BioAssay

CHEMICAL CONTROL

Efficacy of insecticides on *Tuta absoluta* (Meyrick) and other pests in pole tomato

Antonio Cesar dos Santos[1], Regiane Cristina Oliveira de Freitas Bueno[2], Simone Silva Vieira[3], Adeney de Freitas Bueno[4]

[1]*Dow AgroSciences researcher, Rua Alexandre Dumas, 1671, Ala 2B, Chácara Santo Antônio, CEP 04717-903, São Paulo, SP. Brazil. acsantos1@dow.com*
[2]*Post Doctoral Student, Capes PNPD scholarship, University of Rio Verde (FESURV), Rio Verde County, State of Goiás, 75901-970, Brazil. regianecrisoliveira@gmail.com*
[3]*Santa Catarina State University/UDESC. 2090 Luiz de Camões Ave, Conta Dinheiro District, Lages County, State of Santa Catarina, 88520-000, Brazil. simonesilva123@yahoo.com.br*
[4]*Current Address: Embrapa Soybean, P.O. Box 231, Londrina County, State of Paraná, 86001-970, Brazil. adeney@cnpso.embrapa.br*

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Eficácia de inseticidas em *Tuta absoluta* (Meyrick) e outras pragas em tomateiro envarado

RESUMO - Experimentos de campo em 2001 e 2005 foram conduzidos para determinar a eficácia de diversos inseticidas no controle da *Tuta absoluta* e o impacto desse controle na ocorrência das demais pragas do tomateiro. Os inseticidas testados assim como as respectivas doses por 100 litros de água foram: espinosade 4,8; 6,0; 7,2 g. i.a. com e sem Break Thru 0,03% v/v; clorfenapir 12,0 g. i.a.; emamectina 2,0 g i.a. com Joint Oil 0,25 % v/v e indoxacarbe 4,8 g i.a. com Joint Oil 0,25 % v/v. O delineamento experimental foi de blocos ao acaso com 4 repetições por tratamento sendo avaliado o complexo de pragas semanalmente. Todos os produtos testados, com exceção do espinosade sem Break Thru, foram eficientes no controle da *T. absoluta*. Considerando-se o complexo de pragas, espinosade + Break Thru mostrou-se ser o melhor tratamento no manejo da mosca-minadora *Liriomyza* spp.

Palavras-chave: *Lycopersicon esculentum* Mill., controle químico, manejo integrado de pragas.

ABSTRACT - Field studies were conducted on 2001 and 2005 to determine the effectiveness of several insecticides in controlling *Tuta absoluta* and the impact of this control on the occurrence of other pests on tomato. The tested insecticides with their respective rates per 100 liters of water were: spinosad 4.8, 6.0, 7.2 g. a.i. with and without Break Thru 0.03% v/v; chlorfenapyr 12.0 g. a.i., emamectin 2.0 g. a.i. with Joint Oil 0.25 % v/v e indoxacarb 4.8 g. a.i. with Joint Oil 0.25 % v/v. The experiment was designed as randomized complete block with 4 replications per treatment. Trials were evaluated on a weekly basis. All tested treatments, except spinosad without Break Thru, were effective to control *T. absoluta*. Considering the pest complex, spinosad + Break Thru was the best treatment mainly because of the best overall performance on the serpentine leafminer *Liriomyza* spp.

Keywords: *Lycopersicon esculentum* Mill., chemical control, integrated pest management.

INTRODUCTION

Tomato crops are normally attacked by a great variety of insects including the tomato leafminer, *Tuta absoluta* (Meyrick), considered the most important tomato pest (Medeiros *et al.*, 2005). Both yield and fruit quality can be significantly reduced by the direct feeding of *T. absoluta* and secondary pathogens that may enter through the wounds made by the insect. Different strategies might be applied in an Integrated Pest Management (IPM) program to control *T. absoluta* outbreaks including insecticides and biological control and the association of both. Studies have being done on the use of synthetic sex pheromones in order to monitor population levels and trigger applications of chemicals on the right moment (Michereff Filho *et al.*, 2000; Gomide *et al.*, 2001; Salas, 2004). Chemical control has been the main method of control used against *T. absoluta* and growers normally choose the insecticide in a diversity of options officially registered and recommended (França *et al.*, 2000). The effectiveness of insecticides alone might be sometimes impaired because of the mine-feeding behavior of larvae or deficient spraying technology (Lietti *et al.*, 2005).

Usually, several sprayings are required per growing season and it is noted a decrease of the efficacy of products used against *T. absoluta* since the 1980s in tomato crops. Resistance to some active ingredients has been reported in several countries, for example to abamectin, cartap and permethrin in Brazil (Siqueira *et al*., 2000). This reinforces the importance of using a sound chemical control to the success of the IPM program in tomato where less noxious insecticides are chosen and applied only when necessary avoiding the side effects on the beneficial arthropods and environment. However, it is important to point out that tomato leafminer is not the only pest found injuring tomato plants. Other important pests that also normally attack tomato are the serpentine leafminer, *Liriomyza* spp., and the small tomato borer, *Neoleucinodes elegantalis* (Guenée).

Serpentine leafminers are polyphagous insects which worldwide feed on various crops including tomato (Parrella, 1987). Punctures caused by females during the feeding and oviposition processes can result in a stippled appearance on foliage, especially at the leaf tip and along the leaf margins (Parrella *et al.*, 1985). However, the major form of damage is the mining of leaves by larvae, which results in destruction of leaf mesophyll. Both leaf mining and stippling can greatly depress the level of photosynthesis in the plant (Johnson *et al*., 1983). Extensive mining also causes premature leaf drop, which can result in lack of shading and sun scalding of fruit. Wounding of the foliage also allows entry of bacterial and fungal diseases. The small tomato borer, *N. elegantalis* is also an important pest in tomato, and reduction in tomato yield due to its attack might reach 4.68 tons/ha (Loos *et al.*, 2004).

Since most of time these pests occur together in the tomato fields, the broad-spectrum feature of insecticides turns to be very important. Therefore, this research was carried out aiming to evaluate the efficacy of insecticides applied against *Tuta absoluta* on the tomato-pest complex in order to know the most efficient product to be used when more the one pest specie are occurring.

MATERIAL AND METHODS

Two trials were carried out in different important regions of tomato crops (Goias and São Paulo States) and both trials were initiated at the beginning of blooming stage. One preliminary field trial was established in Sumaré, SP, Brazil in 2001 aiming to study the benefits of mixing Break Thru 0.03% v/v with different spinosad rates besides comparing spinosad with chlorfenapyr. The experiment was conducted at a commercial field, with Jumbo variety, where all growers' practices (fungicide and weed control according to the needs) were used. The experiment was conducted from August/11/2001 to September/25/2001 in a Randomize Complete Block design (RCB) with 8 treatments and 4 replications (4 meters large x 7 meters long each). The treatments were: 1. Spinosad 4.8 g a.i./100 L of water (Tracer 10 mL/100 L of water); 2. Spinosad 6.0 g a.i./100 L of water (Tracer 12.5 mL/100 L of water); 3. Spinosad 7.2 g a.i./100 L of water (Tracer 15 mL/100 L of water); 4. Spinosad 4.8 g a.i./100 L of water (Tracer 10 mL/100 L of water) + Break Thru 0.03% v/v; 5. Spinosad 6.0 g a.i./100 L of water (Tracer 12.5 mL/100 L of water) + Break Thru 0.03% v/v; 6. Spinosad 7.2 g a.i./100 L of water (Tracer 15 mL/100 L of water) + Break Thru 0.03% v/v; 7. Chlorfenapyr 12.0 g ai/100 L of water (Citrex 50 mL/100 L of water); 8.Untreated. Excluding treatments number 7 (chlorfenapyr), an factorial analysis (3 x 2) was also run with 3 spinosad rates (4.8; 6 and 7.2 g ai/100 L of water) and 2 Break Thru rates (0 and 0.03% v/v) in order to verify the benefits of adding, or not, Break Thru to tomato pest complex control.

In the 2005 one other field experiments was carried out at Hidrolândia, GO, Brazil from September/27/2005 to November/21/2005. Again, the experiment was conducted at commercial field, with Red Sugar variety, where all growers' practices (fungicide and weed control according to the needs) were used. The experiment was conducted in a Randomize Complete Block design (RCB) with 8 treatments and 4 replications (4 meters large x 7 meters long each). The treatments were: 1. Spinosad 6.0 g a.i./100 L of water (Tracer 12.5 mL/100 L of water); 2. Spinosad 7.2 g a.i./100 L of water (Tracer 15 mL/100 L of water); 3. Spinosad 6.0 g a.i./100 L of water (Tracer 12.5 mL/100 L of water) + Break Thru 0.03% v/v; 4. Spinosad 7.2 g a.i./100 L of water (Tracer 15 mL/100 L of water) + Break Thru 0.03% v/v; 5. Chlorfenapyr 12.0 g ai/100 L of water (Pirate 50 mL/100 L of water); 6. Emamectin 2 g ai/100 L of water (Proclaim 40 g/100 L of water) + Joint Oil 0.25% v/v; 7. Indoxacarb 4.8 g ai/100 L of water (Rumo GDA 16 g/100 L of water) + Joint Oil 0.25% v/v; 8.Untreated.

Treatments were applied using a CO_2 backpack sprayer in a broadcast application using the hollow cone, solid spray tip type of nozzle (TXVK-10). The equipment was set to deliver 1000L/ha, following growers'usual practice. Applications were done on a weekly basis starting in the beginning of natural *T. absoluta* infestation (when plants were beginning to bloom). Six broadcast applications were done. The experiments were evaluated 3 and 7 days after each application (DAA). The parameters evaluated were: number of mines /10 complete leaflets/replication (separating mines done by *Liriomyza* and *T. absoluta*), % of terminals attacked by *T. absoluta* (counting in 10 terminals per plot), and % of damaged fruits (separating *T. absoluta* and *N. elegantalis* damage). For the number of mined leaves the sum of mines of all evaluation dates after each application was summed and analysis was then run on the sum. For the % of plant terminals injuried, the average was done of all evaluations. Data were then transformed into $\sqrt{x+0.5}$ when necessary according to Bartlett's Homogeneity Variance Test to statistical analysis. Results were submitted to ANOVA and treatment means separated by Tukey's test (P = 0.05). Treatments efficacy were calculated by Abbot Formula (Abbott, 1925).

RESULTS AND CONCLUSIONS

Results showed that the adjuvant Break-Thru at 0.03% added to spinosad increased the insecticide performance on *T. absoluta* control offering statistically lower percentage of damaged terminals and fruits (Figures 1A and 2B). The

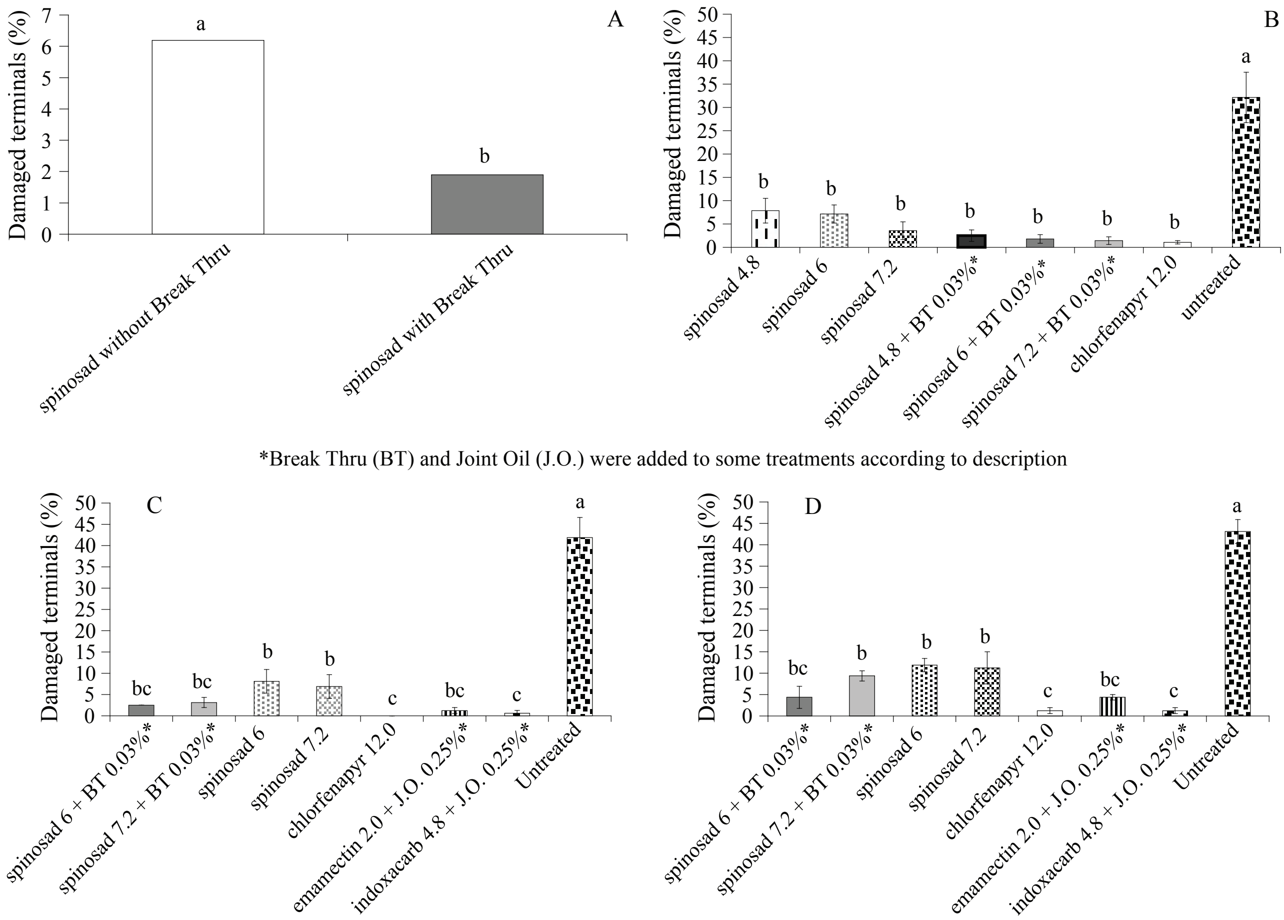

Figure 1. Mean ± SE of different insecticides (grams of a.i./100 L of water) used to prevent *T. absoluta* damage on tomato terminals. (**A**) Factorial analysis, average of 7 days after application, Sumaré, SP, 2001. (**B**) Damaged terminals (Mean±SE), average of 7 days after application, Sumaré, SP, 2001. (**C**) Damaged terminals (Mean±SE), average of 3 days after application, Hidrolândia,GO, 2005. (**D**) Damaged terminals (Mean±SE), average of 7 days after application, Hidrolândia,GO, 2005. Means followed by the same letter are statistically similar by Tukey's test (P=0.05). Statistics done on transformed data in $\sqrt{x+0.5}$

adjuvant was responsible for around 4% less plants terminals (Figure 1A) and tomato fruits (Figure 2B) damaged by *T. absoluta*. Break-Thru also helped to protect the leaves from *T. absoluta* mining. Spinosad with the adjuvant had always numerically or statistically lesser mines than the same rates without the adjuvant (Table 1). In addition, this adjuvant helped on *Liriomyza* spp. control as it is clearly shown on the results reached by spinosad low rates (4.8 and 6 g ai/100L of water) with Break-Thru when compared to same rates without the benefit of the adjuvant (Figure 3C). Advances in spray tank additives, such as Break-Thru, offer new opportunities to improve pesticide performance through better wetting, spreading and plant penetration. Break-Thru is a new generation surfactant with 100% active ingredient, a non-ionic, organo-silicone surfactant based on organo-modified siloxane technology for use with water-based pesticide formulations. It promotes superior wetting, spreading and penetration in crops like tomato, increasing the amount of spray mix that spreads across plant surfaces and penetrates hard-to-reach areas where leaf miners are found, what improved the spinosad results.

Regarding to the comparison among the different active ingredients against *T. absoluta* the results from trial carried out in Sumaré, SP with cultivar Jumbo had a higher infestation of *T. absoluta* attacking the leaves when compared to experiment carried out in Hidrolândia, GO with the cultivar Red Sugar as it might be saw through the untreated plots that had 219.0 ± 43.0 and 149.0 ± 10.6 mines in 60 leaves 7 days after application in Sumaré and Hidrolândia trials, respectively (Table 1). However, both trials conducted at very different conditions showed similar results. At the Sumaré trial (2001) with a higher infestation, chlorfenapyr was numerically the best treatment offering 99.2% control, statistically similar to spinosad with Break-Thru at all tested rates and also similar to the higher rate of spinosad alone, all reaching 88% control or more, regarding to the number of *T. absoluta* mines (Table 1). Similarly, at the Hidrolândia trial (2005), indoxacarb and chlorfenapyr were numerically the best treatments reaching respectively 96.1% and 91.4% control at 3 days after application and respectively 93.6% and 93.3% control at 7 days after application. These treatments were numerically followed by spinosad with Break-Thru, all reaching more than 80% control at both 3 and 7 days after application (Table 1).

Considering the % of plant with damaged terminals by this insect, the results were very similar to the observed with number of mines in the leaves. With the exception of the

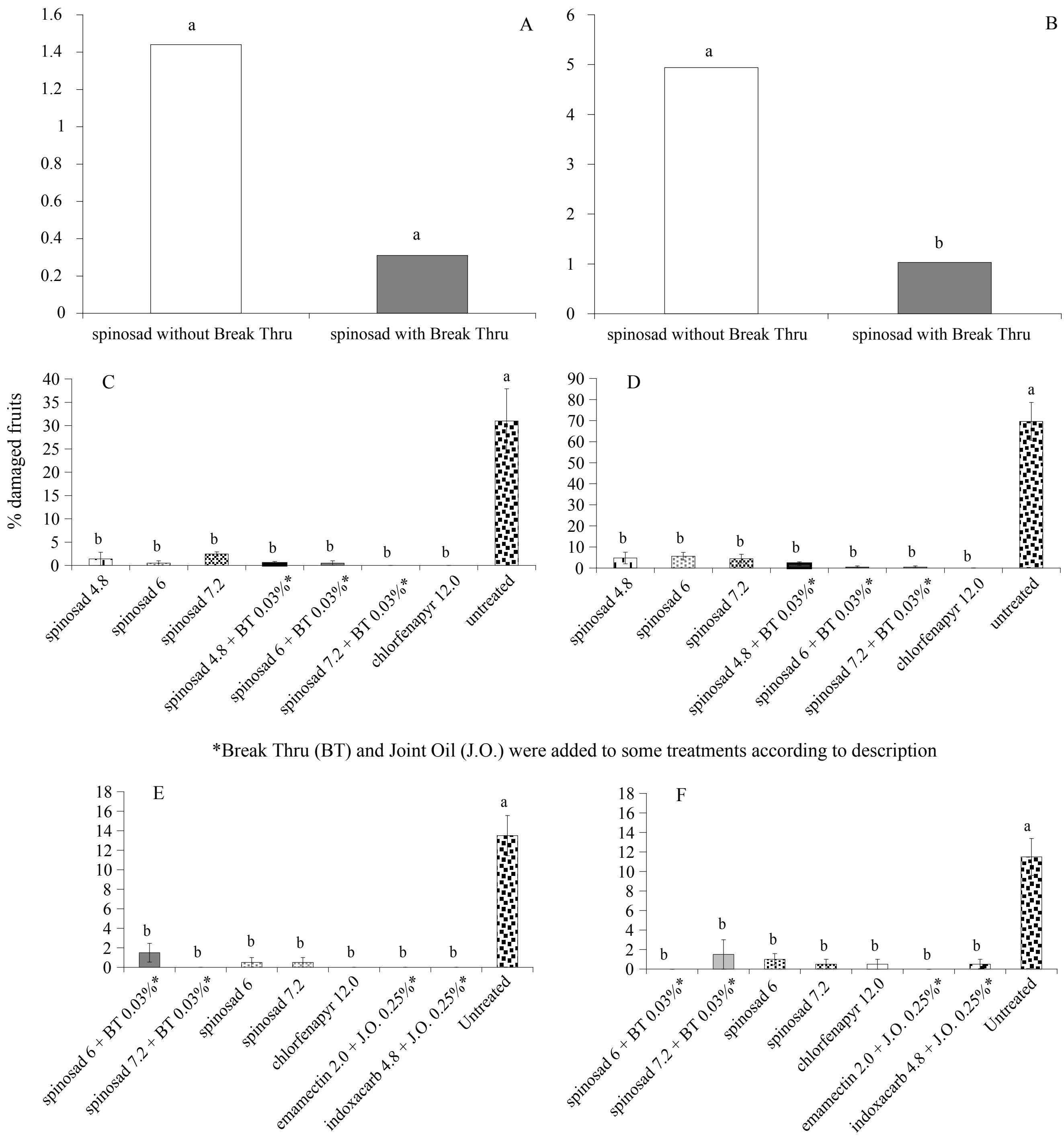

Figure 2. Different insecticides (grams of a.i./100 L of water) used to prevent *T. absoluta* damage on tomato fruits. (**A**) Factorial analysis, 7 days after 5th application, Sumaré, SP, 2001. (**B**) Factorial analysis, 7 days after 6th application, Sumaré,SP, 2001. (**C**) Damaged fruits (Mean±SE), 7 days after 5th application, Sumaré,SP, 2001. (**D**) Damaged fruits (Mean±SE), 7 days after 6th application, Sumaré,SP, 2001. (**E**) Damaged fruits (Mean±SE), 7 days after 5th application, Hidrolândia,GO, 2005. (**F**) Damaged fruits (Mean±SE), 7 days after 6th application, Hidrolândia,GO, 2005. Means followed by the same letter are statistically similar by Tukey's test (P=0.05). Statistics done on transformed data in $\sqrt{x+0.5}$.

trial carried out in Sumaré (2001) that differently from the number of mines in the leaves presented a lower percentage of damaged terminals that trial carried out in Hidrolândia, GO. At Sumaré (2001) all treatments had an excellent performance including spinosad without Break-Thru (Figure 1B), even thought spinosad statistically improved the performance as demonstrated by the factorial analysis (Figure 1A).

At trial carried out in Hidrolândia (2005) similar trends from Sumaré might be observed, however, chlofenapyr, indoxacarb, and spinosad with Break-Thru was clearly better

Table 1. Mean ± SE of *Tuta absoluta* mines on 60 tomato leaves (total). Ten leaves were evaluated/plot after each application (6 applications).

	Sumaré, SP (2001)		Hidrolândia, GO (2005)			
	7 DAA[1]		3 DAA[1]		7 DAA[1]	
Treatment (g a.i./100 L of water)	# mines	E (%)[2]	# mines	E (%)[2]	# mines	E (%)[2]
spinosad 4.8	48.5 ± 11.2 b[3]	77.9	-	-	-	-
spinosad 6.0	65.3 ± 5.5 b[3]	70.2	36.50 ± 5.07 b	74.3	42.25 ± 11.52 b[3]	71.6
spinosad 7.2	26.3 ± 6.2 bc[3]	88.0	34.00 ± 0.82 bc	76.1	36.00 ± 4.04 b[3]	75.8
spinosad 4.8 + Break Thru 0.03 % v/v	12.8 ± 6.5 c[3]	94.2	-	-	-	-
spinosad 6.0 + Break Thru 0.03 % v/v	10.8 ± 4.8 c[3]	95.1	14.75 ± 1.89 de	89.6	21.00 ± 1.41 bc[3]	85.9
spinosad 7.2 + Break Thru 0.03 % v/v	5.5 ± 2.2 c[3]	97.5	22.75 ± 3.86 bcd	84.0	28.75 ± 4.99 b[3]	80.7
chlorfenapyr 12.0	1.8 ± 1.0 c[3]	99.2	12.25 ± 3.35 de	91.4	10.00 ± 2.80 c[3]	93.3
emamectin 2.0 + Joint Oil 0.25% v/v	-	-	19.50 ± 3.28 cde	86.3	20.25 ± 4.55 bc[3]	86.4
indoxacarb 4.8 + Joint Oil 0.25% v/v	-	-	5.50 ± 0.29 e	96.1	9.50 ± 1.50 c[3]	93.6
Untreated	219.0 ± 43.0a[3]	-	142.25 ± 6.80 a	-	149.00 ± 10.55 a[3]	-
CV	27.8	-	17.37	-	14.81	-

[1]Days after application; [2]Efficiency calculated by Abbott (1925); [3]Statistics done on transformed data in $\sqrt{x+0.5}$. Means followed by the same letter in the column are statistically similar by Tukey's test (P=0.05).

than spinosad without the adjuvant on preventing damage of *T. absoluta* on plant terminals (Figure 1C and 1D). Even though controlling *T. absoluta* damaging leaves and plant terminals, this pest causes a much worse damage that is directing boring the fruits. The spinosad control of *T. absoluta* as a fruit borer was also improved by the addition of Break-Thru (Figure 2 B) but overall all treatments provided good control at all trials (Figures 2C, 2D, 2E, and 2F).

Even thought normally *T. absoluta* is the pest to trigger the insecticide spraying, this insect normally occurs together with other pests such *N. elegantalis* and *Liriomyza* spp., making important the insecticide control of these pests as well. *Liriomyza* was present with *T. absoluta* at both trials. Evaluating the number of mines after application, when infestation was higher, there was no difference among the insecticides (Figures 3A and 3B), however at lower infestation it might be observed that spinosad with Break-Thru at all rates were statistically the best treatment (Figure 1C). It happened probably because at higher infestation the pest outbreak was too high to be controlled by the insecticide rate used what did not occurred at lower pest infestation. At Sumaré trial (2001) it was possible to evaluate also the insecticide efficacy on *N. elegantalis*. Even thought the treatments did not differ among themselves, spinosad at higher rate (7.2 g ai/100 L of water) with and without Break-Thru were numerically the best treatments (Figure 1D). For this pest, spinosad efficacy seemed to be not affected by the adjuvant adding.

In conclusion, the results show that all tested insecticide, except spinosad without Break Thru, were effective to control *T. absoluta* and might be used to control this pest outbreaks. Considering the serpentine leafminer, *Liriomyza* spp. spinosad + Break Thru was overall the best treatment showing similar performance to the other insecticide on the 2005 experiment but better performance on the 2001 experiment what might be an advantage in using this insecticide when both pests are occurring at the same time.

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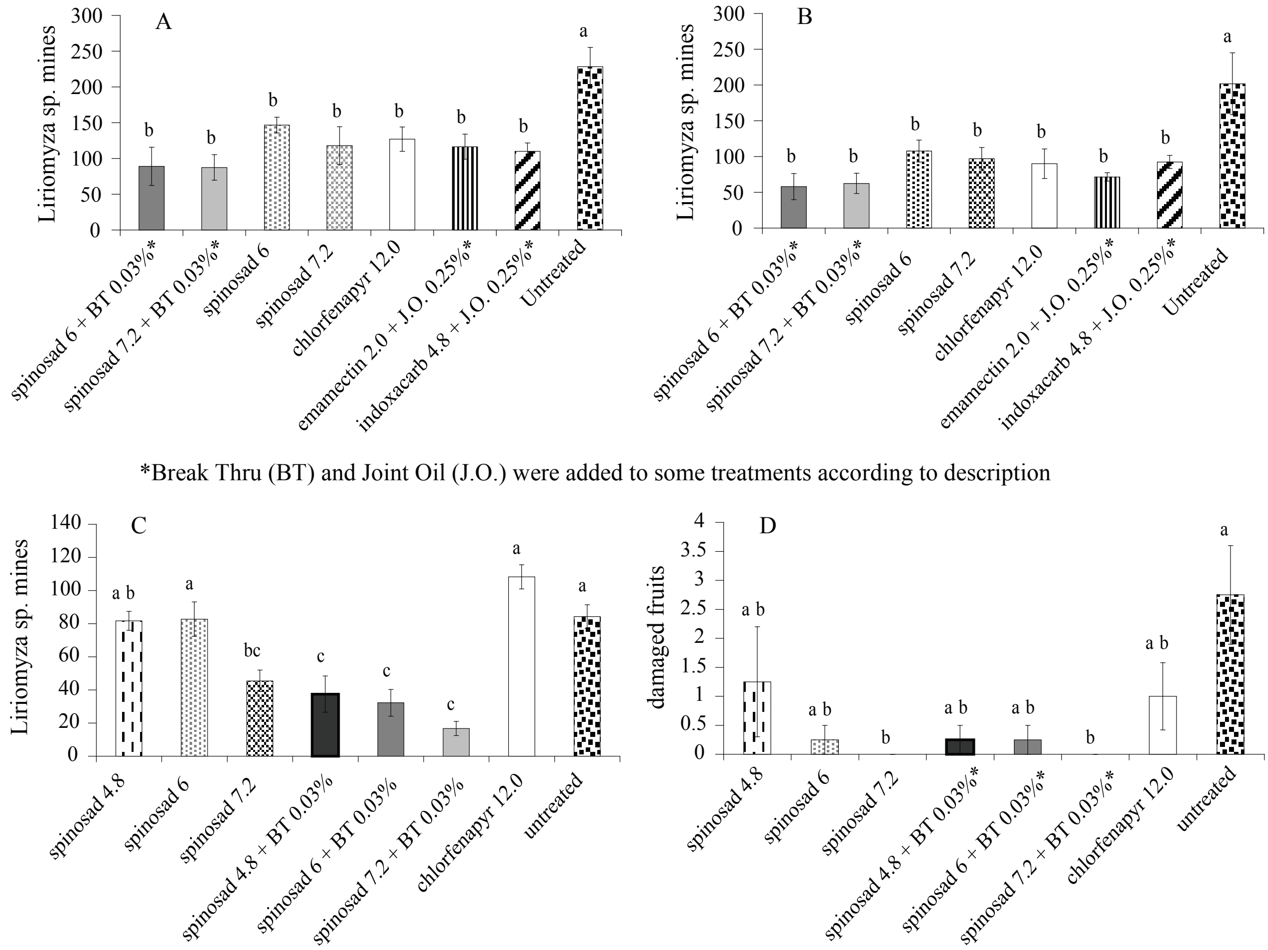

Figure 3. Results of different insecticides (grams of active ingredient/100 L of water) applied focusing *Tuta absoluta* on different pests that were occurring together. (**A**) Mean (±SE) *Liriomyza* mines on 60 tomato leaves (total), 3 days after each application, Hidrolândia, GO, 2005. (**B**) Mean (±SE) *Liriomyza* mines on 60 tomato leaves (total) 7 days after each application, Hidrolândia, GO, 2005. (**C**) Mean (±SE) *Liriomyza* mines on 60 tomato leaves (total) 7 days after each application, Sumaré, SP, 2001. (**D**) Number of damaged fruits (Mean±SE) by *Neoleucinodes elegantalis* in 10 bunches/plot, 2 days after last application, Sumaré, SP, 2001. Means followed by the same letter are statistically similar by Tukey's test (P=0.05).

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