Sampling of *Rhyssomatus subtilis* (Coleoptera: Curculionidae) adults on soybean, using the vertical beat sheet method*

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ABSTRACT

Rhyssomatus subtilis Fiedler (Coleoptera: Curculionidae) adults were sampled in 10 soybean crop fields in Northwestern Argentina throughout 2012 and 2014, using the vertical beat sheet (VBS) method. The obtained values were contrasted with the total number of adults actually present in those fields, which demonstrated that the abovementioned method caught 60% of individuals. Therefore, it became evident that these data needed to be corrected by dividing the values obtained with VBS by 0.65, number obtained with a linear regression analysis.

Key words: black soybean weevil, integrated pest management (IPM), insects.

RESUMEN
Muestreo de adultos de *Rhyssomatus subtilis* (Coleoptera: Curculionidae) en soja, utilizando el método del paño vertical

Se realizaron muestreos de adultos de *Rhyssomatus subtilis* Fiedler (Coleoptera: Curculionidae) con el paño vertical en 10 lotes de soja durante 2012 y 2014, en el Noroeste Argentino, comparando estos resultados con el total de la población de adultos realmente presentes en esos campos. Este método capturó el 60% de la población de adultos de esta especie, por lo que fue necesario corregir los datos dividiendo el valor obtenido con el paño vertical por 0,65, número que se obtuvo mediante un análisis de regresión lineal.

Palabras clave: picudo negro de la soja, manejo integrado de plagas (MIP), insectos.

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INTRODUCTION

The black soybean weevil, *Rhyssomatus subtilis* Fiedler (Coleoptera: Curculionidae), is an important soybean crop pest in Northwestern Argentina (NWA) which is expanding its geographical distribution and causing economic losses through the reduction of yields. Adults produce damage by feeding and ovipositing on soybean plants in their vegetative and reproductive stages. Female weevils deposit their eggs inside the pods and the larvae feed on seed. Unfortunately, little is known about this species life history and behavior, as it is a pest which has just recently been detected attacking soybean crops in NWA (Cazado *et al.*, 2013).

Area-wide integrated pest management (IPM) requires the adoption of a set of practices to reduce pest population and minimize damage to crops (Guedes *et al.*, 2006). To estimate the economic threshold of a pest attacking a specific crop, it is important to determine infestation levels first (Stern, 1973). This information can only be obtained by means of an accurate and efficient sampling technique, which could be used in a wide range of areas (Hillhouse and Pitre, 1974; Luna *et al.*, 1982).

Several sampling methods have been used to estimate soybean arthropod populations, as cage techniques (Pedigo *et al.*, 1972), ground-cloth sampling methods (Boyer and Dumas, 1969), sweep net and D-VaC® (Shepard *et al.*, 1974), and vertical beat sheet (VBS) (Drees and Rice, 1985). According to Drees and Rice (1985), VBS has some advantages over the other methodologies, as it provides an easy way to sample arthropods in later soybean plant development stages, where traditional sampling methods become more tedious, time-consuming and expensive.

In Argentina, the VBS method for sampling insect pests in soybean crops was first assayed by Gamundi (1997) and it currently constitutes the main method used by farmers. This author reports that VBS is the most effective method for sampling and studying soybean pests and predators in soybean crops. It has also been reported that in other crops such as cotton, VBS works well when sampling *Alabama argillacea* Hübner larvae (Sosa *et al.*, 1997).

However, it has to be considered that when they are disturbed, *R. subtilis* adults fall onto the ground and pretend to be dead, so it is possible that total weevil number is actually underestimated when VBS is used. Martson *et al.* (1979) faced a similar problem in sampling *Anticarsia gemmatalis* Hübner larvae with a plant-shake method, so they suggested that the data obtained with this method had to be modified by a correction factor, deriving from a linear regression slope calculated to estimate the accuracy of plant-shake method.

The study presented in this note thus aimed to test the accuracy of the VBS method for sampling *R. subtilis* adults in soybean crops.

MATERIALS AND METHODS

From February to March, years 2012 and 2014, 10 commercial soybean fields in Rosario de la Frontera (Salta province) (S 25º 39' 57.6'', W 64º 56' 58.1'') (n=7), and Burruyacú (Tucumán province) (S 26º 32' 54.6'', W 64º 38' 33.9'') (n=3), in Argentina, were sampled.

The samplings were made throughout several plant growth stages: R3 to R6 (Fehr *et al.*, 1971). At each sampling date, adult numbers were estimated with a 0.5 m vertical beat sheet (VBS) (Gamundi *et al.*, 2003), and a 0.5 m x 0.2 m metallic cylindrical cage (CC). The adults were counted after beating the plants 20 times against the vertical surface of the sheet, so as to dislodge the weevils. After sampling with VBS, at the exact point were sampling had been made, soybean plants were enclosed inside a cylindrical cage. Then, the weevils that still remained on the plant and the ones that had fallen onto the ground were counted. This activity (counting the weevils by means of VBS and CC) was repeated 15 times for each sampling date (n= 150).

To calculate VBS effectiveness, the proportion (P) of weevils caught with VBS was estimated according to Marston *et al.* (1979) as:

$$P = \frac{Xi}{Ni}$$

Where:
Xi= number of adults caught with VBS;
Ni= total of adults caught with VBS + CC.

Data obtained with the two methods and proportion of adults caught with VBS in each field were analyzed using a one-way ANOVA, and means were separated using Tukey HSD tests. On the other hand, the accuracy of the VBS method was examined by linear regression of sample pairs (adults caught with VBS vs. total of adults caught with VBS and CC), and the significance of the regression line slope was tested with a one-way ANOVA. All the data were analyzed with InfoStat, 2008 (Di Rienzo *et al.*, 2008).

RESULTS

Significant differences between the number of adults caught with vertical beat sheet (VBS) and the total number of adults (caught with VBS + CC) were found, except for the sampling of 1 of the 10 fields (Table 1).

The results showed that the VBS method procedure underestimates the total number of *Rhyssomatus subtilis* weevils. Only 60% of all the weevils were caught with VBS, with no significant differences among fields ($F = 1.0$; df =9,150; $P = 0.427$; n=150) (Table 1). Another 40% of *R. subtilis* weevils were found on the ground, and/or on dry leaves in the plants. The accuracy of the VBS method in estimating total adult number is indicated by its regression

Table 1. Number of *Rhyssomatus subtilis* adults collected using vertical beat sheet (VBS) and total of adults (TA), in Rosario de la Frontera (Salta province) and Burruyacú (Tucumán province), from 2012 to 2014.

Fields	Variety	Plant growth stages	Sampling methods*		Proportion**
			TA[1]	VBS	
1	DM 8002 RR	R3	6.3±0.9 a	4.1±0.8 a	60.8
2	DM 8002 RR	R4	12.0±1.7 b	6.9±1.2 a	50.3
3	DM 8002 RR	R5	9.9±1.4 b	6.5±0.9 a	68.3
4	DM 8002 RR	R5	1.9±0.2 b	1.0±0.2 a	56.1
5	DM 8002 RR	R6	21.7±2.1 b	14.3±1.4 a	66.4
6	Munasqa RG	R4	16.3±1.3 b	9.5±1.0 a	58.6
7	Munasqa RG	R6	19.2±1.8 b	12.4±1.2 a	64.3
8	DM 6563 IPRO RSF	R3	8.0±0.9 b	3.9±0.6 a	49.5
9	DM 6563 IPRO RSF	R4	15.5±1.2 b	9.3±1.0 a	59.3
10	DM 6563 IPRO RSF	R5	2.7±0.6 a	1.9±0.5 a	61.3

[1]Number of *R. subtilis* caught with VBS + cylindrical cage.
*Different letters indicate significant differences between means ($P < 0.05$) (Tukey HSD test).
**No significant differences ($P < 0.05$) were found among fields with respect to adult proportion, as obtained with the VBS method (Tukey HSD test).

equation: Y= 0.65X-0.3548. The correlation between the number of adults caught with VBS and total of adults (caught with VBS + CC) was highly significant (P= <0.0001; R = 0.90; R^2 =0.89).

DISCUSSION

Vertical beat sheet was proved to underestimate *Ryssomathus subtilis* population density. Similar results were obtained by Sane *et al.* (1999), who reported a 45% effectiveness of VBS in sampling stink bug complex in soybean. Likewise, VBS only caught 40% of *Horcias nobilellus* Berg adults on cotton, thus underestimating its population (Sosa *et al.*, 1995). It is worth mentioning that the lack of accuracy of VBS in estimating weevil adult population as proved in this study could be accounted for by the fact that *R. subtilis* adults fall onto the ground when they are disturbed, during sampling.

The VBS method estimates 60% of *R. subtilis* adult population. Therefore, in order to improve estimates it is necessary to correct the value thus obtained by dividing it by 0.65, a number which is obtained with linear regression. These results indicate that the method of sampling with VBS may be indicated for *R. subtilis* on soybeans, considering its practicality and accuracy.

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