

Influence of adjuvants in the association with insecticide in the control of *Euschistus heros* in soybean crop

Influência de adjuvantes na associação com inseticida no controle de *Euschistus heros* na cultura da soja

Influencia de adyuvantes en la asociación con insecticida en el control de *Euschistus heros* en cultivo de soja

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Abstract

The objective of this study was to evaluate the influence of adjuvants associated with the spray mixture of insecticides aimed at the control of *Euschistus heros* in the soybean crop. First the treatments were applied and later the cages were assembled, being artificially infested 10 insects per cage. The treatments were composed of the insecticide Engeo Pleno[®] in combination with different adjuvants. The surface tension was reduced in all the treatments that contained the addition of adjuvants, and the treatments with organosilicone were the ones that resulted in the lower levels. The treatments did not present a significant difference, however, a superior efficiency of the insecticide was observed in association with adjuvants. The addition of Assist[®], Break Thru[®] S240 and TA35[®] adjuvants to the thiamethoxam + lambda-cyhalothrin insecticide improves the control of *Euschistus heros*, showing an agronomic efficiency superior to the insecticide applied alone.

Keywords: Application technology; Stink bugs; Residual.

Resumo

O objetivo deste trabalho foi avaliar a influência de adjuvantes associados à calda de inseticidas visando o controle de *Euschistus heros* na cultura da soja. Primeiramente os tratamentos foram aplicados e posteriormente as gaiolas foram montadas, sendo infestados artificialmente 10 insetos por gaiola. Os tratamentos foram compostos pelo inseticida Engeo Pleno[®] em combinação com diferentes adjuvantes. A tensão superficial foi reduzida em todos os tratamentos que continham a adição de adjuvantes, sendo que os tratamentos com

organosiliconados foram os que resultaram nos níveis mais baixos. Os tratamentos não apresentaram diferença significativa, porém, foi observada uma eficiência superior do inseticida em associação com adjuvantes. A adição dos adjuvantes Assist[®], Break Thru[®] S240 e TA35[®] ao inseticida tiametoxam + lambda-cialotrina melhora o controle de *Euschistus heros*, apresentando eficiência agrônômica superior ao inseticida aplicado isoladamente.

Palavras-chave: Tecnologia de aplicação; Percevejos; Residual.

Resumen

El objetivo de este estudio fue evaluar la influencia de los adyuvantes asociados a la mezcla de insecticidas en spray destinados al control de *Euschistus heros* en el cultivo de soja. Primero se aplicaron los tratamientos y posteriormente se ensamblaron las jaulas, siendo infestados artificialmente 10 insectos por jaula. Los tratamientos estuvieron compuestos por el insecticida Engeo Pleno[®] en combinación con diferentes adyuvantes. La tensión superficial se redujo en todos los tratamientos que contenían la adición de adyuvantes, y los tratamientos con organosilicona fueron los que resultaron en los niveles más bajos, los tratamientos no presentaron diferencia significativa, sin embargo se observó una eficiencia superior del insecticida en asociación con adyuvantes. La adición de adyuvantes Assist[®], Break Thru[®] S240 y TA35[®] al insecticida tiametoxam + lambda-cihalotrina mejora el control de *Euschistus heros*, mostrando una eficiencia agronómica superior al insecticida aplicado solo.

Palabras clave: Gerencias; Nuevas estrategias; Tecnología de aplicaciones.

1. Introduction

The Neotropical brown stink bug (*Euschistus heros* Fabricius, 1798). (Pentatomidae) is one of the most recurrent pest species in the soybean crop (*Glycine max* (L.) Merrill) in several regions of Brazil (Sosa-Gómez et al., 2014). Due to its high damage potential, high population density, difficult control and wide geographic distribution (Sosa-Gómez & Silva, 2010).

The damage caused by stink bugs is important for soybean in Brazil, as it is a direct damage, reflecting on seed quality and grain yield (Depieri & Panizzi, 2011; Silva et al., 2012). The main way to control these insect pests is chemical control (Sosa-Gomez & Silva, 2010; Panizzi et al., 2014). However, the difficulty in controlling *E. heros* is related to a series of factors such as physical barrier, climatic conditions and application technology that make it difficult to reach the goal (Ferreira & Di Oliveira, 2008).

Thus the adjuvants are used to achieve a more efficient application, improving the performance or helping the active ingredient to express its full potential. Among the effects, it is worth mentioning the reduction of the surface tension of the spray droplets, increasing its contact surface with the biological target and improving its coverage (Hess; Foy, 2000; Van Zil et al., 2010; Xu et al., 2010; Melo et al., 2006, Cunha et al., 2017). In addition, there are few modes of action available to control stink bugs, so the use of products that potentiate the action of the insecticide, such as adjuvants is an extremely important alternative.

The objective of this study was to evaluate the influence of adjuvants associated with the spray mixture of insecticides aimed at the control of *Euschistus heros* in the soybean crop.

2. Material and Methods

The physicochemical analyzes were performed in the laboratory, evaluated the surface tension, droplet cover and droplet density. Surface tension was determined by the pendent drop method (10 drops per treatment solution) using a DSA 25 goniometer (Krüss GmbH, Hamburg, Germany). For the droplet evaluations, it was used the hydrosensitive cards, making the analysis of drop coverage and droplet density, through DropScope[®] software.

Field trial conducted in the municipality of São Martinho da Serra - RS, whose coordinates are 29°29'16.22 'S and 53°47'5.67'W and altitude of 489 meters. The soil belongs to the mapping unit Júlio de Castilhos and is classified as Argisol. The climate of the region is of the "Cfa" type, with a subtropical rainy climate, with well distributed rainfall throughout the year, without well-defined dry and humid seasons, according to Köppen classification (Santos et al., 2013).

The work was conducted in a commercial crop in the 2015/16 crop, and its implementation was carried out on December 5th, 2015. The spacing used was 0.45 meters between rows, with 18 plants per linear meter totaling 400,000 plants per hectare. The cultivar used was Nidera 5959 RR2, maturation group 5.9 and indeterminate growth habit. The crop was conducted until the moment of implantation of the work without the use of insecticides for the control of stink bugs, since in previous survey no insects were found in the area. The experimental design was completely randomized, with seven treatments and three replicates, totaling 21 experimental units (Table 1).

The experiment consisted in assembling cages on insecticide sprayed soybean associated with different adjuvants for insect management and control. Subsequently, an artificial infestation of adult stink bugs of *Euschistus heros* was carried out, totalizing 10

insects per cage. The experimental units consisted of cages, which had their structure formed by interlocking iron pipes, and covered by a white antiofidic screen, measuring 1 x 1 x 1.2 meters (width x length x height). The edges of the screen were buried so as to avoid the escape of the insects. The assembly of the cages occurred immediately after spraying the area with the treatments (Table 1).

Table 1. Description of the treatments used in the control of *Euschistus heros*.

Treatments	Active ingredient	Dose c.p. ¹ (L/ha)
T1 - Insecticide	Lambda-cyhalothrin + Thiametoxan	0,25
T2 - Insecticide + Assist [®]	Lambda-cyhalothrin + Thiametoxan + MO	0,25 + 0,5
T3 - Insecticide + Break Thru [®] S240	Lambda-cyhalothrin + Thiametoxan + O	0,25 + 0,05
T4 - Insecticide + TA35 [®]	Lambda-cyhalothrin + Thiametoxan + SM	0,25 + 0,05
T5 - Insecticide + Assist [®] + Break Thru [®] S240	Lambda-cyhalothrin + Thiametoxan + MO + O	0,25 + 0,25 + 0,05
T6 - Insecticide + Assist [®] + TA35 [®]	Lambda-cyhalothrin + Thiametoxan + MO + SM	0,25 + 0,25 + 0,03
T7 - Control	No application	

¹c.p. = Commercial product. MO: Mineral oil; O: Organosilicone; SM: Synthetic multifunctional. Source: Authors.

The application of the products was carried out with the aid of a backpacksprayer pressurized by CO₂, containing six Teejet XR 110.02 flat spray nozzles spaced at 0.5 meters. The volume of the spray used was 100 l/ha, and climatic conditions such as temperature, wind and relative humidity were adequate for the application. The application was carried out on 02/13/2016 with soybean crop at phenological stage R5.2. Spraying was carried out without any changes in the canopy shape and arrangement of the plants, aiming to reproduce with greater proximity the sprays performed at the field level.

The stink bugs used in the experiment came from laboratory creation. The placement of the stink bugs was performed immediately after the assembly of the cages, with an average time of about one hour after spraying the treatments. For release, the insects were placed in an open gerbox-type box on the ground inside the cage. At 5 DAT (Days After Treatment) a reinfestation was carried out, being the insects identified by means of paint in the pronotum with red paint, nontoxic and non-washable, being also released in number of 10 insects per cage.

Evaluations were performed at 3, 5, 7, 9 and 11 days after treatment (DAT) and reinfestation was performed at 5 DAT. Qualitative analyses were performed in the evaluations. In the evaluations, only insects that were found dead, and that did not present

movement when pressed in the pronotum were counted, being removed from the interior of the cage after the evaluation. There were counted as alive, the insects found and that presented movement when touched, being returned to the cage after the evaluation. The number of dead individuals was initially submitted to the W test (Shapiro & Wilk 1965) to confirm the normality hypothesis and since the data showed normal behavior, they were submitted to analysis of variance by applying the F test and the means compared by the Tukey test at 5% of error probability, with the aid of Statistical Analysis System - Software SAS 8.0 software (SAS Inc, Cary, USA). For the calculation of control efficiency, the formula described by Abbott (1925) was used:

$$Efc(\%) = \frac{(\%Mo - \%Mc)}{(100 - \%Mc)} \times 100$$

Where:

Efc(%): Corrected Efficiency

%Mo: Percentage of mortality observed

%Mc: Mortality in the control.

3. Results and Discussion

The physico-chemical characteristics of spray treatments showed that the addition of adjuvants significantly altered all the variables evaluated (Table 2). The surface tension was reduced in all treatments containing the adjuvants, and the treatments with organosilicones were the ones that resulted in the lower levels, the use of these products to reduce the surface tension, has already been reported (Wang & Liu, 2007) but not for the associations between insecticides and adjuvants. The coverage area was higher in most adjuvant treatments due to the effect of the products in reducing the surface tension, which results in a better drop coverage. However, the droplet density was similar for all treatments tested.

Table 2. Surface tension, covered area, density, Volume Medium Diameter (VMD), Numerical Mean Diameter (NMD), of the insecticide associated with different adjuvants.

Treatments	Surface tension	Covered area (%)	Density (N/cm ²)
Insecticide	53,4 a	10,2 c	112,7 ab
Insecticide + Assist [®]	24,2 d	11,0 bc	108,7 b
Insecticide + Break Thru [®] S240	23,5 d	14,7 a	103,0 b
Insecticide + TA35 [®]	27,2 c	13,8 ab	135,4 a
Insecticide + Assist + Break Thru [®] S240	29,1 b	11,8 abc	110,7 ab
Insecticide + Assist [®] + TA35 [®]	28,8 b	10,3 c	120,6 ab
CV%	2,45	12,5	10

* Averages not linked by the same letter in the column, differ by the Tukey test (5%). Source: Authors.

In this table we can see relative data to the effect of adjuvant addition in the physical chemical characteristics in the spray. Regarding the field trial, the number of dead bugs (Table 2) in the 3 and 5 DAT evaluations (Days after treatment), there was no significant difference between the isolated application of the insecticide and its association with the adjuvants. However, analyzing the agronomic efficiency, it was verified that the treatment with Assist[®] at 3 and 5 DAT presented the highest control efficiencies 60 and 72.5%, respectively. The results presented with the use of Assist[®] associated with the insecticide are related to the characteristics of the mineral oils that promote an increase of the leaf cover, besides reducing the volatility, the photodegradation of the products and increasing the penetration of the product in the waxy layer of the leaf surface (Curran et al., 1999; Azevedo, 2011).

At 7 DAT there was a reduction in the insect population, especially when the addition of Assist[®] and Break Thru[®] S240 adjuvants was performed with an agronomic efficiency of 85.2%, while the insecticide applied alone showed 77.8%, showing an increase of 7.4% of control in comparison with the insecticide applied alone. The results are similar to those found by Dos Santos et al. (2011) using Break Thru[®] S240 associated with spinosad, at 7 DAT, provided a 16.3% increase in the efficiency of the *Tuta absoluta* control when compared to the isolated spinosad application. Likewise, the results obtained with the addition of Assist[®] corroborate with Melo et al. (2014) who demonstrated increased mortality of *Anticarsia gemmatalis* when using Assist[®] associated with chlorantraniliprole.

For the 9 and 11 DAT the number of dead bugs did not differ significantly from the

insecticide applied alone. Thus, it is possible to observe the efficiency values in the treatments with insecticides applied alone, with the addition of the Assist[®], Break Thru[®] S240 and TA35[®] adjuvant both presenting 92% efficiency.

There was an improvement in agronomic efficiency in the control of adult stink bugs, on average 7 to 14% higher, mainly with the Assist[®] adjuvant found in the evaluations performed between the 3 DAT and 9 DAT. Adjuvants may be responsible for affecting both the rate of penetration and the rate of degradation of the same, and the results are related to a greater penetration and protection of the active ingredients, thus providing a greater availability of the product and giving greater control to the insects (Melo et al., 2015).

For the results of insects placed in reinfestation, in the evaluation performed at 2 days after reinfestation (DAR), resulted in an 11% higher agronomic efficiency in the treatment with Break Thru[®] S240 adjuvant when compared to the insecticide applied alone (Table 3). The same adjuvant, in the evaluation performed at the 4 DAR, presents an agronomic efficiency of 29.6%, resulting in a difference of 22.2% higher when compared to the insecticide applied alone. This fact can be explained by the better penetration and coverage of the droplets in the vegetative canopy of the crop provided by the use of the adjuvant, thus conferring a greater agronomic efficiency in the control of insects, interfering in a positive way in the efficiency of the insecticide (Di Oliveira, 2008).

Table 3. Number of insects and control efficiency of *Euschistus heros* adults as a function of insecticide with adjuvants.

Treatments	<i>Euschistus heros</i>									
	3 DAT		5 DAT		7 DAT		9 DAT		11 DAT	
	N ¹	EF% ²	N	EF%	N	EF%	N	EF%	N	EF%
Insecticide ³	4,7 a	46,7	5,7 a	55,2	8,0 a	77,8	8,7 a	85,2	8,7 a	84
Insecticide + Assist [®]	6,0 a	60	7,3 a	72,4	8,7 a	85,2	9,3 a	92,6	9,3 a	92
Insecticide + Break Thru [®] S240	5,3 a	53,3	7,0 a	69,0	8,7 a	85,2	9,3 a	92,6	9,3 a	92
Insecticide + TA35 [®]	5,3 a	53,3	6,0 a	58,6	8,3 a	81,5	9,3 a	92,6	9,7 a	92
Insecticide + Assist [®] + Break Thru [®] S240	4,3 a	43,3	6,0 a	58,6	8,0 a	77,8	8,7 a	85,2	8,7 a	84
Insecticide + Assist [®] + TA35 [®]	4,3 a	43,3	6,7 a	65,5	8,0 a	77,8	8,7 a	85,2	8,7 a	84
Control	b	-	b	-	b	-	b	-	a	-
CV%	32,6		22,69		15,67		9,62		9,28	

*: Averages not linked by the same letter in the column differ by Tukey's test (5%). 1: Number of dead bugs; 2: Control efficiency calculated by Abbot's formula (1925);3: Thiamethoxam and lambda-cyhalothrin. Source: Authors.

In this table one can see that with the adjuvant addition, it was an improve in the insecticide biologic efficiency. In the last evaluation performed at 6 DAR, there was a decrease in the agronomic efficiency of the insecticide + Break Thru[®] S240 treatment, probably due to factors associated with the durability of the active ingredient and the adjuvant (Table 4). However, for Assist[®] and TA35[®] adjuvants an increase in efficiency was observed, presenting a superiority of 12% when compared to the insecticide applied without association with adjuvants.

The reinfestation data showed that the control efficiency was affected by the addition of adjuvants. This control may be associated with the longer the active ingredient remained in the plant. According to Melo et al. (2015), the use of adjuvants increases the amount of active ingredient within the plant. In this way, this control of stink bugs for longer, may be related to greater amount of active ingredient.

Table 4. Mean and control efficiency of adult *Euschistus heros* reinfested at 5 DAT as a function of the insecticide with adjuvants.

Treatments	<i>Euschistus heros</i>					
	2 DAR		4 DAR		6 DAR	
	N ¹	EF% ²	N	EF%	N	EF%
Insecticide ³	0,3 a	0	1,7 a	7,4	2,7 a	12,0
Insecticide+ Assist [®]	1,0 a	0	2,7 a	18,5	3,3 a	20,0
Insecticide+ Break Thru [®] S240	2,0 a	11,1	3,7 a	29,6	3,7 a	24,0
Insecticide+ TA35 [®]	1,7 a	7,4	2,7 a	18,5	3,3 a	20,0
Insecticide+ Assist [®] + Break Thru [®] S240	1,3 a	3,7	3,0 a	22,2	3,7 a	24,0
Insecticide+ Assist [®] + TA35 [®]	1,0 a	0	2,7 a	18,5	2,7 a	12,0
Control	a	-	a	-	a	-
CV%	48		54,32		44,25	

*: Averages not linked by the same letter in the column differ by Tukey's test (5%). 1: Number of dead bugs; 2: Control efficiency calculated by Abbot's formula (1925); 3: Thiamethoxam and lambda-cyhalothrin. Source: Authors.

This table shows that adjuvant addition increase the insecticide residual. The use of adjuvants in combination with insecticides may be an alternative to improve the efficiency of the active ingredients. This improvement can be related to several aspects of the application technology that are influenced by the adjuvants, from the best coverage and penetration of the product in the plant to protection against unfavorable environmental factors during the application. However, this improvement is not valid for all adjuvants, since the product used and the biological target must be taken into account.

4. Conclusion

The addition of Assist[®], Break Thru[®] S240 and TA35[®] adjuvants to the thiamethoxam + lambda-cyhalothrin insecticide improves control of *Euschistus heros*, up to 9 DAT, showing a superior agronomic efficiency to the insecticide applied alone.

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