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Responses of Rice Mini-Core Collection Accessions to Damage by *Diatraea saccharalis* (*Fabricius*) Stem Borer

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Abstract

This study aimed to observe the response of 32 rice accessions to attack of sugarcane borer (*Diatraea saccharalis* Fabr., 1794). Twenty larvae were placed on the leaf sheaths of rice plants. At 30 days after infestation, the rice plants were cut at ground level and taken to the laboratory to analyse the signs of borer attack, external and internal diameter of the stem and weight of surviving larvae. The results of the morphological traits of the rice plant, response of the plant to insect attack and development of the sugarcane borer larvae indicated a genotypic variation. The accessions that most favored larval survivals were IRAT 124 and MEARIN. Larvae with highest weight (0.0643 g) were found in IAPAR L 99-98 and the largest internal diameters of the rice stem (5.65 mm) were found in LAC 12. These accessions (IRAT 124, MEARIN, IAPAR L 99-98 and LAC 12) remained morphologically grouped with IAC 47, cultivar susceptible to sugarcane borer. The most tolerant materials based on the ability to produce new tillers after larval infestation were BR IRGA 417 and MTU 15. The results of this study indicate that all the morphological traits were able to separate the accessions of rice into different groups in relation to resistance to the sugarcane borer *D. saccharalis.* These materials can be used as donor sources in pre-breeding for genetic resistance to sugarcane borers.

Keywords

Rice, Sugarcane Borer, Morphological Traits, Resistance

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1. Introduction

Rice is one of the most important cereals in the world, which is responsible in developing countries for 95.2% of

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global consumption and 95.9% of production. Brazil ranks ninth in the world production and first outside the Asian continent [1]. Yield can be affected by several abiotic and biotic factors [2]. In regards to the biotic factors, insects are the pests that cause the most damage to this crop; and among these insects, the sugarcane borer *Diatraea saccharalis* Fabricius (Lepidoptera: Crambidae) is found all over the Brazil infesting various grasses and causing economic losses in crops of upland and irrigated rice. This insect is of major importance for rice in the North and Midwest regions of Brazil [3].

The increased level of sugarcane borer damage to upland rice in recent years has been primarily observed in the state of Mato Grosso, Brazil. The increased damage in Mato Grosso is attributed to the expansion of corn (*Zea mays*) and sugarcane (*Saccharum officinarum*), which are primary hosts of the sugarcane borer [4]. The largest problem in the effective management of this pest is the difficulty in monitoring in order to detect the pest before damage occurs. It is most easily detected only after penetration of the stem and the production of white-heads or dead panicles [5]-[9]. It is also difficult to control with pesticides, as proper timing of application is difficult. Moreover, no pesticides are registered for control of the sugarcane borer in Brazilian rice [4].

Host plant resistance (HPR) is a practical way to overcome the stem borer constraint in rice production, and may be a particularly appropriate and important tactic against these insects [10]. Morphological traits are an important factor in conferring HPR, and are responsible for the suitability of a cultivar for feeding by the insects as well as oviposition and development. In many crop species, the degree of a genotype's resistance to insect pests is associated with the plant's morphological characteristics. Borer damage has been reported to affect plant growth and specifically ear development, which negatively impacts grain yield. The number of exit holes is an indication of the number of borers that have successfully completed their life cycle within a stem, while the stem tunnels indicate the extent of plant damage [11] [12].

Host plant resistance has been a major focus of stem borer management studies in both Asia and the United States [13]-[15]. However, limited studies have been conducted to identify sugarcane borer resistant cultivars in Brazil, and there are no identified donor cultivars in the Brazilian genotypes with adequate resistance to the borers for use in the breeding program. Thus, there is a need to enhance the levels of genetic resistance of adapted Brazilian cultivars for use as a component in the integrated management of the sugarcane borer in upland rice.

The objective of this study was to evaluate the response of 32 accessions of the rice mini-core collection of the genebank of the Brazilian Agricultural Research Corporation (Embrapa) Rice and Beans to infestations of the sugarcane borer *D. saccharalis*, identifying sources of resistance to this borer, and to correlate insect resistance with morphological characteristics of the plants.

2. Materials & Methods

2.1. Plant Material

A total of 32 accessions of *Oryza sativa* were included in this study (**Table 1**). These accessions have been maintained at EMBRAPA Rice and Beans Center, located in Santo Antônio de Goiás, Goiás (GO), Brazil (altitude 749 m; 16˚40'43"S; 49˚15'14"W). The rice accessions selected for this study are genotypes of the subspecies *indica* and *japonica* with a wide genetic divergence between them, constituents of the rice mini-core collection [16]. The accessions have potential to be good donors in the pre-breeding program as based in the adaptation to the upland rice production in areas where conditions of stem borers is becoming of increasing importance in Brazil.

2.2. Evaluation of the Resistance Trait of Rice Accessions

The response of rice due to sugarcane borer attack was determined in greenhouse under natural conditions (temperature and relative humidity were recorded by a datalogger model AZ 8829). The water irrigation was performed once a day, and a weeding was used only as weed control. The fertilizer recommended was followed by Sousa and Lobato [17]. The experimental design was a randomized block with ten replications. A replication consisted of ten plants, each of which was infested with two neonate larvae of *D. saccharalis* per plant.

The neonate *D. saccharalis* larvae used to infest the rice plants were obtained from eggs provided by the company Biocontrol®, Sertãozinho, SP, Brazil where the borer was reared on an artificial diet [21]. The cards with the eggs of the sugarcane borer were treated with copper sulfate in the laboratory of Biocontrol® and shipped to Goiás. There they were maintained until larval emergence in the EMBRAPA Rice and Beans Entomology laboratory in acrylic type 350 ml germination boxes (Gerbox) [22] also containing moistened cotton.

Table 1. Identification number, crop system, origin, common name and level of resistance to rice stem borers of selected rice accessions in the mini-core collection of the Embrapa Rice and Beans genebank.

Identification number[1]	Crop system	Country of origin	Common name	Levels of resistance	Stem borer species	Reference
CNA0002293	Irrigated	Thailand	KU 94-2	-	-	-
CNA0002416	Irrigated	Liberia	LAC 12	-	-	-
CNA0002258	Irrigated	Thailand	KU 56-3	-	-	-
CNA0008229	Irrigated	India	BASMATI 370	-	-	-
CNA0002672	Irrigated	Thailand	NAHNG PAYA 132	-	-	-
CNA0010675	Irrigated	Brasil	BR IRGA 417	-	-	-
CNA0007553	Irrigated	Brasil	BRS FORMOSO	-	-	-
CNA0005014	Irrigated	China	WU 10 B	-	-	-
CNA0002480	Irrigated	Cameroon	M 40	-	-	-
CNA0002442	Irrigated	USA	LEBONNET	-	-	-
CNA0003195	Irrigated	Egypt	GZ 944-5-2-2	-	-	-
CNA0010433	Irrigated	Japan	MOGAMI CHIKANARI	-	-	-
CNA0006961	Irrigated	Italy	VITRO	-	-	-
CNA0005853	Irrigated	Russia	WIR 5621	-	-	-
CNA0010438	Irrigated	Japan	TOMOE MOCHI	-	-	-
CNA0002881	Irrigated	Portugal	RIZZOTO 159	-	-	-
CNA0003005	Upland	India	SONA	-	-	-
CNA0005461	Upland	India	CO 18	Resistent	*Scirpophaga incertulas*	[18]
CNA0005462	Upland	India	MTU 15	Resistent	*Chilo suppressalis* *Scirpophaga incertulas*	[18]
CNA0003490	Upland	France	MEARIN	-	-	-
CNA0005465	Upland	India	W 1253	-	-	-
CNA0010503	Upland	Philippines	YN1905-UUL-62	-	-	-
CNA0006422	Upland	Brazil	IAPAR L 99-98	-	-	-
CNA0004480	Upland	France	IRAT 124	-	-	-
CNA0004759	Upland	Nigeria	TOX514-16-101-1	-	-	-
	Upland	Brazil	CURINGA	-	-	-
CNA0005287	Upland	France	IRAT 162	-	-	-
CNA0010476	Upland	Philippines	B8503-TB-19-B-3	-	-	-
CNA0008070	Upland	Brazil	BRS PRIMAVERA	Moderately resistant	*Diatraea saccharalis*	[19] [20]
CNA0004243	Upland	India	OR 63-252	-	-	-
CNA 0002023	Upland	Brazil	IAC 47	Susceptible	*Elasmopalpus lignosellus* *Diatraea saccharalis*	[5] [20]
CA 220268	Upland	Brazil	CANELA DE FERRO			-

[1] The identification number used in the Embrapa Rice and Beans genebank.

The neonate larvae were placed on the leaf sheaths of rice plants with a fine camel's hair brush. Thirty days after infestation, the rice plants were cut close to the ground and taken to the laboratory where the stems were examined. The following phenotypic data of the accessions were recorded: NLL—number of live larvae/stem; IM—individual mass in grams of surviving worms; ED—external diameter of the stem; ID—internal diameter of the stem; NTT—number of total tillers by 30 days after larval infestation (period corresponding to the last larval instar); NSA—number of stems attacked after larval infestation and NLD—number of stems with no larval damage after larval infestation. The diameters of the stem were measured with a caliper model DIGIMESS in the middle part of the plants.

2.3. Statistical Analyses

The data collected in this study were not normally distributed. Thus, we opted for the non-parametric analysis. The Kruskal-Wallis test was performed to evaluate differences among the rice accessions. [23], while multivariate statistics were performed to verify the separation of groups in the population for resistance to *D. saccharalis*. A CVA (Canonical Variable Analysis), the matrix of Mahalanobis distance (D^2) and Tocher's grouping method [24] was calculated using GENES software [25].

3. Results and Discussion

3.1. Evaluation of the Resistance Trait of Rice Accessions

3.1.1. Univariate Analysis

The phenotypic response of rice accessions to the borer, *D. saccharalis*, was significant ($P < 0.05$) by Kruskal-Wallis test at 5% significance level, for the traits evaluated which indicated of the occurrence a genetic variation (**Table 2**). The accesses that were more favorable to the survival of stem borers were IRAT 124 and MEARIN. Among the accessions with the lowest number of live larvae were KU 94-2 and BRS PRIMAVERA which indicated that they were less favorable to the survival of the insect. This was probably due to the antibiotic effect of cultivars on insect biology (**Table 2**).

With the total number of stems after infestation (NTT) and normal stem (NLD), it was observed that BASMATI 370, BR IRGA 417, BRS FORMOSO, SONA, MTU15, MEARIN and W1253 were more tillers after infestation and a higher number of normal stem at the end of the experiment, which was indicative of favorable characteristics of the presence of resistance of the type tolerance by the sugarcane, respectively (**Table 2**).

There is also a relationship between survival (NLL) and individual mass (IM) of surviving larvae with the external diameter (ED) and internal diameter (ID) of the stem. This indicates that the larvae were heavier and had greater survival chances when feeding on plants with larger stem diameters. The morphological characteristics (large external diameter of the stem and an internal diameter of the stem greater than 2.5 mm) which favored the growth and development of the sugarcane borer are common in susceptible accessions.

3.1.2. Multivariate Analysis

The genetic dissimilarity estimated by the Mahalanobis distance (D_2) (**Table 3**) indicated that the accessions that were most divergent (dissimilar) (D^2 max: 21.99) were accession WU 10B (accession ID 8) and IAPAR L 99-98 (23), while MOGAMI-CHIKANARI (ID 12) and CO18 (ID 18) were the most similar (D^2 min: 0.35). With the cluster analysis by Tocher's grouping method, it was possible to observe four groups (**Table 4**), with the largest number (21) of accessions in Group I. This group had important traits for susceptibility to the sugarcane borer while the third group (**Table 4**) consisted of accessions (8: WU 10 B; 10: LEBONNET, 11: GZ 944-5-2-2, 29: BRS PRIMAVERA) that were with traits for resistance indicated in **Table 2**.

By employment of the canonical variable analysis (CVA) clustering method, it was possible to observe the distribution of accessions in a two-dimensional graph (**Figure 1**). The positions of the accessions in the graph were apparently distributed into two groups, one large (Group I) and one medium (Group II) and one isolated accession (WIR 5621) as the most divergent. The first three canonical variables explained 87.52% of the total variability available (**Figure 1**) among the seven characters (**Table 2**) describing the 32 rice accessions.

The results of this analysis allow inferences about the response of the accession under study, which is useful information in determining the number of groups in the cluster analysis. The graphic dispersion of scores of the three canonical variables shows good agreement with the Tocher's grouping method, allowing the cultivars ID 14, 8, 10, 11 and 29 as the most divergent compared others. The use of multivariate analysis allows the identification of parents with genetic divergence and has been studied in breeding programs [26] [27]. Another important fact that should be considered in the choice of parents is whether they belong to different groups, in order to avoid crossing between parents belonging to the same group [25].

Various morphological traits of the rice plant were found to be associated with resistance to the stem borer. The resistance in rice to stem borer was low to moderate and appeared to be under polygenic control [28]. Many morphological, anatomical, physiological, and biochemical factors have been reported to be associated with resistance, each controlled by different sets of genes. Positive correlations were recorded between the number of bored stems and stem diameters, stem thickness, length and width of flag leaves and number of tillers per plant.

The rice accessions with higher tiller and thinner stem diameter such as BR IRGA 417, SONA and MTU 15 were tolerant to sugarcane borer, because thin stem diameter characteristics does not allow larvae to feed and develop inside the plant colm [29]. This meant that with increasing stem diameters, the number of larvae was increased. The data showed that accessions with higher tillering capability after infestation have a distinct capability to recover from the damage caused by the stem borer. The rice resistance to sugarcane borers is associated with tillering capacity of the plant after infestation, a characteristic of tolerant genotypes [7].

Table 2. Number of live larvae on the plant (NLL), individual mass (IM) in grams of surviving larvae, external diameter of stem (ED) and internal diameter of stem (ID) in mm, number of total tillers produced (NTT), number of stems attacked (NSA) and number of stems with no larval damage (NLD) after larval infestation on 32 rice accessions evaluated to detect resistance to *Diatraea saccharalis*.

Accessions[a]	Average						
	NLL	IM	ED	ID	NTT	NLD	NSA
1-KU 94-2	2.4 d	0.0321 abcde	4.89 abcd	2.66 abc	10.3 ab	7.0 a	3.3 ab
2-LAC 12	7.5 abcd	0.0274 bcde	5.65 a	2.95 a	10.2 ab	6.6 ab	3.6 ab
3-KU 56-3	3.5 abcd	0.0385 abcde	5.15 ab	2.80 ab	10.1 ab	7.3 a	2.8 ab
4-BASMATI 370	7.5 abc	0.0527 ab	4.12 abcdefgh	2.05 abcdefghi	11.8 a	7.5 a	4.3 ab
5-NAHNG PAYA 132	4.6 abcd	0.0199 cde	4.63 abcde	2.54 abcdef	9.8 ab	6.5 ab	3.3 ab
6-BR IRGA 417	7.4 abcd	0.0553 ab	3.85 abcdefgh	1.97 bcdefghij	12.8 a	7.4 a	5.4 a
7-BRS FORMOSO	5.7 abcd	0.0395 abcde	4.27 abcdefg	2.09 abcdefgh	11.2 a	7.0 a	4.2 ab
8-WU 10 B	3.9 abcd	0.0137 de	2.94 gh	1.27 j	8.9 ab	5.8 ab	3.1 ab
9-M 40	7.6 abcd	0.0337 abcde	4.29 abcdef	2.16 abcdefgh	10.4 ab	5.6 ab	4.8 ab
10-LEBONNET	2.9 bcd	0.0115 e	3.44 fgh	1.67 hij	10.4 ab	7.6 a	2.8 ab
11-GZ 944-5-2-2	4.8 abcd	0.0209 cde	3.07 h	1.39 ij	11.3 a	6.9 ab	4.4 ab
12-MOGAMI CHIKANARI	4.7 abcd	0.0360 abcde	3.56 fgh	1.83 efghij	10.2 ab	6.1 ab	4.1 ab
13-VITRO	6.3 abcd	0.0445 abcde	4.93 abcd	2.63 abcd	9.9 ab	6.4 ab	3.5 ab
14-WIR 5621	6.1 abcd	0.0401 abcde	3.24 fgh	1.70 defghij	4.6 b	1.1 b	3.5 ab
15-TOMOE MOCHI	3.4 abcd	0.0263 bcde	4.24 abcdefg	2.16 abcdefgh	10.9 a	6.5 ab	4.4 ab
16-RIZZOTO 159	7.7 ab	0.0452 abcd	4.05 abcdefgh	2.01 abcdefgh	9.3 ab	5.1 ab	4.2 ab
17-SONA	5.7 abcd	0.0552 abc	3.66 defgh	1.80 efghij	12.5 a	7.8 a	4.7 ab
18-CO18	5.1 abcd	0.0380 abcde	3.66 efgh	1.91 defghij	11.2 a	6.3 ab	4.9 ab
19-MTU 15	4.6 abcd	0.0451 abcd	3.83 bcdefgh	1.68 hij	12.4 a	8.3 a	4.1 ab
20-MEARIN	8.0 abc	0.0444 abcd	3.87 bcdefgh	1.98 bcdefghij	12.3 a	7.5 a	4.8 ab
21-W 1253	5.1 abcd	0.0452 abcd	3.72 defgh	1.76 ghij	11.1 a	7.6 a	3.5 ab
22-YN1905-UUL-62	4.5 abcd	0.0479 abcd	4.44 abcdef	2.22 abcdefgh	9.3 ab	5.9 ab	3.4 ab
23-IAPAR L 99-98	6.6 abcd	0.0643 a	4.29 abcdefg	2.32 abcdefgh	9.6 ab	4.9 ab	4.7 ab
24-IRAT 124	8.6 a	0.0553 ab	3.79 bcdefgh	1.86 defghij	10.4 ab	5.6 ab	4.8 ab
25-TOX 514-16-101-1	5.5 abcd	0.0497 abc	3.82 bcdefgh	1.94 defghij	10.6 a	6.7 a	3.9 ab
26-BRS CURINGA	3.3 abcd	0.0318 abcde	4.39 abcdef	2.24 abcdefgh	10.3 ab	6.9 a	3.4 ab
27-IRAT 162	3.4 abcd	0.0458 abcde	4.96 abc	2.40 abcdefg	8.5 ab	6.4 a	2.1 b
28-B8503-TB-19-B-3	6.4 abcd	0.0514 abc	4.10 abcdefgh	1.95 cdefghij	10.8 a	5.7 ab	5.1 ab
29-BRS PRIMAVERA	2.8 cd	0.0247 bcde	3.34 fgh	1.77 fghij	9.2 ab	6.0 ab	3.2 ab
30-OR 63-252	4.5 abcd	0.0325 abcde	3.78 cdefgh	1.77 ghij	9.5 ab	6.4 ab	3.1 ab
31-IAC 47	4.9 abcd	0.0352 abcde	5.00 ab	2.55 abcde	10.0 ab	6.0 ab	4.0 ab
32-CANELA DE FERRO	4.9 abcd	0.0285 bcde	5.00 abc	2.51 abcdef	8.6 ab	5.8 ab	2.8 ab
CV (%)	64.13	60.12	23.7	28.21	28.08	42.78	46.65

[a] Numbers 1 - 32 preceding the accession name refer to arbitrary numbers used to identify the accessions evaluated in this study.

Table 3. Dissimilarity, based on the Mahalanobis distance (D^2), between pairs of accessions of rice for the seven characters measured: number of live larvae (NLL); individual mass of larvae in g (IM); external diameter of the stem (ED) and internal diameter of the stem in mm (ID); number of tillers produced after infestation (NTP); number of stems attacked (NSA); number of stems with no larval damage (NLD).

a	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	4.47	0.73	7.70	1.88	9.92	3.54	15.05	4.80	9.09	12.18	5.41	2.45	13.70	2.25	5.95	9.37	5.37	7.55	8.11	6.61	2.67	7.70	10.41	5.76	1.13	2.54	6.54	6.62	5.31	1.03	1.96
2		3.22	9.49	3.51	13.47	6.15	21.04	5.18	14.65	17.93	11.33	2.84	19.38	7.29	7.52	15.11	11.16	12.64	9.78	11.35	6.72	11.95	12.46	10.65	5.62	5.34	10.25	14.32	9.60	2.45	2.12
3			6.77	3.14	9.69	4.01	19.24	5.55	12.64	15.90	7.35	1.18	15.70	4.61	5.86	9.57	7.29	8.35	8.15	7.09	2.45	6.53	9.90	5.94	2.35	1.48	6.84	9.77	6.82	1.20	2.02
4				8.82	0.73	1.47	15.69	3.02	12.77	9.75	3.92	3.20	13.15	6.38	1.71	1.10	3.18	1.79	0.65	1.39	2.53	2.69	0.89	0.97	4.86	5.66	1.12	9.53	4.61	5.10	7.67
5					11.62	3.78	9.48	3.00	4.93	8.26	4.53	3.79	10.79	1.88	5.19	11.59	5.15	8.74	7.54	7.02	4.64	11.28	10.58	6.90	1.51	5.05	8.03	4.43	3.74	1.95	1.19
6						2.66	17.23	4.37	14.68	9.92	4.42	5.71	14.75	7.35	3.06	0.48	2.98	2.10	0.96	2.28	4.31	2.97	1.18	1.58	6.71	9.09	1.21	10.65	6.45	7.38	11.36
7							10.00	0.88	6.88	5.81	1.58	2.15	10.09	1.86	1.25	2.55	1.28	1.42	1.27	1.06	1.26	4.30	2.56	1.04	1.23	3.58	1.13	4.91	1.68	1.87	3.44
8								8.78	1.43	1.62	5.23	17.71	7.85	7.18	10.49	15.08	7.39	10.59	11.98	8.93	13.27	$\boxed{21.99}$	14.15	11.16	8.72	16.99	13.29	2.55	4.10	14.30	12.18
9									6.52	5.36	2.03	2.89	8.24	2.16	1.04	5.06	1.85	3.78	1.91	2.85	2.77	5.97	3.16	2.64	2.18	5.55	2.27	4.95	2.11	2.23	3.14
10										1.88	3.94	12.74	10.30	3.81	8.96	12.78	5.56	8.25	9.61	7.00	9.98	19.10	13.29	9.01	4.80	12.38	11.38	1.57	2.80	9.50	7.85
11											2.62	13.71	9.45	4.45	7.17	8.56	3.37	5.48	6.36	5.03	9.93	16.15	8.96	6.83	6.26	14.79	7.95	2.39	2.80	10.98	11.13
12												5.55	5.62	1.75	1.92	3.48	$\boxed{0.35}$	2.46	2.65	1.37	2.79	6.22	3.57	1.46	1.91	6.50	2.47	1.41	0.77	4.65	5.70
13													12.54	4.76	2.48	6.33	5.31	6.04	4.40	4.64	1.27	3.49	5.04	3.39	2.60	1.62	3.67	9.47	5.29	1.05	2.16
14														9.68	6.04	13.67	7.65	13.19	11.98	9.44	8.53	11.52	9.28	8.42	9.42	12.23	9.74	5.25	5.91	11.98	10.72
15															4.12	6.67	1.70	4.26	5.02	3.91	3.30	8.69	7.52	4.01	0.63	5.54	4.25	2.51	2.06	2.17	3.24
16																3.42	2.04	3.50	1.59	1.86	1.60	3.02	1.16	1.11	3.10	4.55	1.36	5.51	2.29	3.39	4.41
17																	2.49	1.08	1.49	1.28	3.73	3.37	1.64	0.99	5.85	8.19	1.26	8.88	5.19	7.64	11.29
18																		2.04	1.91	1.52	2.90	5.27	3.08	1.32	2.21	7.19	1.68	2.73	1.81	4.40	6.53
19																			1.74	0.55	3.30	5.95	2.90	1.31	3.71	6.58	1.64	6.38	2.78	5.93	8.34
20																				1.35	3.70	4.62	1.14	1.31	4.53	7.77	1.49	7.39	3.63	5.50	7.81
21																					2.15	4.76	1.94	0.43	2.87	5.16	1.52	4.60	1.52	5.17	6.65
22																						2.30	3.41	1.25	1.53	1.22	1.73	5.99	2.79	1.67	3.01
23																							2.61	2.43	6.71	5.42	2.09	12.17	8.16	5.79	9.27
24																								1.22	6.45	7.71	1.04	9.07	4.67	6.96	9.38
25																									2.84	4.48	0.78	5.21	2.30	4.36	6.38
26																										2.63	3.70	3.06	1.61	1.16	1.77
27																											5.37	9.12	5.00	2.00	2.14
28																												7.37	3.61	4.01	6.94
29																													1.58	7.27	6.75
30																														4.22	3.91
31																															0.99

D^2 max: 21.99 (Accessions ID 8 (WU 10 B) and 23 (IAPAR L 99-98) most dissimilar; D^2 min = 0.35 (Accessions ID 12 (MOGAMI CHIKANARI) and 18 (CO18) most similar). See **Table 2** for the names of the accessions 1 - 32.

Only the accessions MTU15 (ID 18) and CO18 (ID 18) have been previously reported to have resistance to *Chilo suppressalis* and *Scirpophaga incertulas* in Asia [18]. However, these materials are presented together with the accession IAC 47 used as a control (susceptible to *D. saccharalis*). The accession from Brazil, BRS PRIMAVERA (ID 29) has been reported to have moderately resistance to *D. saccharalis* [19] [20]. These accessions were classified in phenotypic Groups I and III by Tocher's grouping method (**Table 4**) and were separated according to the dispersion of scores based on the CVA clustering method on seven phenotypic characters of rice resistance to *D. saccharalis* (**Figure 1**).

The classification of IAC 47 as susceptible to *D. saccharalis* has been reported by other authors [5] [8] [18]. The accession has an internal stem diameter greater than 2.5 mm, a morphological characteristic which is favorable to the growth and development of *D. saccharalis*. Accessions like SONA, CO18, MTU15, MEARIN, IAPAR L 99-98 occurred in the same group as cultivar IAC 47, according to the multivariate analysis of phenotypic data.

Table 4. Tocher's grouping method of the 32 accessions of rice based on dissimilarity expressed by Mahalanobis distance estimated from seven characters[a].

Groups	Number of accessions	Accessions[b]
I	21	4, 6, 7, 9, 12,13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 28, 30 and 31
II	6	1, 2, 3, 5, 27 and 32
III	4	8, 10, 11 and 29
IV	1	14

[a]Characters evaluated: number of live larvae (NLL); individual mass of larvae in g (IM); external diameter of the stem in mm (ED); internal diameter of the stem in mm (ID); number of total tillers produced after infestation (NTT); number of stems attacked (NSA); number of stems with no larval damage (NLD). [b]See **Table 2** for the names of the cultivars 1 - 32.

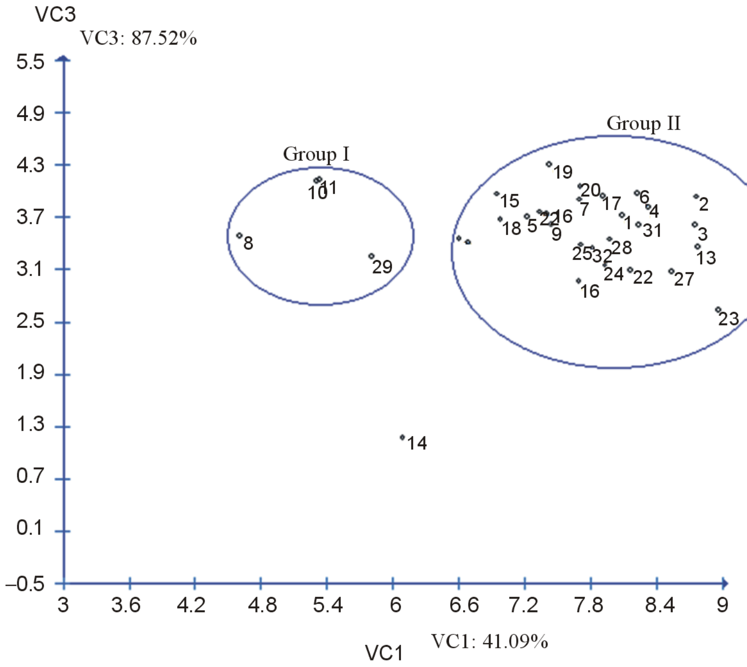

Figure 1. Dispersion of scores of 32 accessions of rice in relation to the three first canonical variables (VC1 and VC3) and cumulative variance (%) based on seven characters of rice resistance to *Diatraea saccharalis*. See **Table 2** for the names of the cultivars 1 - 32.

All of these materials used in this study are representative of the rice mini-core collection of the Embrapa Rice and Beans. Only some of them as IAC 47, BRS PRIMAVERA and "CANELA DE FERRO" were studied for resistance to this borer. This was the first study of the accesses rice. These materials correspond to accessions introduced from different countries and national rice cultivars that have been separated from a core collection. They were selected because due their high genetic variability and its great potential to be used in pre-breeding programs. However, more in depth studies are needed to better understand the levels and the mechanisms of resistance involved in these rice accessions to the sugarcane borers.

4. Conclusions

According to the morphological traits, different groups of accessions were identified in relation to resistance to *D. saccharalis* which were useful for diversity analysis. The multivariate analysis was successful in separating accessions into groups in relation to resistance to *D. saccharalis*. The characteristics evaluated should be an important consideration in screening rice accessions for resistance to sugarcane borer.

Other exploratory studies focused on effects of antibiosis and antixenosis could help elucidate the mechanisms of resistance involved for each material. Also, the aid of molecular area can also be a driving tool to identify genes that confer resistance to insect pests.

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