DAMAGES CAUSED BY *Dichelops melacanthus* (Heteroptera: Pentatomidae) IN CONVENTIONAL AND TRANSGENIC CORN HYBRIDS

DANOS OCASIONADOS POR Dichelops melacanthus *(Heteroptera:Pentatomidae) EM HÍBRIDOS CONVENCIONAIS E TRANSGÊNICOS DE MILHO*

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ABSTRACT: This study evaluated the symptoms of attack by the green belly stink bug, *Dichelops melacanthus* (Dallas, 1851), in conventional and transgenic commercial corn (*Zea mays*) hybrids, the seeds of which were either treated using the insecticide thiamethoxam or without chemical treatment. The experiment was conducted during the 2010/2011 crop season in Pindorama, São Paulo State, Brazil. The percentage of plants with symptoms or injuries was recorded by visually evaluating the degree or intensity of attack symptoms. The height of the plants was also recorded on a weekly basis, until the plants were 40 DAE. We also measured yield compounds, such as the number of rows of grain/spikes, spike weight (with and without straw), and grain weight. The seeds of hybrids that had previously been treated with thiamethoxam showed lower percentage of the number of plants that were attacked. Further, the grain weight of the plants increased 29.5% more than that of plants from untreated seeds. It was also found that transgenic hybrids exhibited lower height reduction in 40 DAE plants than did conventional isolines. Visual inspection is effective in assessing the degree of injury caused by attacks to the developing plants.

KEYWORKS: Insect. Yield. Seed treatment. Transgenesis. *Zea mays*.

INTRODUCTION

With the adoption of no-tillage systems and an increase in the sowing of second harvests, the green belly stink bug, *Dichelops melacanthus* (Dallas, 1851) (Heteroptera: Pentatomidae) has gained prominence as an important early pest of corn (*Zea mays* L.) (CHOCOROSQUI; PANIZZI, 2004). Manfredi-Coimbra et al. (2005) reported that this insect has been considered a secondary pest of the soybean (*Glycine max* (L.) Merrill) for several years, but has also recently become a key pest of corn and wheat (*Triticum aestivum* L.).

Another factor that may have contributed to the significant increase of *D. melcanthus* in corn is the major use of Bt hybrids, as with the adoption of this technology is to reduce the number of insecticide applications of broad spectrum. Greene et al. (2001) observed that these same conditions led to the significant increase in bedbug *Euschistus servus* in the southeastern United States.

The damage that this *D. melacanthus* cause in corn is greater in the early stages of the plant's development, due to sap sucking and the introduction of salivary toxic enzymes into the stem base of seedlings and plants, resulting in the withering of leaves, and eventually, of the whole plant (Gallo et al., 2002). Furthermore, on the beginning of the development, corn is more affected by stinkbugs attack (BIANCO, 2004), and up to sixth leaves completely extended, corn plants define their yield (FANCELLI; DOURADO NETO, 2000), highlighting the importance of these insects on corn plants.

Few studies points out the damage caused by *D. melacanthus* on corn, and the threshold level is not well-defined in Brazil. Gassen (1996) and Chocorosqui (2001) verified a threshold level of 2 *D. melacanthus* m^{-2} on corn seeded on summer in Brazil, while Bianco (2004) observed the same threshold level for winter corn and 1 *D. melacanthus* m^{-2} for summer corn in Brazil. In similar studies, Duarte (2009) observed a threshold level of 0.58 *D. melacanthus* m^{-2}.

More Studies have been conducted on the effects of *D. melacanthus* on wheat and corn (Chocorosqui & Panizzi, 2004; Martins et al., 2009), however, there is still a shortage of studies on the impact of these injuries on the characteristics and indices of plant yield.

Knowing that the damage caused by this insect are higher in the early stage of plant development, Panizzi (2000) recommends the use of chemical seed treatment and foliar sprays on newly

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emerged plants in order to minimize the damage caused. In research conducted in the Central-West region of Brazil, Ávila and Duarte (2012) concluded that the treatment of seeds with thiamethoxam was the most efficient method of controlling *D. melacanthus* in corn second harvests.

Therefore, this study aimed to evaluate the symptoms of attack caused by *D. melacanthus* on commercial hybrids of conventional and transgenic corn plants in their early development, which had previously been either treated with insecticide, or had not.

MATERIALS AND METHODS

The experiment was conducted in 2010/2011 at the São Paulo State Agency of Agribusiness Technology, Regional North Center Polo, Pindorama, São Paulo State, Brazil. The soil at the site of the experiment was classified as a red-yellow argisol, with a medium/abrupt sandy texture (Embrapa, 2009).

The experimental design used was a randomized factorial block (5 × 2 × 2), with four repetitions. The first factor was composed of the conventional hybrids 30F35 (Pioneer®), AG8088 (Agroceres®), DKB 390 (Dekalb®), 2B710 (Dow AgroSciences®), and IMPACTO (Syngenta®). The second factor was composed of the following transgenic plants: 30F35 H (TC1 507, Cry 1F toxin), AG8088 YG (Mon810, Cry 1Ab toxin), DKB390 Pro (Mon 89034, Cry 1A105 (1Ab, 1Ac, 1F) + Cry2Ab2 toxins) 2B710 HX (Herculex® TC1 507, Cry 1F toxin), and IMPACT TL (SYN BT-011, Cry 1Ab toxin). The third factor was the chemical treatment, or not, of seeds with the insecticide thiamethoxam, at the recommended dosage of 600 mL commercial product per 100 kg of seeds, the dose indicated for the control of *D. melacanthus*.

Dichelops melacanthus were reared in the entomology laboratory of the Regional North Center Polo. Adults were collected in the field, identified, and subsequently kept in transparent plastic boxes with air holes (base 18 × 13 cm, height 6 cm). The feed consisted of dry seeds of soybeans, ligustrum (*Ligustrum sinense* L.), and common beans (*Phaseolus vulgaris* L.), based on Laumann et al. (2010). The eggs obtained were wrapped in cotton wool until the emergence of the nymphs, which were kept in a heated biological oxygen demand (BOD) chamber at 25 ± 1°C, with a relative humidity of 65 ± 5%, and a 12-h photophase.

Sowing was carried out on December 28, 2010; and each plot consisted of three 2-m lines, spaced 0.90-m apart, at a density of seven plants per linear meter. Three days after emergence (DAE), five plants per plot were selected and artificially infested with one newly emerged adult *D. melacanthus* per plant. The plants that had been artificially infested with *D. melacanthus* were placed in a rectangular cage of steel (0.8 m in height and 1.0 × 1.0 m base), protected by the fabric "voil" to prevent the insects escaping. The insects were confined for 15 d. After this period, the cages were removed and the insecticide lambda-cyhalothrin (Karate Zeon® CS 250) was applied, at a dose of 300 $mL \cdot ha^{-1}$ using costal pulverizer, for the elimination of live insects. Subsequent sprayings were carried out with the aim of avoiding an attack from other populations of *D. melacanthus*, as well as from other pests, such as the fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae).

After removal of the bugs from the plants, the attack symptoms (injuries) were evaluated using the following visual scale of symptoms or injuries, modified from Brustolin et al. (2011): Score 1, plants without symptoms of attack; Score 2, plants with scored leaves, but without any reduction in height; Score 3, plants with attack symptoms (holes in their leaves), and a reduction in growth; Score 4, plants with holes and tillering on their sides; Score 5, plants with "winding leaves," and the death of the main stem.

Plant height was defined as the height from the ground to the apex of the last leaf expanded. The number of plants with and without symptoms was recorded, for the subsequent calculation of the percentage of plants with symptoms of *D. melacanthus* attack. Visual assessments of the damage to leaves and the percentage of reduction in height were conducted on 18, 25, 32, and 40 DAE. The height of plants without symptoms of attack was also performed for each hybrid on each evaluation date, and was considered as controls to determine the percentage of height reduction caused by *D. melacanthus*.

During harvest, the plants that had been infested with *D. melacanthus* had the following yield characteristics recorded: the weight (g) of the spike (with and without straw), the number of rows of grains/spikes, and the weight (g) of grain per spike, corrected for 13% moisture.

Data were analyzed using ANOVA, and the means compared using a Tukey test at 5% probability. Percentages were transformed using the equation: arcsine $\sqrt{X/100}$, where X is the percentage.

RESULTS AND DISCUSSION

No significant differences in attack symptoms were found between the conventional hybrids and the transgenic plants (Table 1). However, the percentage of attacks on plants grown from seeds treated with insecticide was significantly lower (61%) than that on plants grown from untreated seeds (86.5%). The confinement of the insects during the early development of the plants in cages probably explains the high percentage of plants attacked, even with the seed treatment. For complete elimination, the bugs had to feed on plants with insecticide residues, and consequently cause some damage, such as scoring on the leaves (Table 1). Salivary toxins that are injected by stilettos during the feeding process cause the scoring (Gallo et al., 2002).

Significant differences were noted between hybrids in plant height; the hybrids AG8088 and AG8088 YG exhibited reductions in height because of *D. melacanthus* attacks at all assessed time points (Table 1). However, the hybrid pairs, 30F35/30F35 H and 2B710/2B710 HX, exhibited low height reductions of 8.9% and 11.4%, respectively, at 40 DAE (Table 1). Transgenic hybrids exhibited lower reduction in heights at 19 and 40DAE compared to that by conventional hybrids (Table 1). In addition, the hybrids with insecticide-treated seeds exhibited significantly lower reductions in plant height at all assessed time points compared to plants not treated with insecticide (Table 1).

There was a significant interaction between the reduction in plant height, the nature of the hybrids, and the evaluation time point (Table 1). Up to 19 and 32 DAE, the transgenic hybrids 2B710 HX and DKB390 Pro exhibited a significantly lower height reduction than their conventional isolines, whereas up to 25 and 40 DAE, only the hybrid 2B710 HX exhibited a significantly lower height reduction than the conventional isolines. However, up to 32 DAE the conventional hybrid 30F35 exhibited a lower reduction in height (6.7%) than the transgenic hybrid 30F35 H (14.6%) (Table 2).

For the hybrid versus seed treatment analysis (Table 3), the insecticide-treated hybrid pairs AG8088/AG8088 YG, DKB390/DKB390 Pro, 2B710/2B710 HX, and IMPACTO/IMPACTO TL exhibited lower reductions in plant height up to 25 and 32 DAE, and at 40 DAE all the insecticide-treated hybrids exhibited smaller height reductions than those of hybrids not treated with insecticide (Table 3). Both transgenic as well as conventional plants that had been treated with insecticide showed smaller height reductions up to 19 and 25 DAE than that by plants that were not treated with insecticide (Table 4). Plants whose seeds had not been treated with insecticide had larger reductions in height than those that had been treated (Table 5). At 25 DAE, the hybrids AG8088, AG8088 YG, DKB390 Pro, 2B710, IMPACTO, and IMPACTO TL exhibited smaller height reductions after insecticide treatment than those without treatment. However, for the hybrids 2B710 HX, DKB 390, 30F35 H, and 30F35 there was no significant difference (Table 5).

Among the untreated plants at 32 DAE, the hybrid 2B710 HX had the lowest reduction in height (0.6%), followed by the 30F35 hybrid (6.7%). No significant difference was observed between the treated hybrids. When compared the treated and untreated plants, the hybrids AG8088, AG8088 YG, DKB390, DKB390 Pro, 2B710, IMPACTO, and IMPACTO TL exhibited smaller reductions in height when their seeds were treated with insecticide than when they were not (Table 5). Interestingly, at 40 DAE the untreated hybrid 2B710 HX only exhibited a 1.3% height reduction. Among the treated hybrids, there was no significant difference in height reduction; however, the hybrids AG8088, AG8088 YG, DKB390, DKB390 Pro, 2B710, IMPACTO, and IMPACTO TL had smaller height reductions than untreated hybrids (Table 5).

In general, up to 40 DAE, the treated plants exhibited lower categories of attack symptom (perforated leaves), smaller height reductions, and a lower percentage of attacked plants than untreated plants, demonstrating that the insecticide contributed to the large initial development of the plants, with few symptoms and injuries. Brustolin et al. (2011) highlighted the importance of insecticide treatment for *D. melacanthus* management, and Albuquerque et al. (2006) found that thiamethoxam is an effective pest control agent in the field.

No significant differences were found between conventional and transgenic hybrids in measures of productivity (Table 6). These results were to be expected, because the transgenic hybrids express Cry proteins that are toxic to Lepidopteron pests, but not to stinkbugs. However, a significant difference between treated and untreated plants was found in all the parameters evaluated (Table 6).

Table 1. Percentage of plants with symptoms of attack, visual categorization of damage, and percentage of reduction in plant height (%RPH) at different plant ages, with and without insecticide treatment.

Hybrids (H)	**Pl. attacked (%)**	**19 DAE**		**25 DAE**		**32 DAE**		**40 DAE**	
		Score	**%RPH**[1]	**Score**	**%RPH**[1]	**Score**	**RPH**[1]	**Score**	**RPH**[1]
30F35 / 30F35 H	71.30	2.6	13.35 b	2.4	10.69 b	2.5	10.67 b	2.6	8.89 b
AG8088 / AG8088 YG	83.80	2.9	35.14 a	2.7	24.89 a	2.7	19.44 a	2.7	18.38 a
DKB390 / DKB390 Pro	77.50	2.8	23.57 ab	2.8	17.14 ab	2.7	15.71 ab	2.6	13.70 ab
2B710 / 2B710 HX	62.50	2.4	20.35 b	2.3	15.85 b	2.4	13.46 b	2.3	11.43 b
IMPACTO / IMPACTO TL	73.80	2.7	12.49 b	2.5	13.27 b	2.5	12.63 b	2.5	13.47 ab
Averages	73.75	2.7	20.98	2.5	16.37	2.6	14.38	2.5	13.17
F-Test	1.20^{ns}	0.89^{ns}	7.40**	1.30^{ns}	4.59**	0.57^{ns}	2.74*	0.61^{ns}	3.25*
Transgenesis (TG)									
Conventional	78.00	2.7	25.26 a	2.5	17.21	2.5	15.78	2.5	15.50 a
Transgenic	69.50	2.6	16.70 b	2.6	15.52	2.6	12.99	2.6	10.85 b
F-Test (TG)	1.79^{ns}	0.51^{ns}	6.97*	0.23^{ns}	0.14^{ns}	0.31^{ns}	2.50^{ns}	0.21^{ns}	8.61**
Seed Treatment (ST)									
Untreated	86.50 a	3.1 a	34.40 a	2.9 a	26.14 a	2.9 a	23.14 a	2.9 a	21.86 a
Treated	61.00 b	2.2 b	7.57 b	2.1 b	6.59 b	2.2 b	5.63 b	2.2 b	4.49 b
F-Test (ST)	16.11**	26.10**	89.67**	23.30**	64.19**	20.22**	64.19**	16.27**	108.46**
Interaction									
F-Test (H x TG)	0.75^{ns}	0.66^{ns}	11.04**	1.02^{ns}	3.06*	0.81^{ns}	9.57**	1.15^{ns}	9.44**
F-Test (H x ST)	0.76^{ns}	0.37^{ns}	1.85^{ns}	0.99^{ns}	3.02*	0.43^{ns}	6.72**	0.43^{ns}	4.12**
F-Test (TG x ST)	3.87^{ns}	2.36^{ns}	10.71**	0.55^{ns}	5.98*	0.31^{ns}	1.44ns	2.89^{ns}	3.37^{ns}
F-Test (H x TG x ST)	0.41^{ns}	0.69^{ns}	1.50^{ns}	0.37^{ns}	8.39**	0.59^{ns}	5.47**	0.19^{ns}	3.28*
CV (%)	38.52	30.60	46.52	28.98	48.63	26.64	47.65	27.63	35.30

Averages followed by the same letter in the column do not differ at 5% probability by Tukey test ns – non-significant at 5% probability by Tukey test. **, *; Significant at 1 and 5% probability by *F-test*. [1] Data transformed in arcseno $\sqrt{X/100}$

Table 2. Analysis of the significant interactions related to the percentage reduction in plant height after *Dichelops melacanthus* attack, in conventional and transgenic hybrids.

Hybrids	Transgenesis	
	Conventional	Transgenic
	19 DAE	
30F35 / 30F35H	12.09 b A	14.61 b A
AG 8088 / AG8088 YG	31.74 a A	38.54 a A
DKB 390 / DKB 390 Pro	33.18 a A	13.96 b B
2B710 / 2B710 HX	38.69 a A	2.01 b B
IMPACTO / IMPACTO TL	10.62 b A	14.36 b A
	25 DAE	
30F35 / 30F35H	7.51 b A	13.87 a A
AG 8088 / AG8088 YG	23.37 a A	26.40 a A
DKB 390 / DKB 390 Pro	18.90 ab A	15.39 a A
2B710 / 2B710 HX	26.51 ab A	5.19 b B
IMPACTO / IMPACTO TL	9.77 ab A	16.77 ab A
	32 DAE	
30F35 / 30F35H	6.71 c B	14.63 a A
AG 8088 / AG8088 YG	18.24 abc A	20.63 a A
DKB 390 / DKB 390 Pro	17.69 ab A	13.73 ab B
2B710 / 2B710 HX	26.06 a A	0.87 b B
IMPACTO / IMPACTO TL	10.19 bc A	15.07 a A
	40 DAE	
30F35 / 30F35H	7.77 b A	10.02 a A
AG 8088 / AG8088 YG	17.32 ab A	19.43 a A
DKB 390 / DKB 390 Pro	16.04 ab A	11.39 a A
2B710 / 2B710 HX	21.39 a A	1.47 b B
IMPACTO / IMPACTO TL	15.00 ab A	11.95 a A

Averages followed by the same capital letter in line and tiny in column do not differ significantly from each other by Tukey test at 5% probability.

Table 3. Analysis of the significant interactions related to the percentage reduction in plant height after *Dichelops melacanthus* attack, in relation to hybrid type and seed treatment.

Hybrids	Seed Treatment	
	Untreated	Treated
	25 DAE	
30F35 / 30F35 H	13.07 b A	8.30 ab A
AG 8088 / AG 8088 YG	39.53 a A	10.25 a B
DKB 390 / DKB 390 Pro	25.22 ab A	9.07 ab B
2B710 / 2B710 HX	27.16 ab A	4.53 ab B
IMPACTO / IMPACTO TL	25.72 ab A	0.82 b B
	32 DAE	
30F35 / 30F35 H	9.92 b A	11.43 a A
AG 8088 / AG 8088 YG	30.79 a A	8.08 ab B
DKB 390 / DKB 390 Pro	26.22 a A	5.20 ab B
2B710 / 2B710 HX	24.49 ab A	2.44 ab B
IMPACTO / IMPACTO TL	24.28 a A	0.98 b B
	40 DAE	
30F35 / 30F35 H	12.72 b A	5.07 a B
AG 8088 / AG 8088 YG	32.49 a A	4.26 a B
DKB 390 / DKB 390 Pro	23.35 ab A	4.04 a B
2B710 / 2B710 HX	18.87 b A	3.99 a B
IMPACTO / IMPACTO TL	21.85 ab A	5.09 a B

Averages followed by the same capital letter in line and tiny in column do not differ significantly from each other by Tukey test at 5% probability.

Table 4. Analysis of the significant interactions related to the percentage reduction in plant height after *Dichelops melacanthus* attack, in relation to transgenesis and seed treatment.

Transgenesis	Seed Treament	
	Untreated	Treated
	19 DAE	
Conventional	43.71 a A	6.82 a B
Transgenic	25.08 b A	8.31 a B
	25 DAE	
Conventional	29.36 a A	5.06 a B
Transgenic	22.92 a A	8.13 a B

Averages followed by the same capital letter in line and tiny in column do not differ significantly from each other by Tukey test at 5% probability.

Table 5. Analysis of the significant interactions related to the percentage reduction in plant height after *Dichelops melacanthus* attack, in relation to hybrid type, transgenesis, and seed treatment.

Hybrids	Seed Treatment	
	Untreated	Treated
	25 DAE	
30F35	12.09 cd A	2.93 a A
30F35 H	14.06 bcd A	13.68 a A
AG8088	40.41 ab A	6.33 a B
AG8088 YG	38.64 abc A	14.16 a B
DKB390	23.23 abc A	14.57 a A
DKB390 Pro	27.51 abc A	3.57 a B
2B710	52.60 a A	0.42 a B
2B710 HX	1.73 d A	8.65 a A
IMPACTO	18.45 abcd A	1.08 a B
IMPACTO TL	32.98 abc A	0.57 a B
	32 DAE	
30F35	6.73 cd A	6.69 a A
30F35 H	13.11 bcd A	16.16 a A
AG8088	32.42 ab A	4.07 a B
AG8088 YG	29.16 ab A	12.10 a B
DKB390	25.06 ab A	10.31 a B
DKB390 Pro	27.38 ab A	0.08 a B
2B710	48.40 a A	3.72 a B
2B710 HX	0.59 d A	1.16 a A
IMPACTO	20.30 abc A	0.08 a B
IMPACTO TL	28.26 ab A	1.88 a B
	40 DAE	
30F35	11.19 cd A	4.36 a A
30F35 H	14.25 bc A	5.79 a A
AG8088	31.66 ab A	2.98 a B
AG8088 YG	33.32 ab A	5.55 a B
DKB390	28.06 ab A	4.02 a B
DKB390 Pro	18.65 abc A	4.07 a B
2B710	36.42 a A	6.36 a B
2B710 HX	1.33 d A	1.61 a A
IMPACTO	22.26 abc A	7.74 a B
IMPACTO TL	21.44 abc A	2.45 a B

Averages followed by the same capital letter in line and tiny in column do not differ significantly from each other by Tukey test at 5% probability.

Table 6. Effect of attack by *Dichelops melacanthus* on spike weight (g) (with and without straw), number of rows of grain per spike, and grain weight (g) per plant.

Hybrids (H)	Spike Weight (g)		Number of	Grain Weight
	With Straw	Without Straw	Rows of Grains	(g)
30F35/30F35 H	189.70	167.71	14.13	133.60
AG8088/AG8088 YG	179.40	158.73	13.65	127.83
DKB390/DKB390 Pro	159.36	143.64	13.49	118.74
2B710/2B710 HX	184.94	167.25	15.06	127.68
IMPACTO/IMPACTO TL	180.31	158.25	15.54	123.51
Averages	178.74	159.11	14.38	126.27
F-Test (H)	0.95^{ns}	0.79^{ns}	2.07^{ns}	0.39^{ns}
Transgenesis (TG)				
Convencional	177.53	157.91	14.16	125.92
Transgenic	179.96	160.33	14.60	126.62
F-Test (TG)	0.05^{ns}	0.06^{ns}	0.63^{ns}	0.01^{ns}
Seed Treatment (ST)				
Untreated	148.97 b	131.4 b	13.18 b	104.39 b
Treated	208.52 a	186.84 a	15.57 a	148.16 a
F-Test (ST)	31.28**	31.96**	18.51**	30.68**
Interaction				
F-Test (H x TG)	3.24*	3.68**	2.75*	3.33*
F-Test (H x TS)	0.61^{ns}	0.43^{ns}	0.80^{ns}	0.32^{ns}
F-Test (TG x TS)	0.01^{ns}	0.01^{ns}	0.93^{ns}	0.06^{ns}
F-Test (H x TG x ST)	0.98^{ns}	0.98^{ns}	1.11^{ns}	0.90^{ns}
CV (%)	26.64	27.56	17.32	27.99

Averages followed by the same letter in the column do not differ to 5% probability by Tukey test. ns – non-significant at 5% probability by Tukey test. **, *; Significant at 1 and 5% probability by F test, respectively.

In the present study, seed treatment with thiamethoxam proved efficient in the control of *D. melacanthus* by decreased the feeding time available to the insects, which consequently decreased the damage caused in the initial stages of the plants' development. Fancelli and Dourado Neto (2000) approached the initial period of plant development is when the plants begin to set their productive potential. In addition, proven fact in this work, because thiamethoxam treatment increased grain weight by 29.5% (Table 6).

Corn seedlings in the early stages of development are more susceptible to the attack of *D. melacanthus*, because while feeding the insect inoculates the plant with indole-3-acetic acid, which is considered to be one of the most toxic compounds to corn (Slansky & Panizzi, 1987; Hori, 2000). Silva et al. (2013) found that adult *D. melacanthus* migrate to cornfields looking for shelter and water sources, and can be harmful to plants. Ávila and Panizzi (1995) found that the occurrence of *D. melacanthus* is greater during the plant's vegetative phase, and its population density decreases near the reproductive period.

The conventional hybrids did not differ significantly amongst themselves in terms of productivity; however, the transgenic hybrids exhibited significant differences in parameters relating to productivity. The hybrid 2B710 HX had the greatest mean spike weight (without straw) (203.9 g), and the hybrid DKB390 Pro had the lowest mean spike weight (without straw) (139.4 g). In addition, the hybrid 2B710 HX possessed a mean of 16.93 ranks/spike, and the DKB390 Pro hybrid had a mean of 13.00 ranks/spike (Table 7). When comparing the conventional hybrids with their transgenic isolines, only the hybrid 2B710 HX was significantly superior to its conventional isoline, which proved more susceptible to attack from *D. melacanthus* for all the productivity parameters evaluated (Table 7).

Table 7. Analysis of the significant interactions related to plant productivity, hybrid type and transgenesis.

Hybrids	Spike weight (g)			
	With Straw		Without Straw	
	Conventional	Transgenic	Conventional	Transgenic
30F35 / 30F35 H	210.91 a A	168.47 a A	187.60 a A	147.81 ab A
AG8088 / AG8088 YG	181.13 a A	177.69 a A	161.16 a A	156.31 ab A
DKB390 / DKB390 Pro	161.97 a A	156.75 a A	147.91 a A	139.38 b A
2B710 / 2B710 HX	148.13 a B	221.75 a A	130.63 a B	203.88 a A
IMPACTO / IMPACTO TL	185.50 a A	175.13 a A	162.25 a A	154.25 ab A

Hybrids	Number of rows of grains		Grain Weight (g)	
	Conventional	Transgenic	Conventional	Transgenic
30F35 / 30F35 H	14.84 a A	13.43 ab A	150.29 a A	116.93 a A
AG8088 / AG8088 YG	13.11 a A	14.19 ab A	130.09 a A	125.58 a A
DKB390 / DKB390 Pro	13.98 a A	13.01 b A	121.60 a A	115.88 a A
2B710 / 2B710 HX	13.20 a B	16.93 a A	100.56 a B	154.79 a A
IMPACTO / IMPACTO TL	15.65 a A	15.44 ab A	127.08 a A	119.94 a A

Averages followed by the same capital letter in line and tiny in column do not differ significantly from each other by Tukey test at 5% probability.

A simple linear correlation analysis of the data from the visual assessment and the parameters of productivity found significantly negative relationships, indicating that as the symptoms on the plants increased, productivity decreased (Figure 1).

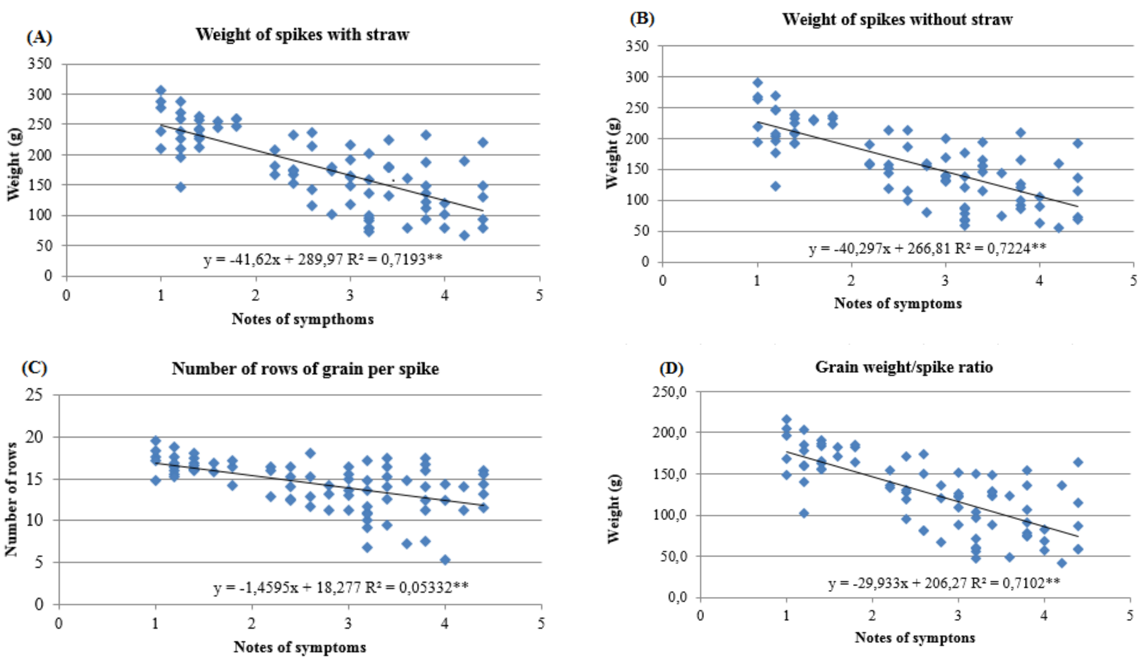

Figure 1. Linear correlations between the visual symptoms of *Dichelops melacanthus* attack and the (A) weight of spikes with straw (g), the (B) weight of spikes without straw (g), the (C) number of rows of grain per spike, and (D) the grain weight/spike ratio.

This result suggests that the visual scale we used is an effective method in determining the damage caused by *D. melacanthus*, especially for weight of spikes with straw, weight of spikes without straw and grain weight/spike ratio, indicating that scale play an important role for these parameters. However, for the number of rows of grain per spike was observed a lower correlation coefficient, indicating that the scale does not play an important role for this parameter (Figure 1).

CONCLUSIONS

Conventional and transgenic hybrids respond differently to *D. melacanthus* attack, and conventional hybrids exhibit a greater reduction in height.

Despite the height reduction in the conventional hybrids, no effects are observed on the productivity.

The results indicate that the conventional hybrid 2B710 is more susceptible to attack by *D. melacanthus* than that the other hybrids.

The chemical treatment of seeds with thiamethoxam reduces the damage caused by *D. melacanthus*, resulting in a 29.5% increase in grain weight.

The visual scale of *D. melacanthus* attack that we used is effective for weight of spikes with straw, weight of spikes without straw and grain weight/spike ratio.

RESUMO: Este trabalho teve como objetivos avaliar os sintomas de ataque de *D. melacanthus* e seus respectivos danos, ocasionados em diferentes híbridos comerciais convencionais e transgênicos, submetidos ou não ao tratamento químico de sementes. O experimento foi realizado no ano agrícola de 2010/2011, em área experimental da APTA, Polo Regional Centro Norte, localizado em Pindorama, SP. Os parâmetros avaliados foram a porcentagem de plantas com sintomas ou injúrias de ataque, avaliando-se o grau ou intensidade de sintomas de ataque nas plantas, através de uma escala visual de notas de danos. A altura das plantas foi avaliada semanalmente até os 40 dias de idade das plantas (DAE). Avaliou-se as características de produtividade como o número de fileiras de grãos/espiga, peso (g) de espiga com e sem palha, e peso de grãos (g). Verificou-se que híbridos cujas sementes foram tratadas previamente com inseticida sistêmico thiametoxam, apresentaram menor porcentagem de plantas atacadas, maior desenvolvimento e aumento de 29,5% no peso de grãos em comparação às plantas oriundas de sementes não tratadas. Verificou-se também que os híbridos transgênicos apresentaram menor redução da altura aos 40 DAE, do que as suas isolinhas convencionais. A escala visual de notas foi eficiente para avaliar o grau de sintomas ou injúrias causadas pelo ataque da praga às plantas em desenvolvimento.

PALAVRAS-CHAVE: Inseto. Produtividade. Tratamento de sementes. Transgenia. *Zea mays.*

REFERENCES

ALBUQUERQUE, F. A.; BORGES, L. M.; IACONO, T. O.; CRUBELATI, N. C. S.; SINGER, A. C. Efficiency of insecticides applied in seed treatment and pulverization, in the control of corn initial pests. **Rev. Bra. Milho Sorgo**, Sete Lagoas, v. 5, p. 15-25, 2006.

ÁVILA, C. J.; DUARTE, M. M. Efficiency of insecticides, applied as seed treatment and in plant pulverization in the control of green belly stink bug, *Dichelops melacanthus* (Dallas) (Hemiptera: Pentatomidae), in corn crop. **BioAssay**, Piracicaba, v. 7, p. 6, 2012.

ÁVILA, C. J.; PANIZZI, A. R. Occurrence and damage by *Dichelops (Neodichelops) melacanthus* (Dallas) (Heteroptera: Pentatomidae) on corn. **Neotrop. Entomol.**, Londrina, v. 24, p. 193-194, 1995.

BIANCO, R. Nível de dano e período crítico do milho ao ataque do percevejo barriga verde (*Dichelops melacanthus*). In: CONGRESSO NACIONAL DE MILHO E SORGO, 25. 2004, Cuiabá, MT. **Anais...** Cuiabá-MT: Associação Brasileira de Milho e Sorgo, 2004. p. 172.

BRUSTOLIN, C.; BIANCO, R.; NEVES, P. M. O. J. Pre and post-emergence insecticides in maize (*Zea mays* L.) associated with seed treatment on *Dichelops melacanthus* (DALLAS) (Hemiptera: Pentatomidae). **Rev. Bra. Milho Sorgo**, Sete Lagoas, v. 10, p. 215-223, 2011.

CECCON, G.; RAGA, A.; DUARTE, A. P.; SILOTO, R. C. Effect of insecticides at sowing on seeding pests and yield off-season maize crop under no-tillage system. **Bragantia**, Campinas, v. 63, p. 227-237, 2004 http://dx.doi.org/10.1590/S0006-87052004000200008

CHOCOROSQUI, V. R. **Bioecologia de *Dichelops* (*Diceraeus*) *melacanthus* (Dallas, 1851) (Homoptera: Pentatomidae), danos e controle em soja, milho e trigo no norte do Paraná.** 2001. 160p. Tese (Doutorado em Ciências) - Universidade Federal do Paraná, Curitiba, 2001.

CHOCOROSQUI, V. R.; PANIZZI, A. R. Impact of cultivation systems on *Dichelops melacanthus* (Dallas) (Heteroptera: Pentatomidae) population and damage and its chemical control on wheat. **Neotrop. Entomol.**, Londrina, v. 33, p. 487-492, 2004.

DUARTE, M. M. **Danos causados pelo percevejo barriga-verde, *Dichelops melacanthus* (Dallas, 1851) (Hemiptera: Pentatomidae) nas culturas do milho, *Zea mays* L. e do trigo, *Triticum aestivum* L.** 2009. 59p. Dissertação Mestrado - Universidade Federal da Grande Dourados, Dourados. 2009.

EMBRAPA - EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA. **Sistema Brasileiro de Classificação de Solos**. Rio de Janeiro, Brazil, 1999, p. 412.

FANCELLI, A. L.; DOURADO NETO, D. Ecofisiologia e fenologia. In: FANCELLI, A. L.; DOURADO NETO, D. **Produção de milho.** Guaíba: Agropecuária, 2000, p. 21-54.

GALLO, D.; NAKANO, O.; SILVEIRA NETO, S.; CARVALGO, R. P. L.; BATISTA, G. C.; BERTI FILHO, E.; PARRA, J. R. P.; ZUCCHI, R. A.; ALVES, S. B.; VENDRAMIM, J. D.; MARCHINI, L. C.; LOPES, J. R. S.; OMOTO, C. (Ed.). **Entomologia Agrícola**. São Paulo: Piracicaba: Brazil: FEALQ Press, 2002, p. 649.

GASSEN, D. N. **Manejo de pragas associadas à cultura do milho**. Passo Fundo: Aldeia Norte, 1996. 127p.

GREENE, J. K.; TURNIPSEED, S. G.; SULLIVAN, M. J.; MAY, O. L. Treatment thresholds for stink bugs (Hemiptera: Pentatomidae) in cotton. **Journal of Economic Entomology,** v. 94, p. 403-409. 2001. http://dx.doi.org/10.1603/0022-0493-94.2.403

HORI, K. Possible causes of disease symptoms resulting from the feeding of phytophagous Heteroptera. In: SCHAEFER, C.W.; PANIZZI, A.R. (Ed.). **Heteroptera of economic importance.** Boca Raton: CRC, 2000. p.11-35. http://dx.doi.org/10.1201/9781420041859.ch2

LAUMANN, R. A.; MORAES, M. C. B.; SILVA, J. P.; VIEIRA, A. M. C.; SILVEIRA, S.; BORGES, M. Egg parasitoid wasps as natural enemies of the neotropical stink bug *Dichelops melacanthus*. **Pesq. Agropec. Bras.**, Brasília, v. 5, p. 442-449, 2010.

MANFREDI-COIMBRA, S.; SILVA, J. J.; CHOCOROSQUI, V. R.; PANIZZI, A. R. Damage of the green belly stink bug *Dichelops melacanthus* (Dallas) (Heteroptera: Pentatomidae) to wheat. **Cienc. Rural**, Santa Maria, v. 35, p. 1243-1247, 2005. http://dx.doi.org/10.1590/S0103-84782005000600003

MARTINS, G. L. M.; TOSCANO, L. C.; TOMQUELSKI, G. V.; MARUYAMA, W. I. Chemical Control of Green Belly stink bug *Dichelops melacanthus* (Hemiptera: Pentatomidae) on maize. **Arq. Inst. Biol.**, São Paulo, v. 76, p. 475-478, 2009.

PANIZZI, A. R. Suboptimal nutrition and feeding behavior of hemipterans on less preferred plant food sources. **Anais da Sociedade Entomológica do Brasil**. Londrina, PR, v. 29, n. 1, p. 1-12. 2000.

SILVA, J. J.; VENTURA, M. U.; SILVA, F. A. C.; PANIZZI, A. R. Population dynamics of *Dichelops melacanthus* (Dallas) (Heteroptera: Pentatomide) on host plants. **Neotrop. Entomol.**, Londrina, v. 42, p. 141-145, 2013.

SLANSKY, J. R.; PANIZZI, A. R. Nutritional ecology of seed sucking insects. In: SLANSKY, J.R.; RODRIGUEZ, J. G. (Ed.). **Nutritional ecology of insects, mites, spiders, and related invertebrates.** New York: Wiley, 1987. p. 1016.