Crop Protection 79 (2016) 20–25

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Effect of green-belly stink bug, *Dichelops furcatus* (F.) on wheat yield and development

Antônio R. Panizzi [a, *], Alice Agostinetto [b], Tiago Lucini [c], Paulo R.V. da S. Pereira [a]

[a] Embrapa Wheat, P.O. Box 3081, Passo Fundo, RS, 99001-970, Brazil
[b] Agronomy School, University of Passo Fundo, Passo Fundo, RS, 99052-900, Brazil
[c] Department of Zoology, Federal University of Paraná, P.O. Box 19020, Curitiba, PR, Brazil

ARTICLE INFO

Article history:
Received 2 June 2015
Received in revised form
4 October 2015
Accepted 6 October 2015
Available online 20 October 2015

Keywords:
Pentatomidae
Damage
Yield
Wheat
Neotropics

ABSTRACT

The green belly stink bug, *Dichelops furcatus* (F.) (Hemiptera: Heteroptera: Pentatomidae) is a pest of corn and soybean in southern Brazil. It also occurs on wheat, but information on its damage to this crop is limited. To determine the need for sustainable IPM programs, the impact of this bug on wheat production should be determined. Studies were conducted in the screenhouse with 1, 2 and 4 bugs caged for 16 days on single plants, cv. 'BRS Parrudo'. During the vegetative period (plants ca. 25 cm tall), all infestation levels significantly reduced plant height and ear head length, but did not reduce grain yield. Feeding damage caused tissue necrosis on leaves. During the booting stage, grain yield was significantly reduced with 2 and 4 bugs per plant; ear heads were small, discolored and abnormally developed. In 2013 and 2014 field trials, plants were infested for 18 days with 2, 4 and 8 bugs per m^2 at vegetative, booting, and milky grain stage. At these infestation levels, there was no significant reduction in grain yield. There was a significant decrease in the number of normal seedlings resulting from seeds exposed to 8 bugs per m^2 at the milky grain stage. Results suggest that, in general, there is no need to control *D. furcatus* on wheat, unless numbers are $\geq$8 bugs per m^2 during reproductive period.

1. Introduction

The green belly stink bug, *Dichelops furcatus* (F.) is a Neotropical pentatomid often recorded in the southern states of Brazil (Chiaradia et al., 2011; Pereira et al., 2013). This polyphagous stink bug has been registered on 27 plant species belonging to 11 plant families, which include cultivated and non-cultivated plants (Smaniotto and Panizzi, 2015). Among the cultivated plants, *D. furcatus* has been reported on soybean, *Glycine max* (L.) Merrill (Fabaceae) (Panizzi et al., 1977), sunflower, *Helianthus annuus* L. (Frota and Santos, 2007), corn, *Zea mays* (L.) (Poaceae) (Roza-Gomes et al., 2011), common oat, *Avena sativa* L. and on wheat, *Triticum aestivum* L. (Poaceae) (Chocorosqui and Panizzi, 2004; Pereira et al., 2013).

Species of *Dichelops* [*D. furcatus* and *Dichelops melacanthus* (Dallas)] are known to cause significant damage to wheat and corn (Chocorosqui and Panizzi, 2004; Manfredi-Coimbra et al., 2005; Roza-Gomes et al., 2011). This has resulted in the recommendation to growers of chemical control by spraying insecticides on the foliage or by seed treatment to prevent the stink bugs damage to these crops (Chocorosqui and Panizzi, 2004; Martins et al., 2009; Ávila and Duarte, 2012).

A dramatic increase in *D. furcatus* abundance in southern Brazil has been attributed to the wide adoption of the no-tillage cultivation system. This system provides food (i.e., fallen seeds of the previous crop) as well as protection (shelter underneath crop residues) during colder months (Chocorosqui and Panizzi, 2004). As temperature rises the bugs move out and feeds on wheat. Because of these field observations, and because of lack of information, studies were conducted on the effect of *D. furcatus* on yield and development of wheat plants.

In this article we report the results of screenhouse and field tests carried out to evaluate the impact of *D. furcatus* on plant height, ear head length, grain yield, and seed quality of wheat plants infested at different phenological stages of development, i.e., during early plant development (tillering), during booting, and during the milky stage of grain formation.

* Corresponding author.
E-mail address: antonio.panizzi@embrapa.br (A.R. Panizzi).

http://dx.doi.org/10.1016/j.cropro.2015.10.006

2. Materials and methods

2.1. Stink bug colony in the laboratory

During May to November 2013, a colony of *D. furcatus* was established in the laboratory from field-collected adults obtained from crop residues and weed plants in areas previously cultivated with soybean and wheat at the Embrapa Wheat Field Experiment Station at Passo Fundo, RS, Brazil (28° 15′ S latitude; 52° 24′ W longitude).

Adults were taken to the laboratory and placed in clear plastic rearing boxes (25 × 20 × 20 cm), lined with filter paper and provided with pods of green bean, *Phaseolus vulgaris* L., raw shelled peanut, *Arachis hypogaea* L., mature seeds of soybean and fruits (berries) of privet, *Ligustrum lucidum* Ait. (Oleaceae). This mixture of foods provided is routinely used to rear stink bugs in the laboratory (Silva and Panizzi, 2007). Boxes were kept in a walk-in chamber at 25 ± 1 °C temperature, 65 ± 5% RH and a photoperiod of 14:10 h (L:D).

Bugs were checked every other day and the food was replaced when necessary. The colony was replenished approximately twice per month with the addition of field-collected adults and nymphs. Adults from the laboratory colony were used to infest the cages, using an approximate sex ratio of 1 female to 1 male.

2.2. Studies conducted in the screenhouse

From September to November 2013, a screenhouse study was conducted at the Embrapa Wheat Research Unit in Passo Fundo, RS state, Brazil. Wheat seeds of cv. BRS Parrudo were seeded in pots (18 × 22 cm). Each pot contained one plant, which was covered with a net supported by a metal frame. Plants were infested at two different phenological stages of development according to scale proposed by Feekes & Large (Large, 1954): vegetative period (stage 3 − V3) with plants ca. 25 cm high, and during the reproductive period (stage 10 − R10), when plants were starting to develop ear heads inside the stems (booting).

Each plant was infested with 1, 2 or 4 stink bugs; control pots were kept uninfested. Each infestation level and control pot was replicated four times in a completely randomized design and repeated twice. The infestation period lasted 16 days, for each of the plant stages tested. At the end of the infestation period for the vegetative stage, the number of leaves showing damage (i.e., stink bug feeding signs with tissue necrosis, and filiform dead tissue at their tips) was recorded. This last procedure was done only in the second repetition. After the infestation period, the bugs were removed and the plants allowed to mature. At maturation, plants were harvested and taken to the laboratory. Plant height, ear head length, and grain yield were then evaluated.

2.3. Studies conducted in the field (2013 and 2014)

For field trials, seeds of cv. BRS Parrudo were planted at the Embrapa Wheat Field Experiment Station in rows spaced 20 cm apart. The soil was fertilized with NPK (5-25-25) with 200 kg ha^{-1} and the herbicide Hussar® (a.i. iodosulfuron-methyl-sodium − 60%) 6 g a.i. ha^{-1} was used to kill the weeds prior to the establishment of the wheat field. From June to November 2013 and 2014, field cages (1.0 × 1.0 × 1.5 m) were set over wheat plants. In 2013, plants were infested at two different phenological stages of development according to Feekes & Large scale (Large, 1954): the vegetative stage (stage 3 − V3) with plants ca. 25 cm high, and during the reproductive stage (stage 11.1 − R11.1), when the grains in the ear heads were developing (milky grain stage). In 2014, plants were infested at the same phenological stages tested in 2013; but an additional stage, the reproductive stage R10 (booting) was also evaluated.

When plants reached ca. 15 cm, plant population in each cage (1 m^2) was thinned to 50 plants. At the appropriate developmental stage, plants in the cages were infested with 0, 2, 4, and 8 stink bugs and arranged in a randomized block design. Each infestation level was replicated four times. The infestation period lasted 18 days for each of the plant stages tested. Survival of the bug was assessed per week. When dead bugs were found in the cage, they were replaced.

After the infestation period, bugs were eliminated from the cages with the application of insecticide [Acefato Nortox® (a.i. Acephate) 750 g a.i. ha^{-1}]. At maturation the cages were removed, plants were harvested and taken to the laboratory. For each cage, the grain yield ha^{-1} was calculated.

In the second year, we examined the seed quality from the plants infested with *D. furcatus* (seeds from the first year were damaged by excess humidity during storage which prevented the analysis). Seeds from plants infested during the milky grain stage were placed in germination paper Germitex® with moisture and placed in an environmental chamber at 0.5 °C for 5 days, and then placed in another chamber at 20 °C and 12 h light photoperiod for another 5 days. After this period, 100 seeds per replicate were analyzed for germination and the number of normal seedlings, i.e., seedlings without any sign of damage in leaves and roots (MAPA, 2009) were counted.

2.4. Statistical analysis

Data from the screenhouse test (plant height, ear head length, leaf damage signs, and grain yield) and field cage tests (grain yield and seed quality) were submitted to analysis of variance (ANOVA), and means were compared using the Tukey test ($P < 0.05$). Plant height and ear head length were averaged across tillers for each plant (experimental unit) prior to ANOVA. All statistics were performed using the statistics program R (version 3.0.3) (R Development Core Team, 2014). Data of grain yield were expressed in kg ha^{-1}, considering 300,000 plants ha^{-1}, according to technical recommendation (Fundação Meridional, 2014).

3. Results

3.1. Studies conducted in the screenhouse

When plants were infested during the vegetative stage for 16 days, plant height (cm) ($F = 7.9$; $df = 3, 28$; $P < 0.0005$) and ear head length (cm) ($F = 9.7$; $df = 3, 28$; $P < 0.0001$) were significantly reduced by stink bug feeding, although there were no significant differences among stink bug numbers (Fig. 1A,C). Stink bug infestation during booting also significantly reduced plant height ($F = 15.3$; $df = 3, 28$; $P < 0.0001$) and ear head length ($F = 7.0$; $df = 3, 28$; $P < 0.0011$) compared to the uninfested plants (Fig. 1B,D).

The number of leaves showing stink bug damage (tissue necrosis at the feeding site) during the vegetative stage was significantly ($F = 14.8$; $df = 3, 12$; $P < 0.0002$) greater with 4 stink bugs per plant compared to those infested with 1 or 0 stink bugs per plant (Fig. 2). There were no differences in leaf damage between plants infested with 1 or 2 bugs per plant. Uninfested plants (controls) showed no signs of damage and were significantly different from plants with 2 or 4 bugs per plant. Statistically similar results were observed for the stink bug damage characterized as leaves with filiform dead tissue at their tips ($F = 11.7$; $df = 3, 12$; $P < 0.0007$) (Fig. 2).

Despite the very high levels of infestation (up to 4 bugs per plant), no significant ($F = 1.16$; $df = 3, 28$; $P < 0.3430$) reduction in grain yield was observed for plants infested during the vegetative