 1146	9
PR 1016	1	PR 1148	2
PR 1028	1	PR 1152	1
PR 1039	8	PR 1155	8
PR 1043	6	PR 1158	6
PR 1047	7	PR 1175	6
PR 1048	6	PR 1203	1
PR 1049	6	PR 1208	1
PR 1059	6	PR 1248	7
PR 1062	5	PR 1249	1
PR 1065	5	PR 61-632	2
PR 1070	1	PR 62-195	1
PR 1082	1	PR 62-739	1
PR 1085	7	PR 63-192	6
PR 1097	1	PR 63-227	4
PR 1111	2	PR 63-525	4
PR 1116	1	PR 64-245	4
PR 64-282	7	PR 67-137	5
PR 64-610	2	PR 67-245	2
PR 64-1548	1	PR 67-406	3
PR 64-1618	1	PR 67-1070	1
PR 64-1791	6	PR 67-1246	1
PR 64-2705	9	PR 67-1336	1
PR 65-109	8	PR 67-1355	5
PR 65-132	1	PR 67-2295	7
PR 65-153	1	PR 67-2467	1
PR 65-413	6	PR 67-3016	1
PR 65-491	1	PR 67-3052	9
PR 65-551	2	PR 67-3073	7
PR 65-556	4	PR 67-3097	9
PR 65-903	3	PR 67-3129	9
PR 65-1279	4	PR 67-3210	8
PR 65-2638	6	PR 68-43	8
PR 66-1240	5	PR 68-77	7
PR 66-1313	1	PR 68-81	7
PR 66-1350	1	PR 68-82	1
PR 66-1367	1	PR 68-100	1
PR 66-2281	1	PR 68-123	3
PR 67-35	3	PR 68-132	1
PR 67-49	9	PR 68-149	1
PR 67-110	4	PR 68-156	1
PR 67-127	5	PR 68-161	2
PR 68-163	2	PR 69-42	1

TABLE—*Continued*

Clone	Rust rating	Clone	Rust rating
PR 68-188	6	PR 69-51	4
PR 68-189	8	PR 69-83	7
PR 68-236	2	PR 69-99	6
PR 68-239	9	PR 69-177	3
PR 68-254	1	PR 69-222	8
PR 68-258	6	PR 69-243	8
PR 68-330	1	PR 69-325	1
PR 68-335	1	PR 69-344	8
PR 68-1020	2	PR 69-347	8
PR 68-1099	1	PR 69-455	4
PR 68-1216	1	PR 69-2030	1
PR 68-2241	6	PR 69-3065	7
PR 68-2246	8	PR 69-3072	6
PR 68-2319	1	PR 69-3081	1
PR 68-3041	2	PR 69-3134	5
PR 68-3042	1	PR 69-3141	1
PR 68-3045	3	PR 69-3172	3
PR 68-3083	9	PR 69-3329	1
PR 68-3120	1	PR 70-3086	1
PR 68-3180	2	PR 70-3159	1
PR 68-3184	2	PR 70-3265	1
PR 68-3190	3	PR 70-3364	5
PR 69-2	9	PR 70-3389	1
PR 69-23	1	PR 70-3391	5
PR 70-3413	9	PR 71-334	1
PR 70-3419	1	PR 71-350	7
PR 70-3462	1	PR 71-358	1
PR 70-3469	1	PR 71-372	6
PR 70-3566	7	PR 71-373	4
PR 70-3855	1	PR 71-400	4
PR 70-3884	1	PR 71-407	7
PR 71-3	1	PR 71-422	4
PR 71-37	1	PR 71-494	3
PR 71-135	2	PR 71-556	1
PR 71-239	9	PR 71-659	8

Out of 194 PR clones examined, approximately 54% were infected, and of these, 27% were rated as susceptible or highly susceptible to the disease (table 3). Of the commercial PR varieties, PR 980, PR 1028, PR 1152, PR 66-2281, PR 64-1618, PR 62-258, PR 61-632, PR 62-195. PR 62-739, PR 63-525, and PR 64-610 are highly resistant to rust; and PR 1059, PR 63-192, PR 64-1791, and PR 65-413 are susceptible. Among the potential commercial varieties, PR 1141, PR 65-153, PR 65-551, PR 67-245, and PR 67-1070 are highly resistant; and PR 64-2705, PR 67-3129, and PR 70-3413 are highly susceptible.

Most of the 35 *S. officinarum* clones tested were infected with rust, although only three of them were rated as susceptible (table 4). The *S. robustum* clones showed considerable resistance.

Rust susceptibility for a total of 73 *S. spontaneum* hybrids (including 22 F_1, 32 BC_1, and 19 BC_2 clones introduced from the USDA Field Laboratory at Houma, Louisiana) was evaluated. Figure 1 shows the percent infection for each of three breeding generations. The lowest percent infection was obtained from the first generation hybrids (F_1), of

TABLE 4.—*Rust reaction of the Saccharum species*

Clone	Species	Rust rating	Clone	Species	Rust rating
Black cane	*S. officinarum*	2	96NG16	*S. officinarum*	3
Djapara red	*S. officinarum*	6	96NG24	*S. officinarum*	2
Fiji 22	*S. officinarum*	2	SS-572	*S. officinarum*	6
Fiji 33	*S. officinarum*	2	Lahaina	*S. officinarum*	5
Fiji 60	*S. officinarum*	4	21NG7	*S. officinarum*	3
Cjuan A	*S. officinarum*	5	51NG13	*S. officinarum*	1
HA Orig 52	*S. officinarum*	3	51NG36	*S. officinarum*	4
NC 24	*S. officinarum*	1	57NG155	*S. officinarum*	2
21NG12	*S. officinarum*	7	57NG237	*S. officinarum*	4
21NG20	*S. officinarum*	2	Molokal 4503	*S. robustum*	1
28NG12	*S. officinarum*	2	Molokal 4861	*S. officinarum*	1
28NG83	*S. officinarum*	3	28NG289	*S. officinarum*	2
28NG110	*S. officinarum*	4	57NG11	*S. officinarum*	1
28NG217	*S. officinarum*	4	57NG54	*S. officinarum*	2
28NG284	*S. officinarum*	4	57NG55	*S. officinarum*	2
28NG288	*S. officinarum*	2	57NG56	*S. officinarum*	1
51NG121	*S. officinarum*	2	57NG83	*S. officinarum*	1
51NG122	*S. officinarum*	2	57-142-4	*S. officinarum*	1
51NG124	*S. officinarum*	2	28NG219	*S. officinarum*	1
51NG127	*S. officinarum*	2	Chunnee	*S. sinense*	4
51NG13	*S. officinarum*	1	Natal Uba	*S. sinense*	6
57NG14	*S. officinarum*	5	Saretha	*S. sinense*	4
57NG41	*S. officinarum*	2	Tainan	*S. spontaneum*	1
57NG76	*S. officinarum*	2	SES 231	*S. spontaneum*	1
57NG83	*S. officinarum*	1	SES 327	*S. spontaneum*	1
57NG228	*S. officinarum*	4	SES 317	*S. spontaneum*	1

S. spontaneum, and the highest from the third generation hybrids (BC_2).

Figure 2 shows the percent infection for the original seedlings of crosses having parental varieties of known susceptibility to rust. The mean values for percent infection of the four groups of crosses are 2.3, 25.8, 30.2, and 90.9 (corresponding to resistant x resistant crosses, resistant × susceptible crosses (or vice versa), susceptible × unknown parent, and susceptible × susceptible crosses, respectively).

DISCUSSION

The two field experiments for determining rust susceptibility in sugarcane are considered successful from the standpoint of the consistent reaction for each of three reference varieties and a number of prereleased clones planted in several farms on the Island. Additional evidence supporting this view is the similar high susceptibility obtained here with varieties B 4362, Co 475, and H 49-5, reported previously outside of Puerto Rico (7, 8).[5]

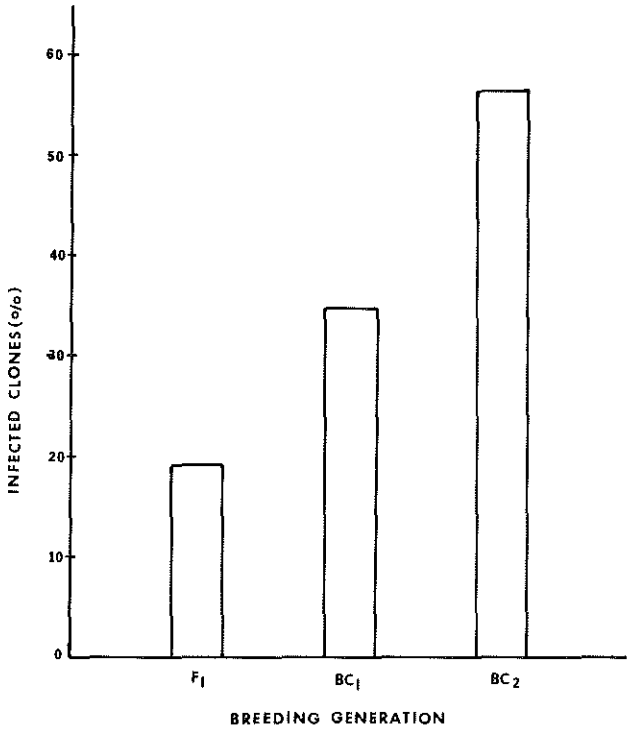

FIG. 1.—Rust reaction for the clones of the F_1, BC_1, and BC_2 hybrids of *S. spontaneum*.

The highest susceptibility levels for most of the clones tested were found in May, and the lowest in July. The July ratings generally tend to be one grade lower than those in May for most of the varieties tested. This suggests that the higher temperatures occurring in June and July at the experimental site are one of the explanations as to why most of test clones recovered gradually from rust infection in July and thereafter.

[5] The senior author observed the variety H 49-5 planted at Canal Point breeding collection was severely infected with this rust during his trip in August, 1979.

However, during the field survey it was often found that the age of cane also has something to do with rust infection. This was evidenced by the fact that only mild infections were noticed in adult canes, while severe infections could be found in adjacent canes of the same variety aged two to six months. These observations indicate that this rust may not be expected to cause economic losses to the varieties rated at their early growing stage as having high or intermediate resistance to the disease.

In view of the fact that most *S. officinarum* clones in the tests were infected with the rust (table 3), and the percent infection of clones of *S. spontaneum* hybrids steadily increased as a result of the nobilization process (fig. 1), the rust susceptibility of the modern commercial hybrids

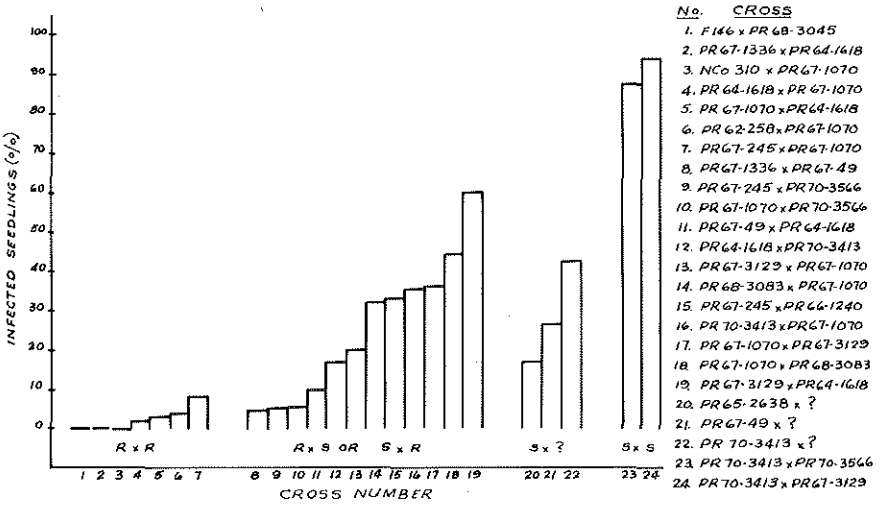

FIG. 2.—Rust reaction for the seedlings of the crosses having parental varieties of known susceptibility in 4 groups: (1) R × R, (2) R × S or S × R, (3) S × ? and (4) S × S.

is assumed to be mainly transmitted by some *officinarum* clones which are susceptible to rust. On the other hand, *S. spontaneum* and *S. robustum* could be considered as a good source of genes for resistance to the disease.

Sugarcane is highly heterozygous. Thus it is difficult to determine the genetic nature of the plant's susceptibility or resistance to the rust. The existence of high polyploidy in sugarcane further complicates the situation. However, the data presented in figure 2 clearly show the trend of inheritance for the character studied. On the basis of a wide range of segregation incident to the degree of susceptibility of F_1 progenies observed during the survey, and a markedly higher percentage of infection obtained from the crosses with both parental varieties having suscepti-

bility to rust, the character for susceptibility is not likely to be determined by a single gene.

Fortunately the current major commercial cane varieties in Puerto Rico were found to be highly resistant to rust. However, about 54% of the breeding clones were infected with rust, and 25 percent were rated as susceptible. Steps have been taken to rebuild our germplasm pool by eliminating susceptible breeding canes, introducing additional rust-resistant varieties, and incorporating this material into the elite breeding lines in order to broaden the base of resistance in our germplasm pool.

RESUMEN

Un total de 452 clones de caña de azúcar se probaron en el campo para evaluar la reacción a la roya. Se usaron variedades comerciales desarrolladas en nuestro programa de mejoramiento, clones originales de la especie *Saccharum* e híbridos de *S. spontaneum* de las generaciones F_1, BC_1 y BC_2. Se hizo un estudio de la tendencia hereditaria de la susceptibilidad a la roya.

El 54% de los clones estudiados estaban infectados con la enfermedad; 15% se evaluaron como susceptibles o muy susceptibles. Se presume que la principal fuente de susceptibilidad a la roya en el género *Saccharum* es *S. officinarum*. La tendencia hereditaria a la susceptibilidad a la roya se estableció mediante el porcentaje de infección que mostraron los seedlings originales.

Cruces de las variedades progenitoras cuya reacción a la enfermedad ya se conoce, sirvieron de base para fijar estos valores. Se examinaron otros factores que influyen en la incidencia de la enfermedad.

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