

EFFICACY OF FLUBENDIAMIDE AND EMAMECTIN BENZOATE IN THE CONTROL OF COTTON BOLLWORM (*Helicoverpa armigera* Hübner) ON SWEET PEPPER

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INTRODUCTION

The cotton bollworm (*Helicoverpa armigera* Hübner) is the polyphagous pest. *H. armigera* has been reported to cause serious losses throughout its range, in particular to tomatoes, pepper, corn and cotton. This pest can cause significant losses in the pepper production (up to 35%). Larvae damage the fruit by puncturing and feeding on their internal contents. The damaged fruits are susceptible to rot agents attack and they are not suitable for use.

H. armigera overwinters in the soil in the pupal stage. Moths emerge in May to June depending on latitude and lay eggs singly on a variety of host plants on or near floral structures. Plants in flower are preferred to those that are not in flower. Depending on the quality of the host, *H. armigera* may also lay eggs on leaf surfaces. Larvae drop off the host plant and pupate in the soil, then emerge as adults to start the next generation. Because *H. armigera* exhibits overlapping generations, it can be difficult to determine the number of completed generations. Typically two to five generations are achieved in subtropical and temperate regions and up to 11 generations can occur under optimal conditions, particularly in tropical areas.

During 2018, in the field trial, we tested the efficacy of flubendiamide (product name: Flubendiamid 200 g/l SC) and emamectin benzoate (product name: Affirm 095 SG) in the control of cotton bollworm on sweet pepper. Flubendiamid 200 g/l SC was tested at application rate of 0.25 l/ha and 0.35 l/ha, while Affirm 095 SG was applied at 1.5 kg/ha. The experiment was performed in a sweet pepper crop at locality Kisiljevo (municipality of Veliko Gradište, Serbia). The trial was conducted according to the completely random block system in four replicates using standard EPPO method for testing the insecticide efficacy in the control of *Helicoverpa armigera* on vegetables and ornamental plants (PP 1/295 (1)).

Three days after treatment (3DAT), the average damage of pepper fruit in untreated plot was 17.5%, and 8 DAT was 22%. Flubendiamid 200 g/l SC showed good efficacy at both application rates and both evaluation periods. Three days after treatment the efficacy ranged from 94.29% to 97.14%. At 8 DAT evaluation, efficacy was 95.45% and 98.86%, respectively. The treatment with Affirm 095 SG had a slightly lower efficacy (3 DAT: 90.0%), while the efficacy were even lower (84.09%), at 8 DAT evaluation.

MATERIAL & METHODS

Table 1. Basic experimental data

Crop	Sweet pepper	
Locality	Kisiljevo (municipality of Veliko Gradište, Serbia)	
Phenophase	10% of the fruits show the typical color of a ripe fruit (BBCH 81)	
Type, experimental plan and number of replications	Field trial, randomized complete block design, 4	
Size of experimental plot	25 m ²	
The amount of liquid	500 l	
Treatments	FLUBENDIAMID 200 g/L SC (a.i. flubendiamide)	250 ml/ha (2,5 ml / 100 m ²)
	FLUBENDIAMID 200 g/L SC (a.i. flubendiamide)	350 ml/ha (3,5 ml / 100 m ²)
	AFFIRM 095 SG (a.i. emamectin benzoate)	1,50 kg/ha (15 g / 100 m ²)
	Control (untreated plot)	-
The evaluation parameter	Number of damaged fruits by larvae	
Assessment method	Standard method: EPPO PP 1/295 (1) / 2016	100 fruits in each experimental plot were examined and the number of damaged fruits was determined (two evaluations after the second treatment)
Analysis of the test results	The efficacy of insecticides was determined using Abbott's formula and the significance of differences between treatment effects was determined according to the Student's t-test. The analysis of variance was performed in Microsoft Excel (EPPO standard PP 1/152 (4)).	
Dates of insecticide applications	August 5, 2018 (1 st)	August 14, 2018 (2 nd)
Dates of results assessments	3 days after the second treatment - 3DAT (August 17, 2018)	8 days after the second treatment - 8DAT (August 22, 2018)

RESULTS

Table 2. Efficacy of the insecticides in the control of *H. armigera* on sweet pepper, 3 days after the second treatment (3DAT)

Trade names of insecticides	Amount of product per ha	Number of damaged fruits out of 100 examined per replication				Average fruit damage % ± Sd*	Efficacy (%)
		A	B	C	D		
FLUBENDIAMID 200 g/L SC	250 ml/ha	1	0	2	1	1.0 ^a ± 0.82	94.29
FLUBENDIAMID 200 g/L SC	350 ml/ha	1	1	0	0	0.5 ^a ± 0.58	97.14
AFFIRM 095 SG	1,50 kg/ha	3	1	1	2	1.75 ^a ± 0.96	90.00
Control (untreated plot)	-	19	20	13	18	17.5 ^b ± 3.11	-

LSD_{0.05} = 0.0948; LSD_{0.01} = 0.1741

*Mean values followed by the same letter(s), within the same column are insignificantly different ($P \leq 0.05$; $P \leq 0.01$) according to Student's t -test.

At the Kisiljevo locality, the average damage of pepper fruits by the cotton bollworm caterpillars in untreated plot (control), 3DAT, was moderate to high and amounted to 17.5% (Table 2).

In the evaluation of 3DAT, the tested preparation FLUBENDIAMID 200 g/L SC, in both application amounts (250 - 350 ml/ha), showed good efficacy and it ranged from 94.29% to 97.14%, respectively. The treatment with AFFIRM 095 SG (1.50 kg/ha) had a lower degree of efficacy and it was 90.0%.

No statistically significant differences were found in the effects between treatments with insecticides. There are statistically very significant differences between all insecticide treatments and untreated plot.

Table 3. Efficacy of the insecticides in the control of *H. armigera* on sweet pepper, 8 days after the second treatment (8DAT)

Trade names of insecticides	Amount of product per ha	Number of damaged fruits out of 100 examined per replication				Average fruit damage % ± Sd*	Efficacy (%)
		A	B	C	D		
FLUBENDIAMID 200 g/L SC	250 ml/ha	1	0	2	1	1.0 ^{ab} ± 0,82	95,45
FLUBENDIAMID 200 g/L SC	350 ml/ha	0	1	0	0	0,25 ^b ± 0,50	98,86
AFFIRM 095 SG	1,50 kg/ha	5	3	2	4	3,5 ^{ac} ± 1,29	84,09
Control (untreated plot)	-	25	24	17	22	22,0 ^d ± 3,56	-

LSD_{0.05} = 0.1023; LSD_{0.01} = 0.1879

*Mean values followed by the same letter(s), within the same column are insignificantly different ($P \leq 0.05$; $P \leq 0.01$) according to Student's t -test.

The average damage of sweet pepper fruits by *H. armigera* caterpillars in the control, 8DAT, increased compared to the previous assessment and amounted to 22% (Table 3).

The tested preparation FLUBENDIAMID 200 g/L SC, in both application amounts (250 - 350 ml/ha), in the assessment of 8DPT, showed good efficacy and it ranged from 95.45% to 98.86%, respectively. The treatment with AFFIRM 095 SG (1.50 kg/ha) was less effective and amounted to 84.09%.

Statistically significant differences, at a significance level of 0.05, exist between the effects of the FLUBENDIAMID 200 g / L SC treatment (350 ml/ha) and AFFIRM 095 SG treatment (1.50 kg/ha).

No statistically significant differences were found in the effects between all other insecticide treatments. There are statistically very significant differences between all insecticide treatments and untreated plot.

CONCLUSION

According to this results, new diamide insecticide flubendiamide showed very good efficacy and can be successfully used in *H. armigera* control on sweet pepper.

Since emamectin benzoate has shown lower efficacy, the alternative application of the insecticides with different modes of action during the growing season should be considered in the implementation of anti-resistance strategy.



Figure 1: Damaged fruits and larvae of *H. armigera*