CROP PROTECTION

Resistance of Commercial Hybrids and Lines of Sorghum, *Sorghum bicolor* (L.) Moench., to *Diatraea saccharalis* (Fabr.) (Lepidoptera: Pyralidae)

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Resistência de Híbridos e Linhagens de Sorgo, *Sorghum bicolor* (L.) Moench. a *Diatraea saccharalis* (Fabr.) (Lepidoptera: Pyralidae)

RESUMO – Híbridos comerciais e uma coleção de linhagens de sorgo da Embrapa, foram avaliados quanto a resistência à broca da cana-de-açúcar, *Diatraea saccharalis* (Fabr.). Dois experimentos foram instalados no campo em Sete Lagoas, MG, na época da “safrinha”, em blocos casualizados, com três repetições e conduzidos sob infestação natural. As plantas foram avaliadas quanto ao estande, ciclo, altura e número de plantas quebradas ou tombadas e produção de grãos. Observou-se também a infestação da broca, o número de galerias, o número total de internódios e o número de internódios danificados para o cálculo do Índice de Infestação (II) e Índice de Intensidade de Infestação (III). Entre os híbridos comerciais, BR 304 e CMSXS9701 apresentaram os menores II enquanto que Z 732 e Esmeralda destacaram-se com os menores III. Entre as linhagens, 9815017 apresentou o menor II, e 9816003 o menor III. Os dois índices correlacionaram-se positivamente com a altura das plantas nos dois ensaios e negativamente com o ciclo das linhagens. Entretanto, nenhuma correlação foi observada entre eles no ensaio dos híbridos. No ensaio das linhagens verificou-se o ajuste de uma curva logarítmica entre os índices. Embora exista variabilidade genética entre os híbridos comerciais de sorgo para resistência a broca da cana, sob altas infestações, perdas significativas na produtividade poderão ocorrer em todos os híbridos avaliados. Por outro lado, a variabilidade genética observada entre as linhagens de sorgo indicaram um grande potencial para a seleção de cultivares resistentes nos programas de melhoramento.

PALAVRAS-CHAVE: Insecta, broca da cana-de-açúcar, MIP do sorgo, interação inseto-planta.

ABSTRACT – Commercial sorghum hybrids and Embrapa’s lines were evaluated regarding resistance to sugarcane borer. Two field experiments were conducted in Sete Lagoas, MG, under natural infestation, during the second cropping season in a randomized complete block with 3 replicates. The plants were evaluated regarding to stand, maturity cycle, plant height, and number of broken or lodging stalks and yield. The borer incidence, number of galleries, number of healthy and damaged nodes were also evaluated to calculate the Infestation Index and Intensity Infestation Index. Among the commercial sorghum hybrids, Br 304 and CMSXS 9701 were the least infested wile Z 732 and Esmeralda were the least damaged. Among the lines, the least infested was 9815017 and least damaged 9816003. The two indexes were correlated positively with plant height in both experiments and negatively correlated with the lines cycle. However, there was no correlation between the Indexes for the hybrids. Among the lines the data fit to a logarithmic curve. Although there is a significant variability among commercial sorghum hybrids regarding sugarcane borer susceptibility, under high borer density, a significant yield loss can be computed to all hybrids. On the other hand, the genetic variability regarding sugarcane borer resistance among the sorghum lines indicated a significant potential for use in a breeding program of resistant cultivars.

KEY WORDS: Insecta, sugarcane borer, sorghum IPM, insect-plant interaction.

In Southeast and Western regions of Brazil, the sorghum planting time has changed from the beginning of the rainy season (October/November) to the middle of the summer (February/March) changing dramatically the importance of insect pest. Sorghum midge was the major sorghum pest in Brazil during the 70's, although, during the 80's, the greenbug became the most important pest. More recently in the Western areas, the sugarcane borer, *Diatraea saccharalis* (F.), has become a key pest of maize, rice and sorghum (Waquil 1998, not published).

According to Teetes *et al.* (1983) and Ortega (1987), *Diatraea* species are widely distributed in the Americas. The first indications of borer attack are small damaged areas on the leaves and/or leaf axis. After the larvae enter the stalk, they are well protected from human observation and most natural enemies. As the larvae develop and the leaves unfold, rows of pinholes become visible during the midwhorl stage. When the infestation occurs in the seedling stage, larval feeding can damage the growing point causing "dead-heart" leading to plant death. During the vegetative plant development, the insect gallery causes broken stalks and plant lodging, which are the most common damage symptoms. Under field conditions the highest infestation occurs between 60 and 80 days after planting (Lara & Perussi 1984), when galleries are more frequent in the panicle peduncle, causing panicle death or peduncle breakage.

To control this borer in sugarcane, the release of the wasp *Cotesia flavipes* (Cam.) is recommended. Recently, the release of *Trichogramma galloi* (Zucchi) with *C. flavipes* (Botelho *et al.* 1999) was also recommended. However, the viability of the biological control of the sugarcane borer in annual crops like maize, rice and sorghum still requires further studies. Another possibility is the use of plant resistance against *D. saccharalis*. Genetic variability among sorghum genotypes has been demonstrated (Lara *et al.* 1980, Boiça Jr. & Lara 1983, Lara & Perussi 1984, Pereira *et al* 1987). The objective of this study was to evaluate the Brazilian commercial hybrids and adapted lines from the breeding program of Embrapa Milho e Sorgo regarding resistance to the sugarcane borer.

Material and Methods

To evaluate the resistance of sorghum to *D. saccharalis,* two field-experiments were conducted at the Embrapa Milho e Sorgo experimental fields, in Sete Lagoas, MG, Brazil. The commercial hybrids collection was obtained from the Grain Sorghum National Trial (GSNT) supported by seed industries and organized by Embrapa Milho e Sorgo while the lines evaluated were obtained from the Plant Pathology National Trial (PPNT) (Table 1). Both experiments were conducted under natural sugarcane borer infestation, during the second season planting time (3rd to 4th week of February), used by most farmers from Southeast and Center West regions of Brazil. The experiments were conducted in a randomized block design with three replicates. Each plot consisted of three 5 m long x 0.75 m wide rows. Recommended regional agronomic practices were followed throughout the season. During the development of the GSNT, the following plant variables were recorded: stand, maturity cycle, plant height, number of broken or lodging stalks and yield. Borer incidence and damage were also evaluated by splitting the stalks and recording the number of plants and nodes with damage in 10 randomly sampled stalks per plot. These variables were used to calculate the Infestation Index (II) and Intensity Infestation Index (III), where II= (100 X number of infested plants)/(total number of evaluated plants) and III= (100 X number of infested nodes)/(total number of evaluated nodes). All variables were submitted to ANOVA using the MSTAT Program. When necessary, the means were split by the

Table 1. List of commercial hybrids (GSNT) and lines (PPNT) of sorghum, used in this work.

Commercial sorghum hybrids (GSNT)				
1–A 9904	6–C 42	11–CMSXS 9701	16–A6 304	21–DK 860
2–BR 305	7–BR 306	12–CMSXS 9801	17–AG 1018	22–DK 57
3–AG 1017	8–P 8419	13–BR 304	18–CMSXS 9703	23–Esmeralda
4–AG 3002	9–Z 745	14–Z 822	19–74E7	24–Z 732
5–BR 303	10–C 51	15-83Y12	20–P 8118	
Sorghum lines (PPNT)				
1–9816024	11–9817013	21–9815009	31–BR 700	41–9816014
2–9816010	12–9815013	22–9816022	32–9815019	42–BR 501R
3–815021	13–9815020	23–9815016	33–BR 303	43–9815003
4–BR 304	14–98170221	24–9816004	34–9817027	44–9815017
5–BR 800	15–9815004	25–9816001	35–9816021	45–BR S605
6–9816020	16–9817023	26–SC283	36–9815014	46–BR 005R
7–BR 701	17–9817011	27–9816011	37–9817012	47–9816009
8–9815011	18–9816017	28–9815001	38–9816012	48–9816016
9–9817017	19–9815012	29–BR 601	39–9817036	49–BR 008R
10–9815015	20–9816023	30–BR 009B	40–BR S306	50–9816003

Duncan's Multiple Range Test (DMRT) ($P \leq 0.05$). Correlations among plant variables and Infestation Index as well as Intensity Infestation Index, were also performed.

Results and Discussion

The level of infestation recorded in these two experiments was relatively higher (about five times for Infestation Index and 10 times for Intensity Infestation Index) than the ones reported by Lara *et al.* (1994, 1997) and Boiça Jr. e Lara (1993). The Infestation Index differences were larger for the evaluated lines (50% to 100%) than for the commercial hybrids (83.3% to 100%). The same was observed for the Intensity Infestation Index, which varied from 13.6% to 96.6% among the lines and from 32.2% to 74.7% among the hybrids (Figs. 1 and 2). Usually, late planting of crops susceptible to sugarcane borer results in up to 80% of infestation, mainly in the Western States of Brazil. Since Sete Lagoas is located in the Southeast region, the level of infestation observed in these two experiments was about three times higher than the usual. So, these two experiments were not suitable to evaluate the susceptibility/resistance of the sorghum genotypes regarding non-preference to oviposition, due to the narrow range of the Infestation Index. However, among the lines, where the Intensity Infestation Index ranged from 13.6% to 96.6%, the experiment was very efficient in differentiating sorghum genotypes. If plant resistance mechanisms, acting before the small sugarcane borer larvae enter the stem, were the same as to the larval feeding in the stem, both indexes would have a very high correlation. However, it was observed that many hybrids showed different response.

Grain Sorghum National Trial (GSNT). The ANOVA showed significant differences among hybrids regarding the variables: stand, total number of nodes, maturity cycle (days to 50% flowering), plant height, percentage of plant lodging, grain weight/ plant and yield. Also, significant differences were observed for the total number of damaged nodes, Infestation Index and Intensity Infestation Indexes. However, no significant differences were observed in the number of galleries per plant or per peduncle and the number of plants with damaged peduncles.

Regarding the grain weight/ plant and yield, the hybrids were split into seven and nine groups, respectively. Using the percentage of plant lodging, it was possible to distinguish seven groups ranging from 0.7% to 10.0%. The lowest yielding hybrid produced only 49.5% of the top hybrid (3,266 bushels/acre). Based on the Infestation Index, the hybrids could be split into three groups, being the DK 860 and Z 732 the least infested (83.3%) next to nine hybrids with 100% infestation. The mean test for Intensity Infestation Index splits the hybrids into eight groups. The least damaged hybrids were Esmeralda and Z 732 with 32.2% of damaged nodes and the

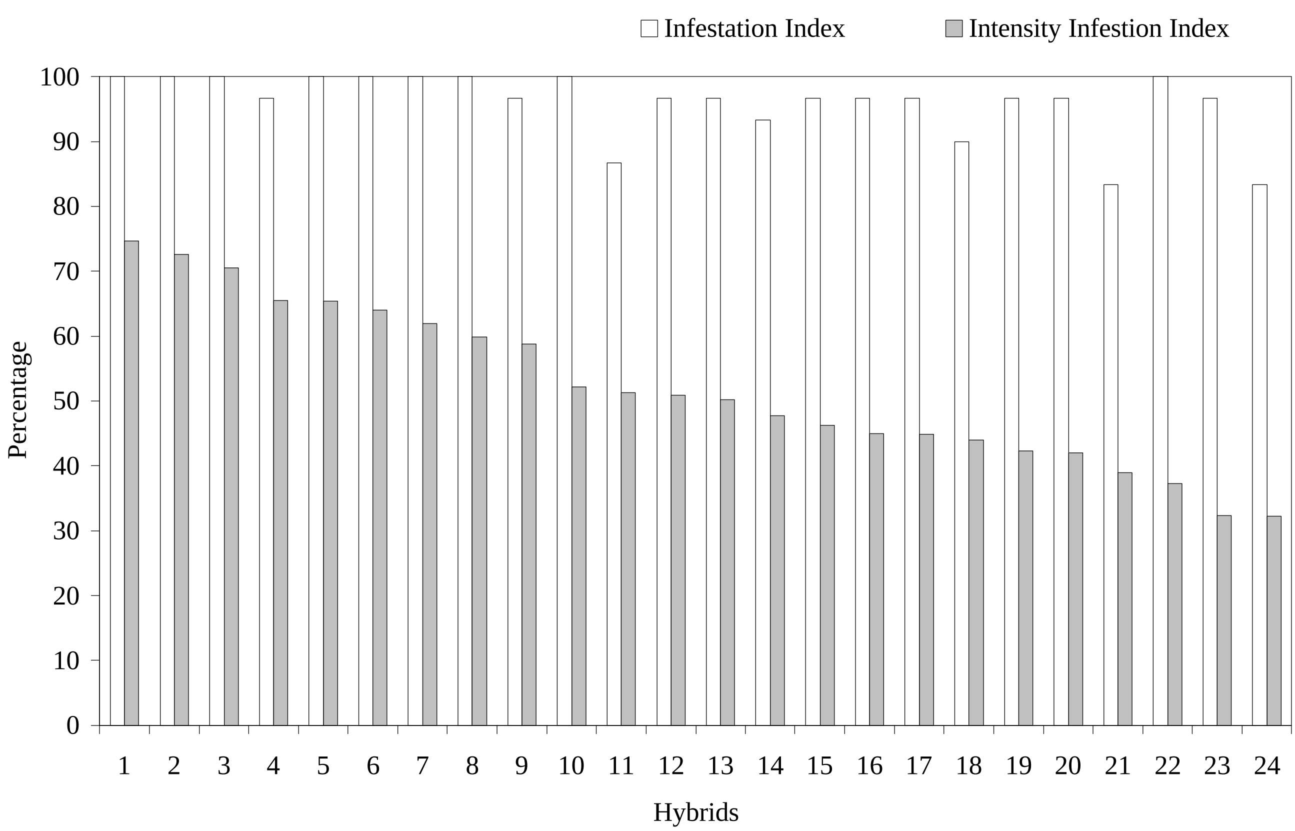

Fig. 1. Infestation Index and Intensity Infestation Index of sugarcane borer on Brazilian sorghum commercial hybrids listed in Table 1.

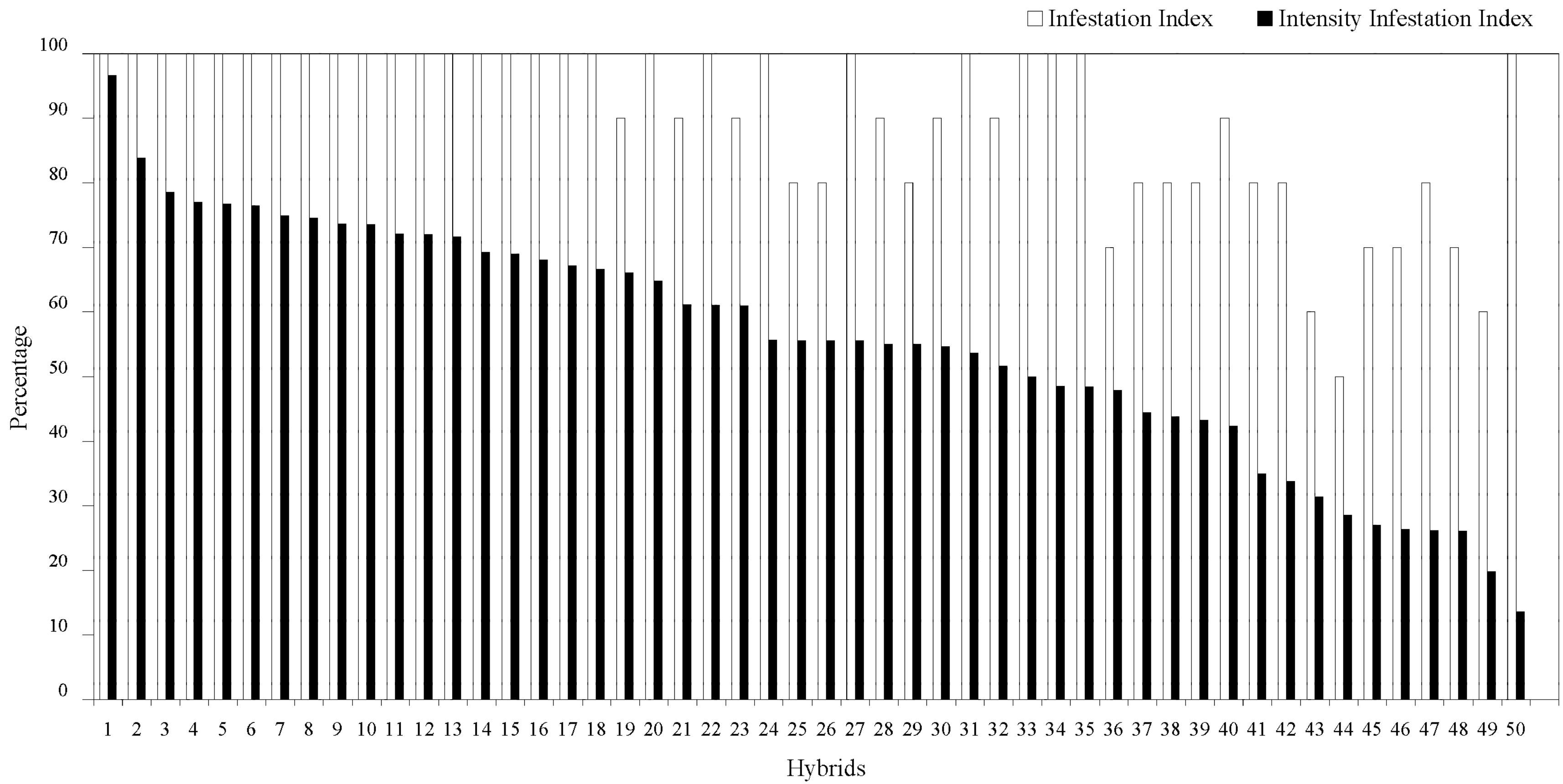

Figure 2. Infestation and Intensity Infestation Index of sugarcane borer on Brazilian sorghum lines.

damage on the most susceptible ones ranged from 58.8% to 74.7%. Relating both indexes, there was no correlation between Infestation Index and Intensity Infestation Index for the hybrids (Fig. 3).

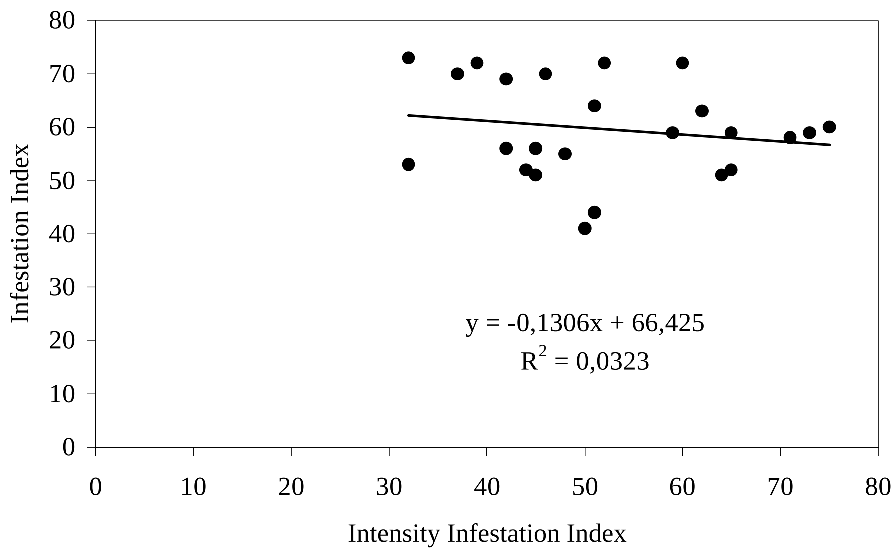

Figure 3. Relationship between Intensity Infestation Index and Infestation Index for the Grain Sorghum National Trial.

The simple correlation between these two indexes (Infestation Index and Intensity Infestation Index) with the plant variables showed significance to height and lodging (Table 2). There was also significant negative correlation between the Intensity Infestation Index and cycle. On the other hand, stand and yield were not correlated with either Infestation or Intensity Infestation Indexes. The correlation between yield and grain weight per plant was high (0.640), however some hybrids like CMSXS 9701 (n. 11) and 74E7 (n. 19) showed different patterns (Fig. 4).

Although there was variability among the Brazilian hybrids regarding sugarcane borer Infestation Index and Intensity Infestation Index, the calculated means for both variables indicated a high susceptibility of these sorghum genotypes. The larger variability observed for the Intensity Infestation Index (eight groups of hybrids) compared with Infestation Index (three groups of hybrids) suggested resistance being more associated to nonpreference for feeding and antibiosis than tolerance and nonpreference for oviposition. For the spotted stem borer (SSB) *Chilo partellus* (Swinhoe), Jotwani (1978) reported that antibiosis is the major resistance mechanism in sorghum. The least infested hybrids (Infestation Index) were DK 860 and Z 732 and the least damaged (Intensity Infestation Index) were Z 732 and Esmeralda. Since infestation was evaluated at harvest time, sugarcane borer damage causing plant death was not computed. Thus, significant differences observed in plant stand could be attributed to sugarcane resistance. However, this variable was not correlated, either with Infestation Index or Intensity Infestation Index. On the other hand, the significant correlation between lodging and both Infestation Index and Intensity Infestation Index was expected, because the damage made by the larvae digging the gallery makes the stem more susceptible to lodging. The significant negative correlation between plant cycle and Intensity Infestation Index may be related to the

Table 2. Correlation coefficient between sugarcane borer Infestation Index and Intensity Infestation Index with sorghum plant variables.

Variables	Infestation Index	(P)	Infestation Intensity Index	(P)
Stand	0.142	(0.234)	0.252	(0.288)
Lodging	0.363	(0.002)	0.260	(0.027)
Cycle	- 0.085	(0.477)	-0.330	(0.005)
Height	0.457	(0.000)	0.406	(0.000)
Yield	0.106	(0.375)	0.215	(0.069)

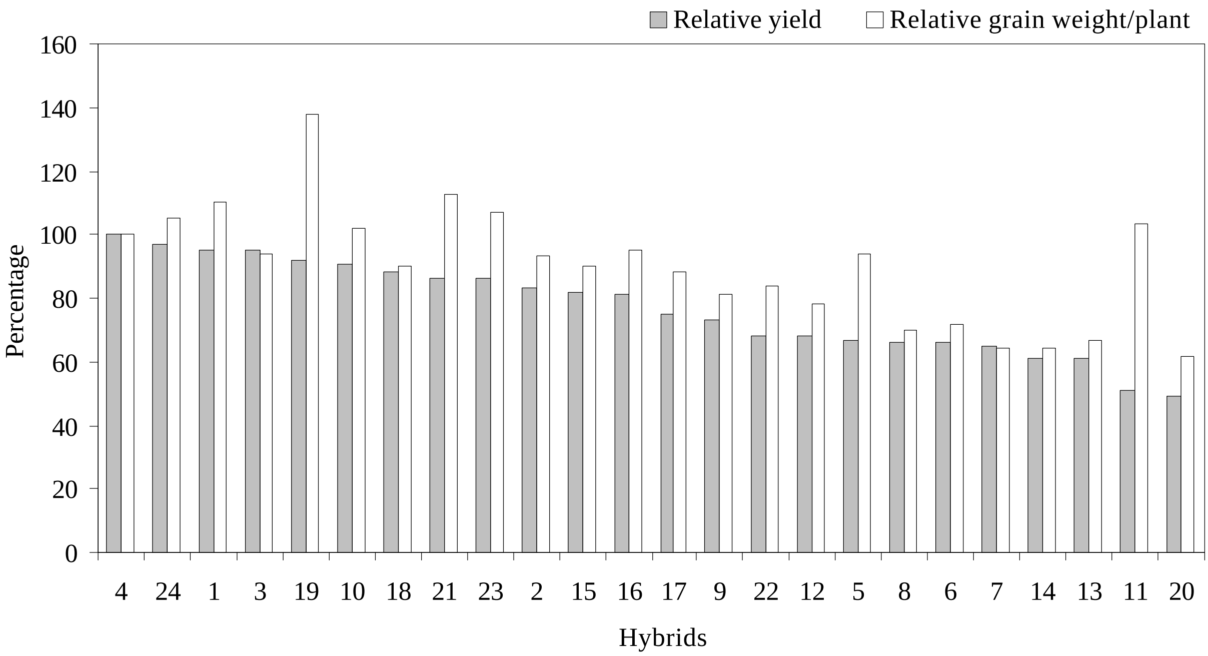

Figure 4. Relative yield (100*Yield/AG2002) and relative grain weight per plant of the Brazilian collection of commercial sorghum hybrids (listed in Table 1) sugarcane borer infestation.

wildness of the sorghum genotypes. Because maturity is directly related to cycle, this can be a very important factor affecting the correlation between these two variables. Also, a significant positive correlation was found between plant height and both indexes. For SSB, Sharma and Nwanse (1997) reported a negative correlation between plant height and leaf damage and dead-hearts.

Plant height may play an important role in determining sugarcane borer infestation levels if the line is among shorter ones, but in a sorghum field with uniform plant height, this effect may not be noticeable. The low correlation between the two indexes and yield was expected, as this characteristic is dependent on many factors. However, a small correlation with Intensity Infestation Index indicates some effect of larval damage in the stalk, reducing the yield. So, besides direct loss caused by plant lodging, stalk breakage and "dead-hearts", damage also resulted from the galleries and subsequent reduced plant production. The correlation coefficient between yield and the grain weight/ plant was only 0.64 (not close to 1.00) due to the interaction among the genotypes (Fig. 4). Regarding yield loss, without lodging or stalk breakage, some genotypes may be more tolerant to borer damage than others. Although the range of Infestation Index was not wide (from 83.3% to 100%). The range of Intensity Infestation Index was enough to detect no trend between both indexes (Infestation Index and Intensity Infestation Index). So, Infestation Index and Intensity Infestation Index can be related to different resistance mechanisms and codified by different independent genes.

Plant Pathology National Trial (PPNT). Because this trial includes genotypes from different genetic backgrounds and yield potential, it was evaluated using only the Infestation Index and Intensity Infestation Index. The results of these two variables are shown in Fig. 2. Using the variable Infestation Index, the hybrids were split into five groups and ranged from 50% on the line 9815017 to 100% on most lines. The Infestation Index average for the most susceptible group was 97.9%. Taking the Intensity Infestation Index, the mean discrimination showed 14 groups. The index ranged from 13.6% on the line 9816003 to 96.6% on the line 9816024. The Intensity Infestation Index average for the most susceptible group was 75.0%. The Intensity Infestation Index average for all trials was 57.14 ±8.59. Although the correlation (0.65) between these two variables was significant ($P \leq 0.001$), some lines did not follow the trend such as the 9816003 which presented the lowest Intensity Infestation Index (13.6%) and the highest Infestation Index (100%). Relating the Infestation Index and Intensity Infestation Index a trend was observed following the logarithmic curve (Fig. 5).

Results obtained in this trial were similar to those reported for the GSNT concerning variability of the Infestation Index compared to the Intensity Infestation Index. However, there was a higher variability of the Intensity Infestation Index in the PPNT trial than on the GSNT trial. The Intensity Infestation Indexes of the lines were distributed fairly uniformly between 13.64% to 96.61% in 14 groups. The least susceptible group to the sugarcane borer included 11 lines which averaged 28.2%± 7.65. Evaluating the potential of these lines to be used as donors in a breeding program, the line 9816003 was about seven times less infested than the most infested one. Comparing sources of sorghum resistance to sugarcane borer at two planting dates and at infestation levels lower than those observed in our study, Lara *et al.* (1997) reported differences from three to six times between

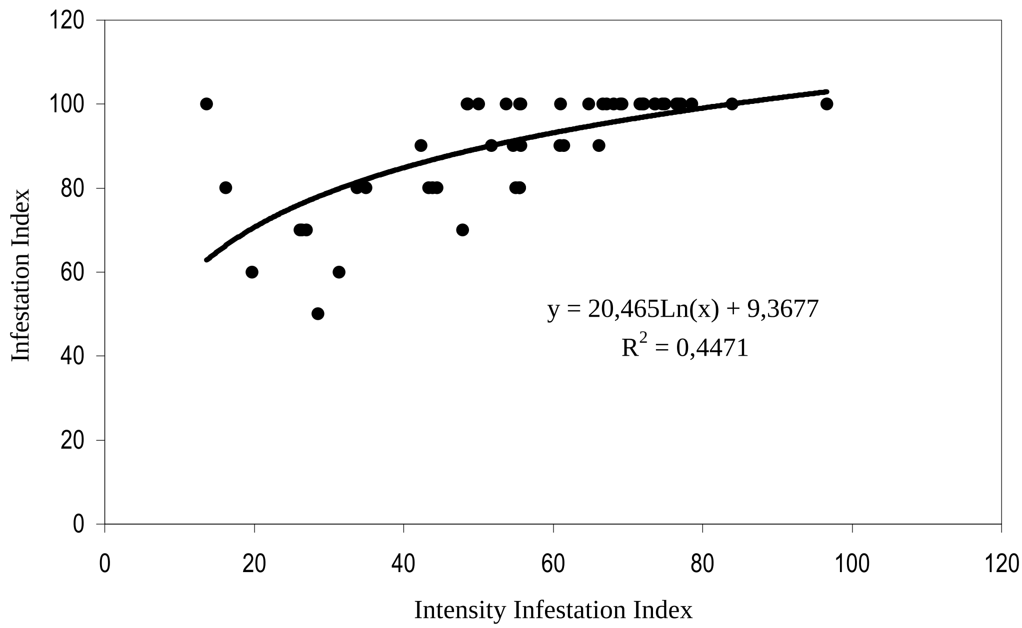

Fig. 5. Relationship between Intensity Infestation Index and Infestation Index for the Plant Pathology National Trial.

the highest and lowest Intensity Infestation Index. Using the number of "dead-heart" variable, to evaluate resistance of sorghum to the SSB, Sharma & Nwanze (1997) reported differences between resistant and susceptible up to four times under artificial infestation. Relating both indexes (Infestation and Intensity Infestation) for the lines, contrary to what was documented for the commercial hybrids, there is a clear trend following the logarithmic curve. In this case, the lines may have the same genetic background and consequently the same mechanisms. However, some observed outliners suggest the existence of different genes for borer resistance.

In conclusion, although there is a significant variability among commercial sorghum hybrids, regarding sugarcane borer susceptibility under high borer density, a significant yield loss can be computed to all hybrids. However, no significant differences were observed among the hybrids or lines for peduncle damage. So, depending on actual pest density in the field, this species can be a key pest of sorghum. Also, the sorghum genetic variability, regarding sugarcane borer resistance among the lines from the Plant Pathology trial, indicated a significant potential for use in a breeding program of resistant cultivars.

Acknowledgments

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