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RESEARCH NOTE

Determination of damage caused by different populations of *Diloboderus abderus* (Coleoptera: Scarabaeidae) larvae on wheat

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Abstract

Wheat (*Triticum aestivum* L.) is the most widely cultivated cereal crop worldwide because it is an important food source for humans. South America has long been associated with wheat production and export. Given the increased application of no till in the last decades, the scarabid *Diloboderus abderus* has become the main soil pest of this crop. The larvae of this insect (white grubs) feed on roots, causing plant weakening and death. The aim of this work was to determine the relationship between the soil population of *D. abderus* larvae and the number of established wheat plants. In a plot cultivated with the wheat cultivar Don Mario Algarrobo at a seeding rate of 130 kg ha^{-1} and with high population levels of this pest, 1-m^2 sites with 20-39; 40-60; 80-100; 120-160 and or 200-240 plants were established. At the tillering phenological stage, the number of tillers per plant and of insect larvae in each subplot was counted. The results showed a significant reduction in plant density with increasing soil larval population. The crop counterbalanced the reduction in plant number by increasing the tiller number per unit area. The present work shows that population levels above 11 larvae m^{-2} generate a significant reduction in the number of wheat plants established in the crop.

Keywords: White grubs, wheat plant stand, scarab beetles, wheat tillering, *Triticum aestivum,* insect pest.

Introduction

Wheat (*Triticum aestivum* L.) is a highly important food source for humans and is cultivated in diverse environments worldwide. This crop also meets a large proportion of the demand for animal feed and has many industrial uses (FAO, 2014). Wheat crop productivity is affected by several factors, with damage caused by insect pests being one of the most important. *Diloboderus abderus* Sturm 1826 (Coleoptera: Scarabaeidae) is a soil-dwelling insect that causes the greatest damage to wheat in South America (Fava & Imwinkelried, 2004). This species has three larval stages (white grubs) and an annual life cycle (Mareggiani & Pelicano, 2010). No-tillage, the main agricultural productive system in Argentina, Brazil and Uruguay, has caused increases in *D. abderus* populations in most of the cultivated areas (Silva and Salvadori, 2004). Larvae of this coleopteran feed on roots of wheat seedlings at 10-30 cm in depth, causing seedling weakening or even death (Fig. 1). Severe infestations can lead to a decline of plant density and significant yield losses. Wheat crop partly counteracts the reduced number of tillers per unit area by increasing tiller number in each established plant (Xu et al., 2015). Knowledge of this behavior is important, since it influences the final crop production.
Aragón (2002) determined the economic threshold of 5 larvae m^{-2} for damage of this pest to wheat crop. This value is often exceeded in the wheat-producing regions. The aim of this work was to determine the relationship between *D. abderus* larval population and the number of established wheat plants. This is the first work that quantifies the reduction of wheat plant stands in white grub-infected fields.

Results and Discussion

Density of wheat plants established in the field was associated with the number of *D. abderus* larvae present in the soil. A significant reduction in plant stand was observed with increasing larval population (F=39.89; df= 4,29; P<0.0001) (Figure 2). Only third-stage larvae were recorded in insect counts because of the stage of the plant growth cycle at the count time and the environmental conditions (14.3ºC; 88.3% RH and 59 mm of rainfall). The presence of more than 10 larvae m^{-2} significantly reduced plant number. Plant density per unit area is one of the main yield components in wheat, and achieving an appropriate plant stand has a positive effect on yields (Urruty et al., 2017). Tillering capacity is an important trait in wheat architecture, since the number of tillers per plant determines the spike number and has a direct effect on grain production (Naruoka et al., 2011).

Fig 1. *Diloboderus abderus* in the wheat crop. A) Wheat crop not affected by *D. abderus*; B) wheat crop affected by *D. abderus*; C) plants whose roots have been consumed by larvae of *D. abderus*; D) larvae of *D. abderus*; and E) galleries generated by larvae of *D. abderus* in the soil.

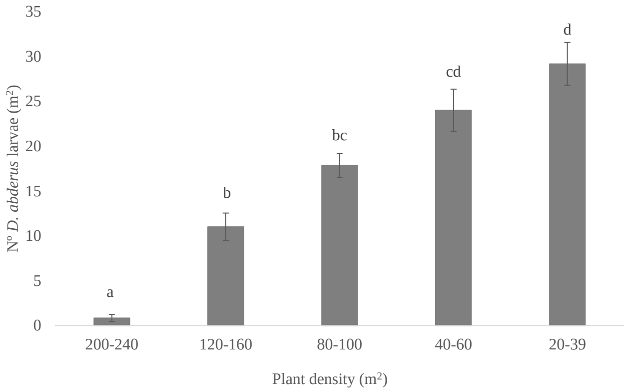

Fig 2. Effect of the number of *D. abderus* larvae on the number of wheat plants established in the field. Results are expressed as mean ± standard error of the mean. Different letters indicate significant differences between densities, according to the Tukey test (P<0.05).

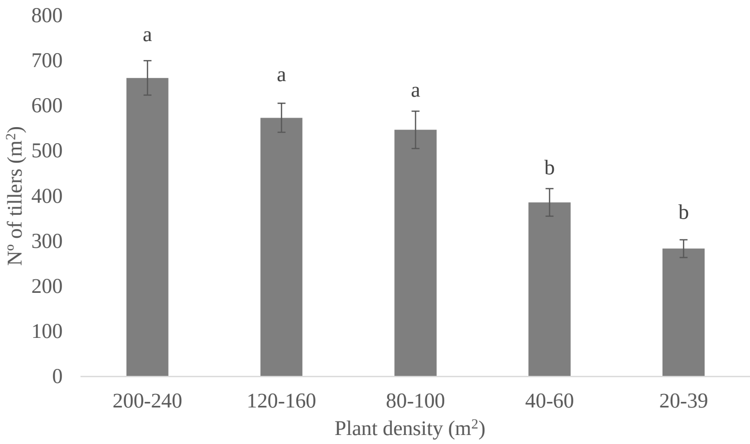

Fig 3. Number of wheat tillers per m^{-2} observed in sites under different plant densities. Results are expressed as mean ± standard error of the mean. Different letters indicate significant differences between densities, according to the Tukey test (P<0.05).

A significant reduction in the number of tillers in the crop was observed at densities below 80-100 plants m^2 (F=21.1; df= 4.29; P<0.0001) (Figure 3). The reduction of plant numbers caused by *D. abderus* larvae modified the crop spatial distribution pattern; consequently, the established plants adapted to the new density conditions by adjusting their structure and physiology (Vos et al., 2010). The crop counter-balanced the reduction in the number of plants by increasing number of tillers per plant (Barnes and Bugbee, 1991). At stem elongation, death of many of the tillers that have formed –the smallest ones and those appearing last– occurs and the number of potential spikes generated by the plant is reduced. As indicated by Berry et al. (2003), the greater the initial differentiation of tillers per plant, the lower the tiller survival. Hence, achieving a good establishment is important to ensure a suitable number of spikes per square meter originated from the main stem and fertile tillers. Accordingly, the lack of statistical difference observed in the number of tillers generated at the highest plant densities does not mean that those tillers will produce the same number of spikes at harvest.

Aragón (2002) indicated that the presence of this insect pest at 30 larvae m^{-2} can produce losses of 70 to 90 % in wheat crop production. Accordingly, while determining the effects of *D. abderus* on yield was not within the scope of this work, we consider that densities between 20 and 60 plants m^{-2} in our study may have had such yield loss values.

Materials and methods

Crop and insects

Density of *D. abderus* larval population was determined in a commercial wheat plot with previous low or null incidence of larva mortality due to parasitoids or other entomopathogenic agents. In addition, no other soil pests affecting this crop were recorded. This situation is not common in the Argentine Pampas and therefore provided an excellent opportunity to investigate damage caused by this pest under field conditions without underestimating larval populations that had died before being quantified.

The study was conducted in Esperanza, Santa Fe, Argentina (31º 26´S, 60º 50´W). The soil in the cultivated plot is Aquic Argiudoll, and had the following characteristics: 2.0 % OM, pH 5.6, and 5:66:29 sand, silt and clay, respectively. The plot had been under agricultural rotation using no-till for 7 years before the start of the trial and had soybean as preceding crop. On June 3 2017, the wheat cultivar Don Mario Algarrobo was sown at a seeding rate of 130 kg ha^{-1} (350 seed m^{-2}) and a row spacing of 17.5 cm.

Experimental treatments

The evaluations were performed 87 days after sowing, when the crop reached the tillering phenological stage Z 2.1, according to the scale of Zadoks et al. (1974). In a completely randomized design, 30 1-m^2 sites were delimited in different sectors of the plot and the number of established plants in each site was counted. Based on the plant densities, five treatments with six replications were defined: 20-39; 40-60; 80-100; 120-160 and 200-240 wheat plants m^{-2}. Then, the number of tillers per plant was counted and the total soil of each site (30 cm in depth) was collected with a shovel and inspected visually for white grubs. Larvae were identified according to the raster pattern (Alvarado, 1980). Environmental conditions were recorded using a data logger (Hobo Onset Corp.).

Statistical analyses

Results were analyzed using an analysis of variance (ANOVA) and differences between means were compared using the Tukey test at the 5% probability level; all analyses were performed using INFOSTAT statistical software (Di Rienzo et al., 2016).

Conclusion

We conclude that populations higher than 11 *D. abderus* larvae m^{-2} severely reduce the number of established wheat plants. This is the first research that quantifies the reduction in the wheat plant stand caused by *D. abderus* larvae and their effects on tillering.

Acknowledgments

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