EFFECTS OF METHYL-ISONICOTINE WITH BLUE STICKY TRAP ON *FRANKLINIELLA OCCIDENTALIS* PERGANDE (THYSANOPTERA: THRIPIDAE) ON PEPPER GREENHOUSE

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Abstract

This research aims to detect the effects of an attractant with the active ingredient of methyl-isonicotinate (Lurem TR) produced by Koppert (Biological Systems, Antalya, TR) against the F. occidentalis adults. The attractant and blue sticky traps were integrated in order to observe and monitor the questioned effects in Aksu and Kumluca districts of Antalya province between April and August, 2014. In the study, two characters, attractant and certificated control pheromone (P-Anisaldehit, Ferothrip, Akdeniz Flora Company, Antalya, TR) preferred as positive control were used and compared. The obtained results demonstrated that the combination of the preparate and blue trap with the active ingredient of methyl-isonicotinate, shows promising effects against F. occidentalis.

Key words: *Frankliniella occidentalis, methyl-isonicotine, sticky trap, pepper*

1. INTRODUCTION

Vegetable cultivation under greenhouse conditions is an important branch of agricultural production and it *provides huge* and significant *contributions* to the Turkish economy. The total greenhouse area in Turkey is 649.118,12 da. Pepper cultivation under greenhouse conditions, with 1.363,183 tons of production, ranks second in Turkey following the tomato production (Anonymous, 2015). Fresh peppers are rich sources of nutrients and mainly composed of water (88%), carbohydrates (8.9%), proteins (2.2%) and fibers (1.56%). Peppers are also good source of Ca (17.7 mg/100g), Fe (1.11 mg/100g), K (340 mg/100g), Na (6.7mg/100g), thiamin (0.08 mg/100g), riboflavin (0.08mg/100g), niasin (0.9 mg/100g) and ascorbic acid (240 mg/100g) (Gebhardt and Thomas, 2002).

In pepper cultivation, pathogens and pests play a major role in decreasing the crop productivity to be achieved *between planting and harvesting.* Flower thrips, *Frankliniella occidentalis* Pergande (Thysanoptera: Thripidae), is a major pest, causing serious damage on pepper cultivation in greenhouses (Anonymous, 2011). It is widespread throughout the world and leads to economic losses. These species are polyphagous and thus have high wide range of host plants (Dağlı and Tunç, 2006).

Adults, being usually 0.5-2 mm in length, are slender and dorso-ventrally flattened with light yellow or yellowish brown body color. There are eyelash-like fringes on the edge of their wings. *Eggs of* flower thrips *are too small to be visible* to the eye and are inserted into plant tissues. The hatched *nymphs* are fairly *active* and move towards the *undersides* of the *leaves* to *feed*. Flower thrips are highly productive, with up to 15 generations produced per year and each female lays typically between 150 and 300 eggs throughout a lifetime.

F. occidentalis females cause discolorations and deformations on the peppers and these effects cause a reduction in crop yields and *market value*. Flower thrips are able to survive throughout the year in greenhouses as long as they meet the necessary requirements (Anonymous, 2011). Adults and nymphs puncture the epidermis of the leaves, flowers, or stems and soak in the exuding sap. Feeding on leaf tissue forms white-silver spots as the thrips damage the surface of the leaf and soak in the contents of the cells.

This case decreases the assimilation capacity of the plant. The leaves eventually become brittle and curled. The silvery spots can be seen on the fruit or capsules and ultimately, deformity of the *fruit may occur. They* also *create specks* of *black feces on* the underside of the *leaves. Some viruses can be transmitted by flower thrips, which may result in economic damage* (Dağlı and Tunç, 2006). In many countries, pesticides are often used to control flower thrips but the efficiency of chemical control method is very low. The effect of insecticide applications is lower due to some factors such as the presence of eggs in the plant tissue, presence of adults and nymphs in the interior parts of the flower and protection of the pupa by the soil (Robb and Parella, 1995).

In addition to the challenging characteristics of flower thrips, resistance status of populations against insecticides belonging to different groups also decreases the efficiency *of the chemical control programs* (Immaraju et al., 1992; Brodsgaard, 1994; Zhao et al., 1995; Karadjova, 1998; Kontsedalov et al., 1998; Jensen, 2000; Espinosa et al., 2002). For these reasons, a number of studies have recently been accelerated to find alternative control methods to replace the use of chemicals.

Seasonal population variations, the relative intensity and *the presence* of thrips species on the crops can be determined through different sampling methods. One of these methods is the use of colored sticky traps. It *is a low-cost method* to determine the relative abundance and the presence of thrips species. Colored sticky traps also bring contributions to reducing the density of the pest populations through the capture of thrips (Southwood, 1978). For example, it has been reported that the blue color attracts more *F. occidentalis* than white color does in the greenhouses (Vernon and Gillespiea, 1990; Roditakis et al., 2001). The blue and yellow traps have also been found more attractive for *F. Occidentalis* than white traps on broccoli fields (Chen et al., 2004).

The present research was carried out to determine the effects of an attractant with the active ingredient of methyl-isonicotinate (Lurem TR), produced by Koppert (Biological Systems Company, Antalya, TR), against the *F. occidentalis* adults. The attractant and blue sticky traps were integrated to observe and monitor the relevant effects.

2. MATERIALS AND METHODS

This research was carried out in Aksu and Kumluca districts of Antalya province between April and August, 2014. The main material of this study consists of two pepper greenhouses infested with *F. occidentalis*.

2.1. Field Studies

The trials carried out in Kumluca were conducted in a pepper (Hunty-F1 variety) greenhouse (with 2500 m^2 surface area) infested with *F. occidentalis* on April 18, 2014. The trials carried out in Aksu were conducted in two different pepper (Safran-F1 variety) greenhouses (each with 1200 m^2 surface area) on April 22, 2014. The distance between the greenhouses was 5 m. and since the area required for trials was 2400m^2, these two greenhouses were analyzed together.

During the trials, measurements were conducted when the plants were in their flowering and fruit period. The length of the plants was measured 40-50 cm for the first counting. During the trials the sizes of the plants varied up to 180 cm. Furthermore, interval and row spacing were measure 80-120 cm and 40-60 cm, respectively. A minimum of six replicates were performed in accordance with the randomized block design. In the study, two characters being the attractant with the active ingredient of methyl-isonicotinate (Lurem TR, Koppert, Biological Systems Company, Antalya, TR) and certificated control pheromone (P-Anisaldehit, Ferothrip, Akdeniz Flora Company, Antalya, TR) preferred as positive control were used and compared. The traps were placed in the middle of the trial plot, 10 meters distance between the traps was provided and the traps on the same line were placed diagonally. Every sampling *plot size was taken as* 200 m^2. Attractant and pheromone traps used in the study and the ratio of the active substance are shown in Table. 1

Table 1. The preparations and the ratio of active ingredients used against flower thrips on pepper greenhouses in 2014

Commercial Name	Company	Active Ingredient	Active Ingredient Ratio	Trap
Lurem-TR	Koppert	Methyl-Isonicotinate	2,90 gr	Horiver-TR (10x20cm)
Ferothrip*	Akdeniz Flora	P-Anisaldehit/dispenser	1,20 gr	Hiperlife (10x20cm)

*Positive control trap

The traps were placed *with the planting of seedlings* according to the user guides. The countings were initiated by the date of the *first capture* of *adults* by traps and continued for the following eight weeks. During the trials, at least one counting was conducted per week. All adults captured by the traps were counted and recorded. In order to determine the relationship between the adults captured with traps and pests in crops, the number of the pests on plants was also evaluated. All adult *thrips were counted* on 10 *randomly selected* plants in each plot. For this procedure, 2 flowers and 2 leaves from each plant were chosen and thrips countings were conducted. The *counting* of the thrips on the leaves was *performed* with a *binocular microscope and* thrips on the flowers were shaken over a white sheet of paper. Due to sunlight and other environmental factors, the traps and dispensers were changed every month depending on the duration of the effect of the pheromone and the condition of the sticky traps

2.2. Laboratory Studies

The samples of the blue sticky traps with *pheromone capsules, and the blue sticky traps* with the attractant were replaced weekly by new ones and placed on trap boxes (10x20 cm) *to prevent any contact and then counts were performed.*

2.3. Data Analysis

The formula of the Trap Efficiency (%) (Anonymous, 2013) was applied to the results obtained from the trials, and IBM SPSS Statistics 20 package program was used for data analysis. The differences of trap efficiencies were evaluated by the t-test (p=0.05).

$$\boldsymbol{Trap\ Efficiency}\ (\%) = \frac{\mathbf{A}}{\mathbf{A+B}}\mathbf{x100}$$

A: The total number of the thrips captured by the traps

B: The total number of the thrips captured by the control trap

3. RESULTS AND DISCUSSION

The number of *F. occidentalis* adults captured with traps and the percentage of the trap efficiency in Kumluca and Aksu are presented in Table 2-3.

Table 2. The number of *Frankliniella occidentalis* adults captured with traps and the percentage of the trap efficiency in Kumluca on April 25, 2014.

Traps	R	25/04/2014		02/05/2014		09/05/2014		16/05/2014		23/05/2015		30/05/2014		06/06/2014		13/06/2014	
		A	**TE (%)**	**A**	**TE (%)**	**A**	**TE (%)**	**A**	**TE (%)**	**A**	**TE (%)**	**A**	**TE (%)**	**A**	**TE(%)**	**A**	**TE (%)**
Methyl-Isonicotinate (Lurem TR)	**1**	450	52.94	380	50.67	500	47.17	300	48.39	430	53.75	240	50.00	174	45.31	160	44.44
	2	460	48.94	510	54.84	760	53.90	440	52.38	400	53.33	360	56.25	132	35.48	100	28.57
	3	410	48.24	360	51.43	560	52.83	720	62.07	400	42.55	300	50.00	504	71.19	350	66.04
	4	527	48.48	600	55.05	800	55.17	480	48.00	380	52.05	300	57.69	270	35.71	300	45.45
	5	720	55.38	690	57.50	780	46.99	640	55.17	420	48.28	350	46.67	228	54.29	200	57.14
	6	750	50.34	620	43.06	840	47.19	1000	62.50	550	52.38	320	51.61	228	53.52	250	55.56
	Mean	**552.83**	**50.72**	**526.67**	**52.09**	**706.67**	**50.54**	**596.67**	**54.75**	**430.00**	**50.39**	**311.67**	**52.04**	**256.00**	**49.25**	**226.67**	**49.53**
P-anisaldehit (Ferothrip)	**1**	400	-	370	-	560	-	320	-	370	-	240	-	210	-	200	-
	2	480	-	420	-	650	-	400	-	350	-	280	-	240	-	250	-
	3	440	-	340	-	500	-	440	-	540	-	300	-	204	-	180	-
	4	560	-	490	-	650	-	520	-	350	-	220	-	486	-	360	-
	5	580	-	510	-	880	-	520	-	450	-	400	-	192	-	150	-
	6	740	-	820	-	940	-	600	-	500	-	300	-	198	-	200	-
	Mean	**533.33**	-	**491.67**	-	**696.67**	-	**466.67**	-	**426.67**	-	**290.00**	-	**255.00**	-	**223.33**	-

Table 3. The number of *F. occidentalis* adults captured with traps and the percentage of the trap efficiency in Aksu on April 29, 2014.

Traps	**R**	**29/04/2014**		**06/05/2014**		**13/05/2014**		**20/05/2014**		**27/05/2014**		**03/06/2014**		**10/06/2014**		**17/06/2014**	
		A	**TE(%)**	**A**	**TE(%)**	**A**	**TE(%)**	**A**	**TE(%)**	**A**	**TE(%)**	**A**	**TE(%)**	**A**	**TE(%)**	**A**	**TE(%)**
Methyl-Isonicotinate (Lurem TR)	**1**	16344	39.92	14160	65.92	18600	53.45	25200	59.15	6720	57.14	2300	47.92	750	48.39	300	51.72
	2	25800	69.38	8400	52.63	21600	48.00	22800	50.67	5040	42.42	2450	46.67	900	47.37	400	50.00
	3	37200	81.79	12000	54.05	27600	58.97	16200	41.54	5280	67.69	2700	52.94	1350	50.94	500	43.48
	4	25200	41.58	7800	38.24	28200	55.29	21600	41.38	4440	33.94	3100	48.44	1600	48.48	1000	48.78
	5	37800	64.29	17400	53.70	32400	58.70	27600	55.42	4620	45.03	2800	51.85	1450	55.77	1100	53.66
	6	36600	52.14	29520	59.85	26400	50.57	34800	54.21	8040	58.26	3200	53.78	1500	47.62	1300	52.00
	Ort:	**29824**	**58.18**	**14880.0**	**54.07**	**25800.00**	**54.16**	**24700.00**	**50.39**	**5690.0**	**50.75**	**2758.3**	**50.27**	**1258.3**	**49.76**	**766.67**	**49.94**
P-anisaldehit (Ferothrip)	**1**	24600	-	7320	-	16200	-	17400	-	5040	-	2500	-	800	-	280	-
	2	11388	-	7560	-	23400	-	22200	-	6840	-	2800	-	1000	-	400	-
	3	8280	-	10200	-	19200	-	22800	-	2520	-	2400	-	1300	-	650	-
	4	35400	-	12600	-	22800	-	30600	-	8640	-	3300	-	1700	-	1050	-
	5	21000	-	15000	-	22800	-	22200	-	5640	-	2600	-	1150	-	950	-
	6	33600	-	19800	-	25800	-	29400	-	5760	-	2750	-	1650	-	1200	-
	Ort:	**22378**	-	**12080.0**	-	**21700.00**	-	**24100.00**	-	**5740.0**	-	**2725.0**	-	**1266.6**	-	**755.00**	-

R: Replicates; A: Adult; TA: Trap Efficiency

As presented in Table 2, the preparation, with the active ingredient of methyl-isonicotinate, is seen to be effective against the adults with the average of 50.72 %, 52.09 %, 50.54 %, 54.75 %, 50.39 %, 52.04 %, 49.25 %, 49.53 % following 7, 14, 21, 28, 35, 42, 49, 56 days from the beginning of the experiment. As presented in Table 3, the preparation, with the same active ingredient, is seen to be effective against the adults with the average of 58.18%, 54.07 %, 54.16 %, 50.39 %, 50.75 %, 50.27 %, 49.76 %, 49.94 % following 7, 14, 21, 28, 35, 42, 49, 56 days from the beginning of the experiment. The results of *the countings were evaluated according to the formula given in the "Vegetable Pests Standard Drug Testing Methods".* The average number of the adults captured with

the sexual traps used in the experiments, the average of countings made in the leaves and flowers and t-test results are presented in Table 4-5.

Table 4. The average of t-Test results in Aksu

Character	Average number of adults / Trap	Average number of nymphs / Flower	Average number of nymphs / Leaf
Methyl-Isonicotinate (Lurem TR)	13209,66±1166,32	59,02±4,65	7,08±1,54
P-anisaldehit (Ferothrip)	11343,08±1152,22	62,60±3,70	7,37±0,98
t	1,139	-0,602	-0,157
p	0,281	0,561	0,879

The results of the statistical analysis presented in Table 2 are supported by the results presented in Table 4. Lurem-TR, being an attractant and monitoring tool, and Ferothrip, being a positive control pheromone, were determined to be in the same statistical value range ($p>0.05$) (t_{adult} (9.99)= 1.139; p=0.281, t_{flower} (9.51)= -,602; p= 0.561, t_{leaf} (8.48)= -,157; p= 0.879).

Table 5. The average results of t-Test in Kumluca

Character	Average number of adults / Trap	Average number of nymphs / Flower	Average number of nymphs / Leaf
Methyl-Isonicotinate (Lurem TR)	450,89±34,07	33,60±1,96	0,04±0,02
P-anisaldehit (Ferothrip)	422,91±30,53	32,27±2,16	0,02±0,02
t	0,612	0,456	0,620
p	0,555	0,659	0,550

The statistical analysis results presented in Table 5 support the results presented in Table 3 and 4. Lurem-TR, being an attractant and monitoring tool, and Ferothrip, being a positive control pheromone, were determined to be in the same statistical value range ($p>0.05$) (t_{adult} (9.88)= 0.612; p=0.555, t_{flower} (9.90)= 0.456; p= 0.659, t_{leaf} (9.49)= 0.620; p= 0.550).

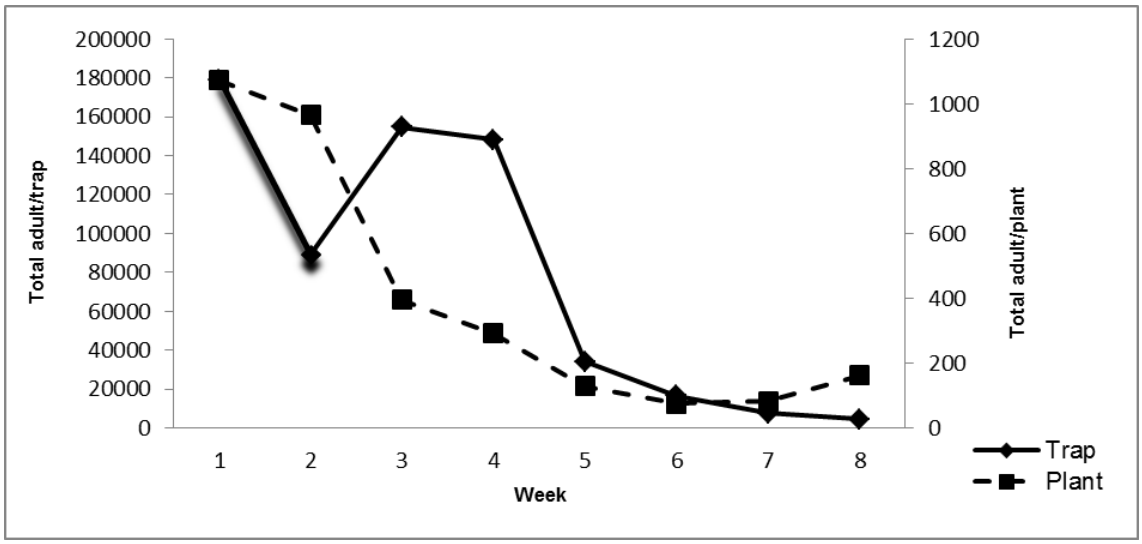


Figure 1. The weekly changes in the number of thrips on plants and captured by the traps in Aksu.

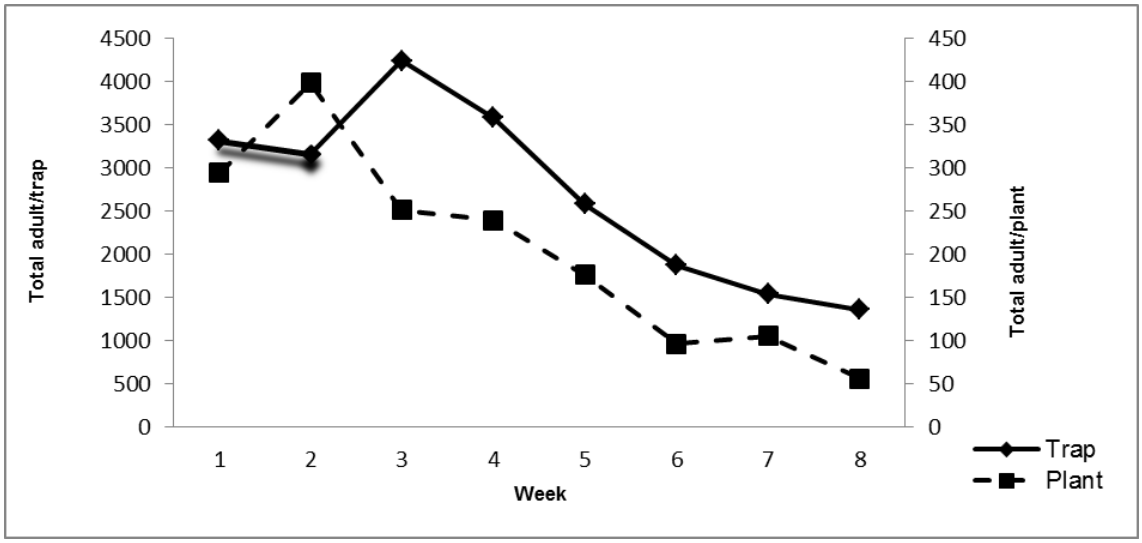


Figure 2. The weekly changes in the number of thrips on plants and captured by the traps in Kumluca.

According to Figure 1, the number of the individuals is seen to decrease during the first week and increase following two weeks. Figure 1 also shows an increase in the number of individual on the plants as of the second week. The number of the trapped individuals and thrips on the plants reached the minimum level in the eighth and sixth weeks, respectively. According to Figure 2, the number of the trapped individuals is seen to decrease during the first week and increase following two weeks. The number of the individuals on the traps and plants reached the minimum level in the eighth week. It may be mentioned here that the number of the thrips on the plants decreased in parallel with the improvement in trap efficiency for both greenhouses.

According to the results obtained from the trials in Kumluca, Lurem-TR is determined to be effective against the adults with the average of 50.72 %, 52.09 %, 50.54 %, 54.75 %, 50.39 %, 52.04 %, 49.25 %, 49.53 % trap efficiency following 7, 14, 21, 28, 35, 42, 49, 56 days from the beginning of the experiment. Similarly, according to the trial results in Aksu, Lurem-TR is seen to be effective with the average of 58.18 %, 54.07 %, 54.16 %, 50.39 %, 50.75 %, 50.27 %, 49.76 %, 49.94 % trap efficiency following 7, 14, 21, 28, 35, 42, 49, 56 days from the beginning of the experiment.

With more than 20% trap efficiency, the preparation with the active ingredient of methyl-isonicotinate is appeared to be effective against the flower thrips. The efficiency results have been supported by the results of the analysis obtained from the countings conducted in the test area. Lurem-TR, being an attractant and monitoring tool, and Ferothrip, being a positive control pheromone, was determined to be in the same statistical value range ($p>0.05$).

In order to evaluate the relationship between the adult thrips captured on traps and individuals on plants, population densities were represented by graphs. It may be mentioned here that the number of the thrips on the plants decreased in parallel with the improvement in trap efficiency for both greenhouses. Namely, there is a correlation between the population size of the thrips on the plants and the trap efficiency.

Hoodle et al. (2002), reported that yellow sticky traps are more attractive for *Scirtothrips perseae* Nakahara attacking avocados in California and white sticky traps are more attractive for *F. occidentalis. The attractant potential* of water mixtures with volatile chemicals against adult thrips in the Netherlands and New Zealand were investigated (Teulon et al., 1993). The researchers reported that ethyl nicotinate, p-anisaldehyde and benzaldehyde increase the attractiveness of the water trap by 35 fold and the amount of the female *F. occidentalis* captured by the sticky traps with p-anisaldehyde can be increased by 1.8 – 6 fold. Tomassini et al. (2004), showed that the correlation between the thrips captured on the blue sticky traps and the damage on the nectarines was significant.

Pearsall and Myers (2001), observed a significant correlation between the number of the trapped *F. occidentalis* and the average temperature. In the same study, the increase in the number of the trapped *F. occidentalis* was determined to be parallel with the increase in temperature.

When both the literature review and the results of the study are examined together, the blue sticky trap is seen to be effective against the *F. occidentalis* and it can be used practically as a biotechnical method. It has been demonstrated with the results of this study that the *combination of* blue trap and the preparate, with the active ingredient of methyl-isonicotinate, shows *promising effects against F. occidentalis.*

4. CONCLUSION

In pepper cultivation, pathogens and pests play a major role in decreasing crop productivity to be achieved *between planting and harvesting.* Flower thrips, *Frankliniella occidentalis* (Pergande (Thysanoptera: Thripidae)), is a major pest, causing serious damage on pepper cultivation in greenhouses. In many countries, pesticides are often used to control flower thrips but the efficiency of chemical control methods is very low. The effect of insecticide applications is lower, due to some factors such as the presence of eggs in the plant tissue, presence of adults and nymphs in the interior parts of the flower and protection of the pupa by the soil.

In addition to the challenging characteristics of flower thrips, resistance status of populations against insecticides belonging to different groups decreases the efficiency *of chemical control programs.* For these reasons, a number of studies have recently been accelerated to find alternative control methods to replace the use of chemicals. The present study was carried out to determine the effects of an attractant with the active ingredient of methyl-isonicotinate (Lurem TR) produced by Koppert (Biological Systems Company, Antalya, TR) against the *F. occidentalis* adults. The attractant and blue sticky traps were integrated to observe and monitor the relevant effects in Aksu and Kumluca districts of Antalya province between April and August, 2014. In this study, two characters being the attractant and certificated pheromone (P-Anisaldehit, Ferothrip, Akdeniz Flora Company, Antalya, TR) preferred as a positive control were used and compared. The obtained results demonstrated that the *combination of* the blue trap and the preparate, with the active ingredient of methyl-isonicotinate, shows *promising effects against F. occidentalis.*

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