CROP PROTECTION

Impact of Cultivation Systems on *Dichelops melacanthus* (Dallas) (Heteroptera: Pentatomidae) Population and Damage and its Chemical Control on Wheat

VIVIANE R. CHOCOROSQUI[1] AND ANTÔNIO R. PANIZZI[2]

[1]*Depto. Zoologia, Universidade Federal do Paraná, C. postal 19020, 81531-990,Curitiba, PR. Present address: Centro de Pesquisa Agropecuária de Clima Temperado (CPACT), Embrapa, Rodovia BR 392, km 78, C. postal 403, 96001-970, Pelotas, RS*
[2]*Centro Nacional de Pesquisa de Soja (CNPSo), Embrapa, C. postal 231, 86001-970, Londrina, PR*
e-mail: panizzi@cnpso.embrapa.br; corresponding author

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Impacto de Sistemas de Cultivo na População e Danos de *Dichelops melacanthus* (Dallas) (Heteroptera: Pentatomidae) e seu Controle Químico em Trigo

RESUMO - Resultados de avaliações de campo indicaram que o pentatomídeo neotropical *Dichelops melacanthus* (Dallas) está associado ao trigo, *Triticum aestivum* L. Em sistema de plantio direto, ninfas e adultos foram encontrados principalmente no solo, próximos aos caules das plantas e sob restos da cultura de verão precedente, em geral, soja, *Glycine max* (L.) Merrill, ou milho, *Zea mays* L. Em trigo sob cultivo convencional observou-se incidência mínima dos percevejos. *D. melacanthus* causou danos substanciais em trigo sob plantio direto, atacando particularmente plantas jovens (plântulas), provocando redução de até 34% no número de espigas e de 31% no peso de grãos. Todas as fases do desenvolvimento da planta do trigo foram suscetíveis ao ataque de *D. melacanthus*, sendo que a maior redução no rendimento ocorreu devido à ação dos percevejos do alongamento dos caules (26,5%) ao estágio de grão leitoso (33,1%). O tratamento de sementes com inseticidas foi eficiente para evitar a perda de rendimento de grãos.

PALAVRAS-CHAVE: Insecta, insecticida, percevejo, plantio direto, tratamento de sementes

ABSTRACT - Results of field evaluations indicated that the neotropical pentatomid *Dichelops melacanthus* (Dallas) is associated with wheat, *Triticum aestivum* L. In the no-tillage cultivation system, adults and nymphs were mostly found on the soil, near the plant stems and underneath crop residues of the preceding summer crop, usually soybean, *Glycine max* (L.) Merrill, or corn, *Zea mays* L. Wheat grown under the conventional cultivation system showed minimal bug attack. *D. melacanthus* caused substantial damage to no-tillage wheat plants, particularly to seedlings. Bug attack reduces the number of seed heads of up to 34%. Seed yield was reduced in 31% due to the bugs' feeding, compared to plants free of damage. All developmental phases of the wheat plant were susceptible to the attack of *D. melacanthus*, and the greatest yield reduction occurred from stem elongation (26.5%) to milky grain stage (33.1%). Seed treatment using insecticides was efficient, greatly reducing the grain production losses.

KEY WORDS: Insecta, insecticide, no-tillage, seed treatment, stink bug

Phytophagous pentatomids are usually seed-feeders, attacking plants during the reproductive period and are of economic importance worldwide (McPherson & McPherson 2000, Panizzi *et al.* 2000). In some areas, such as in the neotropics, stink bugs will reproduce throughout the year, feeding on cultivated and uncultivated plants, with some species spending part of their life time on the soil underneath crop residues (Panizzi 1997).

With the current change in cultural practices, such as the replacement of conventional cultivation by no-tillage cultivation systems, species of stink bugs that spend part of their life time on the soil might be favored by this practice. The neotropical *Dichelops melacanthus* (Dallas) was recently observed to feed on wheat, *Triticum aestivum* L. (Gramineae) seedlings in southern Brazil, where this crop is cultivated during winter following the main summer crops, soybean [*Glycine max* (L.) Merrill] and corn (*Zea mays* L.).

This stink bug was previously recorded feeding and damaging young corn plants, and because of its growing importance as a pest, chemical control measures were recommended to prevent economic damage to this crop (Ávila & Panizzi 1995, Gomez 1998).

D. melacanthus is also reported as a minor pest of soybean (Galileo *et al.* 1977), along with another species of the same genus, *D. furcatus* (F.), which is often referred to as a soybean pest (Galileo *et al.* 1977, Panizzi & Corrêa-Ferreira 1997). Because the two species are similar in appearance (Grazia 1978) it is likely that many of the reports on these species feeding either on soybean or corn contain misidentification of the species under investigation.

One reason to explain the dramatic increase in numbers of *D. melacanthus* is the somewhat recent (< than 10 years) massive adoption by growers of the no-tillage cultivation system in southern Brazil. Because this stink bug is frequently found on the soil underneath debris, we suspect that this cultural practice is favoring its numbers. Therefore, a study was conducted to survey the number of *D. melacanthus* on wheat grown on different cultivation systems, i.e., no-tillage and conventional cultivation, and to evaluate the effect of insecticide application in post-emergence on its damage. We also describe the symptoms of *D. melacanthus* feeding on wheat, determine the most susceptible phase of plant development to the bugs' attack, and evaluate the effect of seed treatment to control this pest.

Material and Methods

The studies were conducted at the Embrapa Soybean (Empresa Brasileira de Pesquisa Agropecuária – Centro Nacional de Pesquisa de Soja) farm in Londrina, Paraná, Brazil (latitude 23° 11' S, longitude 51° 11' W).

Stink Bug Presence and Control vs. Damage on Different Cultivation Systems. Two areas were selected out of two wheat fields established during May 1999 located side by side. In the first area, cultivated with the wheat line WT 95068, and under a no tillage cultivation system, two plots (50 x 40 m) were established. One plot was sprayed on July 15, 1999 with the insecticide endosulfan (525 g a.i./ha) and the other plot was kept free of insecticide and used as the control. The second area, cultivated with cv. BR-18, and under a conventional cropping system, was also divided in two plots as described, and treated as above.

From July 15 to September 8, 1999, weekly samples of *D. melacanthus* were taken from the four plots. Samples consisted of counting the number of insects (nymphs and adults) in an area of 0.70 m^2 (1 x 0.7 m) selected at random using a wooden frame. Five sample units were taken each week from each of the untreated plots and the number of bugs recorded. The mean (± SEM) number of bugs/sample was calculated from each sampling date. Data were plotted in a graph to illustrate and compare the abundance of *D. melacanthus* on wheat under both cultivation systems. Because the wheat cultivars were not the same, the data on stink bug abundance were not compared statistically.

To evaluate the damage by *D. melacanthus* to wheat, seven samples of 1 m^2 (1 x 1 m) of plants were collected at harvest, from each of the four plots. Plants were taken to the laboratory and the following parameters were evaluated: number of seed heads/m^2, weight of 1000 grains, and grain yield/m^2. Data were compared between the plots within each cultivation system and were analyzed with analysis of variance (ANOVA) and means compared using the *t* test ($P \leq 0.05$).

Stink Bug Damage vs. Plant Phenology. To evaluate the damage by *D. melacanthus* on wheat plants at different developmental stage, a study was conducted in the greenhouse, from March to September, 2000. Adult stink bugs (10 d-old) were obtained from a colony established in the laboratory. Pots (40 x 28 cm) were prepared with soil treated with phosphine, used to eliminate infestation by eggs, larvae or other insects. Five seeds of wheat cv. BR-18 were placed in each pot. Dry wheat leaves were placed on the surface of the soil, simulating the no-tillage cultivation system. Five pots were prepared for each treatment. After plant emergence, each pot was infested with two adults of *D. melacanthus* during the following plant developmental stages (six treatments): seedling (from plant emergence to appearance of the first tiller); tillering (from beginning of plant tillering to beginning of stem elongation); stem elongation (from beginning of stem elongation to emission of flag leaf); booting (from emission of flag leaf until appearance of first head); heading (from head set to milky grain stage); and grain development (from milky grain stage to complete head maturation). Control plants free of bugs were used for comparison. Treatments were assigned at random.

Plants from all treatments were covered with cages from emergence until complete maturation. The following parameters were evaluated: number of abnormal tillers and dead plants, number of seed heads, percentage of abnormal heads (green and empty), and grain yield/pot (g). Data were submitted to analysis of variance (ANOVA), and the means compared using the Tukey test ($P \leq 0.05$).

Seed Treatment vs. Stink Bug Damage. To evaluate the effect of seed treatment to mitigate *D. melacanthus* damage to wheat plants, a study was conducted in the field at Embrapa Soybean, during May-September, 2000. The damage caused on wheat plants, with treated and untreated seeds, was evaluated using two population levels (4 and 8 bugs/m^2). Adults 10 d-old, obtained from the laboratory colony were used. On a no-tillage cultivation system area previously cultivated with corn, six treatments (replicated 4X) were randomly distributed in plots. Each plot consisted of 1 m^2, with two lines of 1 m of wheat cv. BR-18 (density of 250 seeds/m^2). The treatments were: control 4 (no seed treatment, with 4 insects/m^2); control 8 (no seed treatment, with 8 insects/m^2); imidacloprid 4 and imidacloprid 8 (Imidacloprid 600 SC, 36 g a.i./100 kg of seeds, with 4 and 8 bugs/m^2, respectively); thiamethoxam 4 and thiamethoxam 8 (Thiamethoxam 700 WS, 24.5 g a.i./100 kg of seeds, with 4 and 8 bugs/m^2, respectively). The plots were covered with cages to prevent escape of the bugs and infestation by other pests.

Upon plant emergence, insects were placed in the cages and kept until plant harvest, when the following parameters were evaluated: grain yield/plot (g), weight of 1000 seeds, and % germination of seeds from each treatment. Data were submitted to analysis of variance (ANOVA), and means compared using the Tukey test ($P \leq 0.05$).

Results and Discussion

Stink Bug Presence and Control vs. Damage under Different Cultivation Systems. Nymphs and adults of *D. melacanthus* were captured in greater numbers on the wheat plots under no-tillage cultivation system than on wheat plots under conventional cultivation (Fig. 1). Because, the paired fields were cultivated with different cultivars, data can only suggest that this difference was due to the distinct cultivation systems used.

In the no-tillage cultivation plots, the bugs were more abundant during July, reaching the population peak of 3.0 bugs/m^2 at the beginning of the month, decreasing to approximately 0.8 bugs/sample latter in July. In the beginning of August, the number of bugs captured decreased to 0.5 bugs/m^2, down to zero in the two subsequent sampling dates, and rising again to approximately 0.3 bugs/m^2 late August-early September, when wheat reached maturity and was harvested. On the plots with wheat under the conventional cultivation system, *D. melacanthus* was captured on two occasions only (25% of the total sampling dates), in late July and late August, and in small numbers (0.3 bugs/m^2).

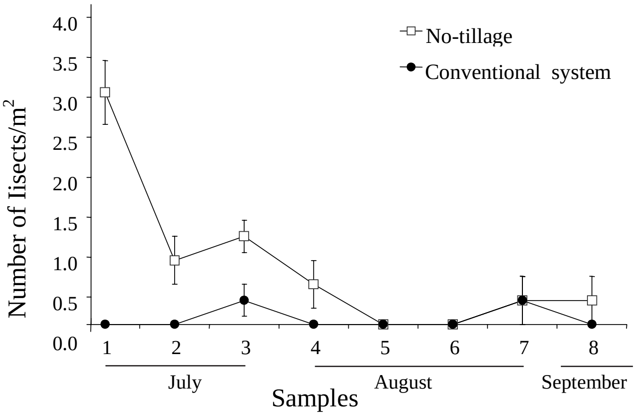

Figure 1. Mean (± SEM) number of nymphs and adults of *D. melacanthus* captured in wheat fields under different cultivation systems.

The damage by *D. melacanthus* to wheat was greater in the area under the no-tillage cultivation system that did not receive the chemical application of insecticide compared to the area under chemical control (Table 1). Again, although these results suggest that the damage effect is related to the different stink bug populations, they should be considered with precaution because of the different cultivars used.

In the no-tillage, the plot without chemical control had the total number of seed heads, grain weight/sample and grain yield/plot significantly ($P \leq 0.05$) reduced, compared to the plot that received the application of insecticide (Table 1). The percentage reduction in the number of seed heads and grain yield was ca. 30%. The weight of 1,000 grains, although not statistically different, was 5.2% less on the no-tillage plot without control compared to wheat on the no-tillage cultivation system that received insecticide.

In general, in the plot under conventional cultivation system, no significant differences were observed for the various wheat yield parameters measured, comparing the area under chemical control with the area that did not receive insecticide (Table 1). In some cases (number of seed heads, seed weight/sample and grain yield), a tendency of greater values were observed in the area without bug control, indicating no stink bug damage on wheat under the conventional cultivation system.

Because different wheat cultivars were used for the two cultivation systems (i.e., no-tillage and conventional), no statistical comparisons were possible between the systems, either untreated or treated with insecticides. However, when chemical control was not used, a drastic reduction in wheat yield parameters was observed in the no-tillage system compared to the wheat under conventional cultivation. These results clearly indicate a bug effect, even considering that the cultivars were different.

Results on the population surveys of *D. melacanthus* on wheat under different cultivation systems suggest that the crop under the no-tillage system supports the bug presence. This cultivation system which does not disturb the environment created by the preceding crop, favors this insect because it spends most of its lifetime on the ground either feeding on corn seedlings (Ávila & Panizzi 1995) or wheat seedlings. In addition, *D. melacanthus*,

Table 1. Damage by *D. melacanthus* to wheat cultivated under no-tillage and conventional tillage systems and with and without chemical control.

Treatments[1] (n = 7)	Yield parameters (mean ± SEM) No. of seed heads	Weight of 1000 grains (g)	Grain yield (g)
No-tillage (no chemical control)	264.6 ± 18.52 b (-33.8%)[2]	29.4 ± 0.66 a (-5.2%)	260.8 ± 25.35 b (-30.6%)
No-tillage (chemical control)	400.0 ± 13.49 a	31.0 ± 0.43 a	376.0 ± 13.02 a
Conventional (no chemical control)	382.7 ± 12.04 a (+17.5 %)	36.6 ± 0.28 a (- 2.6%)	418.9 ± 20.10 a (+10.9%)
Conventional (chemical control)	325.7 ± 15.08 b	37.6 ± 0.57 a	377.6 ± 18.64 a

Means followed by the same letter in the columns, under each tillage system, do not differ significantly using *t* test ($P \leq 0.05$).

[1] No statistics were used to compare the data between the plots with no-tillage and conventional cultivation systems (with and without chemical control) because different genotypes were used.

[2] In parentheses changes (%) in the wheat yield parameters in the no chemical control plots were based on differences compared to the chemical control plots.

enters in a state of arrestant development (diapause) underneath debris when the crops are not in the field (Chocorosqui & Panizzi 2003), and is favored in areas undisturbed such as the areas under no-tillage cultivation.

Another pentatomid pest of soybean, *Euschistus heros* (Fabricius), also enters into diapause on the soil underneath fallen dead leaves, after the crop is harvested (Panizzi & Vivan 1997). This behavior protects the bugs from parasitism by tachinid flies, what does not happen with the pentatomid, *Nezara viridula* (L.), which does not hide but continues to feed on alternate host plants during mild winters of the neotropics (Panizzi 1997, Panizzi & Oliveira 1999).

Because *D. melacanthus* feeds on wheat stems near the ground, the crop residues produced under the no-tillage cultivation provide shelter and protection. The feeding behavior of this pentatomid on wheat contrasts with that of other hemipterans, which prefer to feed on seed heads, such as the so-called sunn pests - *Eurygaster* spp. (Scutelleridae), and *Aelia* spp. (Pentatomidae) - major pests of wheat and other cereals in the Near and Middle East, Southwestern Asian countries and the Mediterranean region (Javahery 1995), and *Dysdercus cingulatus* F. (Pyrrhocoridae), pest of wheat in India (Srivastava & Gupta 1971). However, several species of hemipterans (mostly pentatomids and lygaeids), usually associated with host plants in the reproductive period, have been reported to feed and damage seedling corn or corn latter in the vegetative period (Negrón & Riley 1985, 1987; Townsend & Sedlacek 1986; Sedlacek & Townsend 1988).

The impact of the damage by *D. melacanthus* on wheat cultivated in the no-tillage cropping system significantly reduced the number of seed heads and grain yield, which demonstrates for the first time that this stink bug has become an important pest of this cereal. In a similar way, several other species of insects, that spend part of their lifetime in the soil, have become increasingly important pests due to the implementation of the no-tillage cropping system (Oliveira *et al*. 1997). Despite the several advantages of this cultivation system, such as water erosion control and decrease in labor, the no-tillage cropping system favors soil inhabiting insect pests. In the case of *D. melacanthus,* control measures are needed to control this bug in wheat that is under the no-tillage system.

Wheat plants attacked by *D. melacanthus* during the vegetative growth showed abnormal maturation with green spikes at harvest. Despite the great number of wheat plants/m² that is used and the natural tillering of the plants, stink bug damage can be easily detected during the vegetative growth.

Considering the different infestation periods, there were no statistical differences in the number of abnormal tillers and dead plants (Table 2). The greatest number of abnormal tillers (1.8) and dead plants (2.8) was observed for plants infested during the stem elongation. Abnormal tillers were not observed on plants infested by *D. melacanthus* during the milky grain stage and on control (uninfested) plants. The number of dead plants was also low in these two treatments (0.6).

The number of seed heads/pot did not differ among treatments (Table 2). However, plants attacked during stem elongation presented a significantly higher percentage of abnormal green seed heads at maturation (26.0%), in comparison to plants infested during tillering (1.5%), milky grain stages (0.0%), or uninfested plants (control - 0.0%). No statistical difference was detected among the other treatments. The percentage of abnormal empty seed heads (no grain formation) was higher for the stem elongation treatment in comparison to the control. There were no significant differences among the other treatments.

Grain yield was significantly lower for wheat plants infested during the stem elongation, booting, heading and milky grain stages, compared to the uninfested (control) plants, for which grain yield was similar to plants infested during the seedling or tillering stages (Fig. 2). Lower reduction in grain production, due to *D. melacanthus* attack, was observed during the tillering (7.3%) and seedling (15.4%) stages, which production was compared to the control. From stem elongation on, grain production was considerably reduced, varying from 26.5% (stem elongation) to 33.1% (booting).

Table 2. Damage caused by *D. melacanthus* on different developmental stages of wheat in greenhouse potted plants, infested with 2 adults/pot with each pot containing five plants (n = 5).

Stage	Number/pot (mean ± SEM)			Abnormal seed heads (mean ± SEM)	
	Abnormal tillers	Dead plants	Seed heads	Green (%)	Empty (%)
Seedling	1.0 ± 0.32 a	1.2 ± 0.37 a	11.8 ± 0.73 a	8.5 ± 2.52 ab	8.5 ± 2.52 ab
Tillering	0.4 ± 0.24 a	1.8 ± 0.91 a	11.8 ± 0.37 a	1.5 ± 1.54 b	3.2 ± 1.97 ab
Stem elongation	1.8 ± 1.11 a	2.8 ± 0.86 a	12.2 ± 1.43 a	26.0 ± 8.59 a	16.1 ± 7.91 a
Booting	0.4 ± 0.24 a	1.8 ± 0.76 a	12.2 ± 0.80 a	6.5 ± 3.33 ab	8.0 ± 3.79 ab
Heading	1.2 ± 0.73 a	1.6 ± 0.68 a	12.2 ± 0.58 a	9.5 ± 6.22 ab	9.5 ± 6.22 ab
Milky grain	0.0 ± 0.00 a	0.6 ± 0.40 a	11.0 ± 0.71 a	0.0 ± 0.00 b	1.5 ± 1.54 ab
Control	0.0 ± 0.00 a	0.6 ± 0.60 a	11.6 ± 0.68 a	0.0 ± 0.00 b	0.0 ± 0.00 b

Means followed by the same letter in each column do not differ significantly using Tukey test ($P \leq 0.05$).

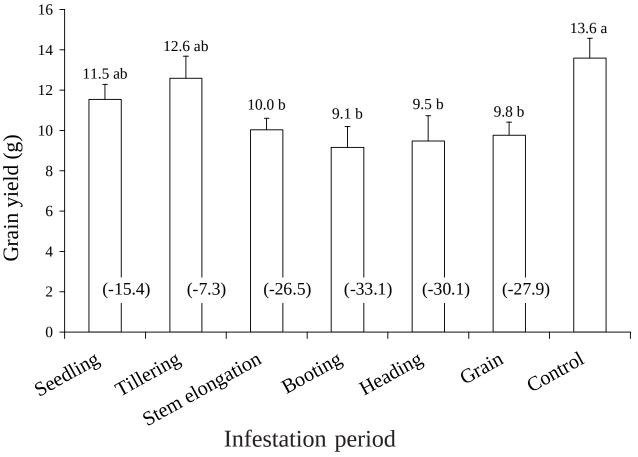

Figure 2. Grain yield (g) of wheat plants attacked by *D. melacanthus* in different developmental stages, in comparison to the uninfested control plants. Means (± SEM) followed by the same letter do not differ significantly using Tukey test ($P \leq 0.05$) (n = 5) (% reduction in grain production in parentheses).

Seed Treatment vs. Stink Bug Damage. In general, the wheat grain yield was significantly lower for the control plants infested with bugs, in comparison to the treatments on which the seeds received insecticides, either imidacloprid or thiametoxan (Fig. 3). When seeds were treated with imidacloprid, grain production was ca. 28-32% greater than the grain production of the control plots whereas the treatment with thiamethoxam yielded ca.19-23% more than the control plots. However, because no statistical differences among treatments, we can only say that seeds treated with imidacloprid tended to produce the highest yields.

The quality of the wheat seeds, considering germination (%), was similar for all treatments, including the plots that received the infestations (i.e., 4 and 8 stink bugs/m^2) and which seeds were not treated with insecticides (Fig. 4A). Some reduction in the weight (g) of 1000 seeds was observed for the control plots (infested with 4 stink bugs/m^2, but not for the plots infested with 8 stink bugs/m^2), compared to the ones which seeds were chemically treated (Fig. 4B).

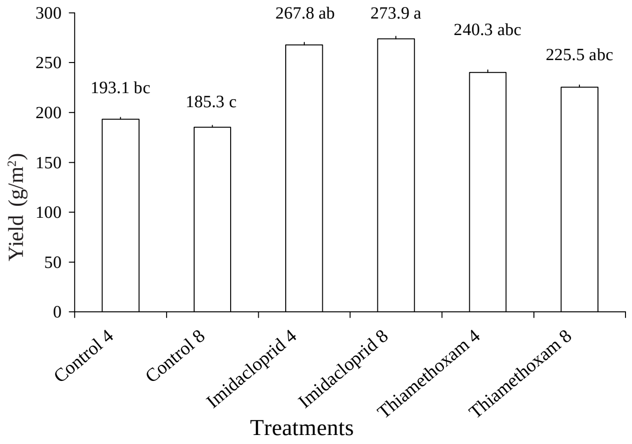

Figure 3. Effect of seed treatment on the production of wheat yield (g/m²) with two levels of *D. melacanthus* infestation (4 and 8 bugs/m^2) in the field. Means (± SEM) followed by the same letter do not differ significantly using the Tukey test ($P \leq 0.05$) (n = 4).

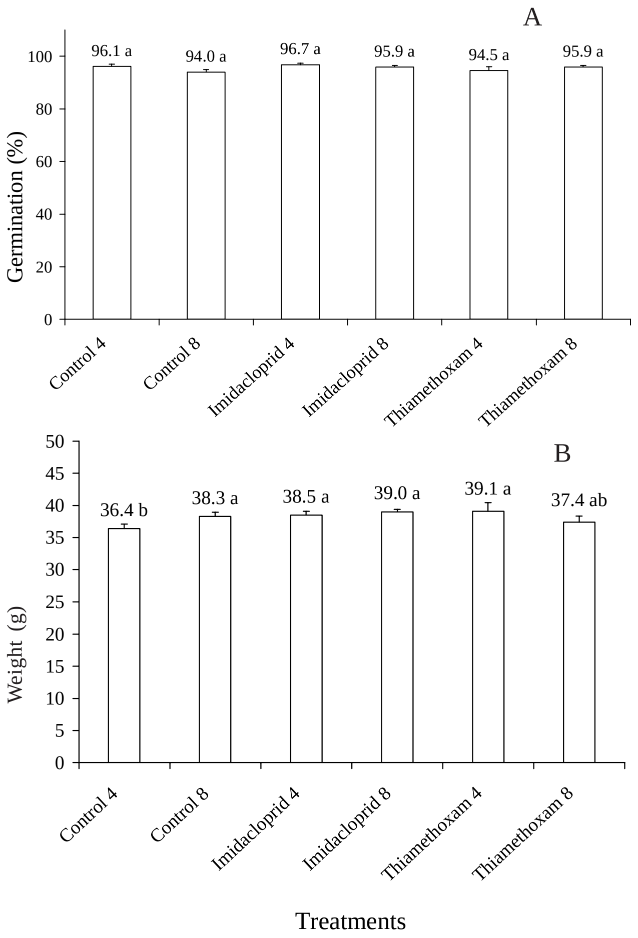

Figure 4. Effect of seed treatment with insecticides on germination [A] and on weight of 1000 wheat seeds [B] from field plants with different levels of infestation of *D. melacanthus* (4 and 8 bugs/m^2). Means (± SEM) followed by the same letter do not differ significantly using the Tukey test ($P \leq 0.05$) (n = 4).

Results of these studies demonstrate that the stink bug *D. melacanthus* is an important pest that may cause significant damage to wheat, in particular, due to the large-scale adoption of the no-tillage cultivation system that favors its biology. Similar to other species of pentatomids, *D. melacanthus* populations are increasing fast in numbers due to its ability to survive under less favorable conditions on the soil. Results also demonstrate that insecticides applied to seeds, and sprayed on plants mitigate the impact of *D. melacanthus* to wheat. Other management strategies of this pest could also include plowing to dislodge the insects from their shelters, and avoidance of seed harvest losses to reduce food availability on the soil.

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