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Effects of biological insecticides NeemAzal T/S and Pyrethrum FS EC and their interaction with organic products in treatments of pea aphid *Acyrthosiphon pisum* (Harris) (Hemiptera: Aphididae) on *Pisum sativum* (L.)

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SUMMARY

The efficacy and effects of two biological insecticides, NeemAzal T/S® and Pyrethrum FS EC, applied individually and in combination with Polyversum (a biological growth regulator and fungicide) and Biofa (an organic foliar fertilizer), in controlling *Acyrthosyphon pisum* population density were studied. Nurelle D (a synthetic insecticide), applied alone and in combination with Flordimex 420 (a synthetic growth regulator), was used as a standard. The products were applied once (at budding stage) or twice (at budding and flowering stages). Twenty-four variants were studied. The interaction of Pyrethrum with Biofa was the most efficient variant of the biological products, causing a reduction in aphid density that reached 48.2% after double treatment, while Pyrethrum+Polyversum (42.5%) was the second most successful treatment. The combination of Pyrethrum with Biofa achieved the highest efficacy and synergism and their efficacy approached that of the synthetic insecticide.

Keywords: Forage pea; Acyrthosiphon; Biopesticides; Insecticides

INTRODUCTION

One of the major pests with economic impact on field pea crops in Bulgaria is *Acyrthosyphon pisum* (Harris) (Hemiptera: Aphididae). The damage that aphids cause can be direct by phloem sap extraction, which may cause a reduction in photoassimilates and crop yield, or indirect by transmitting plant viruses (Dedryver et al., 2010). Nault (1997) found that staggering 50% of insect-borne plant viruses are transmitted by aphids. Additionally, aphids can cause damage to crops by their sucrose-rich excreta, termed honeydew, which can attract other pest species (Gratwick, 1992) and provide an ideal medium for sooty moulds that cover host-plant foliage and hinder the photosynthetic capacity of plants (Jones & Jones, 1974).

Many products of the existing insecticide groups, such as organophosphates, carbamates and pyrethroids, are effective against aphids but they have a long history of use. Resistance to those insecticides is a serious problem for farmers and the environment, beneficial insects and natural enemies (Dixon, 1985; Sylvester & McClain, 1978; Blackman & Eastop, 2000; Després et al., 2007). In reaction to the known harmful effects of such conventional pesticides, there is a growing tendency to use pesticide alternatives to reduce risks. The use of biological plant pesticides has been strongly recommended as a suitable alternative for plant protection with minimum negative risks (Isman, 2006; Pavela, 2007). They are compatible with integrated pest management (Horowitz & Ishaaya, 2004). Such alternatives include azadirachtin- and pyrethrum-containing products that are environmentally friendly and applicable in organic farming. The biological efficacy of pyrethrum and neem products, applied alone or in combination with different organic products, has not been sufficiently studied and compared, or their impact on population density of pests. Therefore the purpose of the present study was to determine the impact of the biological insecticides NeemAzal-T/S and Pyrethrum on *Acyrthosyphon pisum* population density, and their interaction with two organic products, and to compare their biological efficacy with Nurelle D (applied individually and in a combination) in spring forage pea.

MATERIAL AND METHODS

A trial was conducted on the spring forage pea (*Pisum sativum* L.) variety "Pleven 4" in the experimental field of the Institute of Forage Crops, Bulgaria, over the period 2011-2013. The two-factor field trial was conducted using a split-plot design: factor A – products and their mixtures, including 12 levels; factor B – stages of treatment, including 2 levels: b_1 – at budding, b_2 – at budding and at flowering. Combining the levels with the two factors 24 variants were obtained. The effects of the biological insecticides NeemAzal T/S® and Pyrethrum FS EC, Polyversum (biological growth regulator and fungicide) and Biofa (organic foliar fertilizer), applied individually or in combination, on *Acyrthosyphon pisum* population density were studied. Nurelle D (synthetic insecticide), applied individually and in combination with Flordimex 420 (synthetic growth regulator), was used as a standard. Trial variants and product characteristics are shown in Table 1.

The sowing rate was 120 seeds m^{-2} in 4 replications and plot size was 6.5 m^2 (about 650 plants per plot).

Aphids in all 24 variants were counted immediately after the first treatment at the budding stage (one day after treatment) and counting continued until the above-ground biomass has dried (between mid-May and the end of June - approximately 45 days). Over the period, population density was recorded by sweepings with an entomological net once a week. The data in Table 2 regarding pest abundance in the studied variants were averaged for the indicated 45-day period. The efficacy of insecticides and their combinations (5-12 variants in Table 1) was also estimated in variants of double treatment, at the stages of budding and flowering. Estimations were made 1, 3, 5 and 7 days after the second treatment, i.e. at flowering, because the population density of *Acyrthosiphon pisum* reaches maximum values at that stage (Nikolova, 2010). The efficacy of the insecticides was calculated according to Abbott's formula and the entomological net was used for sweeping. In the present study, data on population density of aphids and product efficacy were based on differentiation between sexual and asexual forms. The data were statistically analyzed by One-way ANOVA and the significance of mean differences was determined by Fisher's LSD test at $P < 0.05$.

RESULTS

After treatment of plants with two growth regulators (Polyversum and Flordimex 420) and the foliar fertilizer Biofa, a slight rise of 3.3-5.2% on the average in population density of the pest was observed over the study period, regardless of the stage of treatment (Table 2).

Table 1. Characteristics of products

Trial variants	Time and number of treatments	Active ingredients	Application rates, per ha
1. Control	At budding stage (once) At budding and at flowering stages (twice)	Treated with distilled water	300 l
2. Biofa	At budding stage (once) At budding and at flowering stages (twice)	Organic matter (9%), alginic acid (4%), natural plant hormones, total nitrogen (0.20%), total phosphorus (P_2O_5) - 8%, soluble potassium (K_2O) - 14%	500 ml
3. Polyversum	At budding stage (once) At budding and at flowering stages (twice)	*Pythium oligandrum* (strain M1), 1 x 106 oospores/g of product, natural product with a double effect: a fungicide and growth regulator	100 g
4. Flordimex 420	At budding stage (once) At budding and at flowering stages (twice)	420 g/l ethephon, a synthetic growth regulator which stimulates the formation of generative organs	50ml
5. NeemAzal T/S	At budding stage (once) At budding and at flowering stages (twice)	1% azadirachtin A + 0.5% azadirachtin B, W, G, D and 2.5% neem substance	500 ml
6. Pyrethrum FS EC	At budding stage (once) At budding and at flowering stages (twice)	32 % extract of pyrethrum (25% pyrethrin) + 32 % sesame oil + 36 % adhesives (soft potassium soap)	50 ml
7. Nurelle D	At budding stage (once) At budding and at flowering stages (twice)	50 g/l a.i. cypermethrin + 500g/l a.i. chlorpyrifos-ethyl	400 ml
8.NeemAzal+Biofa	At budding stage (once) At budding and at flowering stages (twice)	1% azadirachtin A + 0.5% azadirachtin B, W, G, D and 2.5% neem substance + organic matter (9%), alginic acid (4%), natural plant hormones, total nitrogen (0.20%), total phosphorus (P_2O_5) - 8%, soluble potassium (K_2O) - 14%	500 ml+500ml
9. Pyrethrum+Biofa	At budding stage (once) At budding and at flowering stages (twice)	32 % extract of pyrethrum (25% pyrethrin) + 32 % sesame oil + 36 % adhesives (soft potassium soap) + organic matter (9%), alginic acid (4%), natural plant hormones, total nitrogen (0.20%), total phosphorus (P_2O_5) - 8%, soluble potassium (K_2O) - 14%	50 ml+500 ml
10. NeemAzal+Polyversum	At budding stage (once) At budding and at flowering stages (twice)	1% azadirachtin A + 0.5% azadirachtin B,W,G,D and 2.5% neem substance + *Pythium oligandrum* (strain M1), 1 x 106 oospores/g of product	500 ml+100 g
11. Pyrethrum+Polyversum	At budding stage (once) At budding and at flowering stages (twice)	32 % extract of pyrethrum (25% pyrethrin) + 32 % sesame oil + 36 % adhesives (soft potassium soap) + *Pythium oligandrum* (strain M1), 1 x 106 oospores/g of product	50 ml+100 g
12. NurelleD+Flordimex	At budding stage (once) At budding and at flowering stages (twice)	50 g/l a.i. cypermethrin + 500g/l a.i. chlorpyrifos-ethy + 420 g/l ethephon	400 ml+50 ml

Table 2. Means of *Acyrthosyphon pisum* aphids per 100 sweepings over the vegetation period

Variants	Stages of treatment	Number of aphids per 100 sweepings	+ / - compared to C, %	Number of aphids per 100 sweepings	+ / - compared to C, %	Number of aphids per 100 sweepings	+ / - compared to C, %	Number of aphids per 100 sweepings	+ / - compared to C, %
		2011		**2012**		**2013**		**2011-13**	
1.	b	117.5 ef		398.2 ef		553.1 ef		356.3 f	
Control (C)	b+f	124.6 gh		413.5 g		537.5 f		358.5 g	
	Mean	**121.0**		**405.9**		**545.3**		**357.4**	
2.	b	126.1 f	7.3	407.0 f	2.2	578.1 ef	4.5	370.4 f	4.0
Biofa	b+f	132.6 h	6.4	450.4 g	8.9	562.5 fg	4.7	381.8 h	6.5
	Mean	**129.3**	**6.9**	**428.7**	**5.6**	**570.3**	**4.6**	**376.1**	**5.2**
3.	b	120.3 ef	2.4	400.6 ef	0.6	585.6 ef	5.9	368.8 f	3.5
Polyversum	b+f	126.8 g	1.7	439.1 g	6.2	542.3 f	0.9	369.4 g	3.0
	Mean	**123.5**	**2.1**	**419.9**	**3.4**	**564.0**	**3.4**	**369.1**	**3.3**
4.	b	127.0 f	8.1	403.0 f	1.2	590.5 f	6.8	373.5 f	4.8
Flordimex	b+f	129.2 gh	3.7	440.2 g	6.5	557.5 fg	3.7	375.6 gh	4.8
	Mean	**128.1**	**5.9**	**421.6**	**3.9**	**574.0**	**5.3**	**374.6**	**4.8**
5.	b	102.8 d	-12.5	374.4 cd	-6.0	478.0 d	-13.6	318.4 e	-10.6
NeemAzal	b+f	88.3 f	-29.1	366.0 f	-11.5	365.0 e	-32.1	273.1 f	-23.8
	Mean	**95.6**	**-21.0**	**370.2**	**-8.8**	**421.5**	**-22.7**	**295.8**	**-17.2**
6.	b	99.3 cd	-15.5	353.2 bcd	-11.3	443.1 cd	-19.9	298.5 de	-16.2
Pyrethrum	b+f	79.8 e	-35.9	293.0 cd	-29.1	312.8 cd	-41.8	228.5 e	-36.2
	Mean	**89.5**	**-26.0**	**323.1**	**-20.4**	**378.0**	**-30.7**	**263.5**	**-26.3**
7.	b	77.2 a	-34.3	327.4 abc	-17.8	336.3 a	-39.2	247.0 b	-30.7
Nurelle D	b+f	46.4 b	-62.7	250.2 b	-39.5	170.0 a	-68.4	155.5 b	-56.6
	Mean	**61.8**	**-48.9**	**288.8**	**-28.8**	**253.2**	**-53.6**	**201.3**	**-43.7**
8.	b	94.3 bcd	-19.7	329.8 abcd	-17.2	427.0 bc	-22.8	283.7 cd	-20.4
NeemAzal+Biofa	b+f	71.3 de	-42.8	324.0 de	-21.6	296.3 c	-44.9	230.5 e	-35.7
	Mean	**82.8**	**-31.5**	**326.9**	**-19.5**	**361.7**	**-33.7**	**257.1**	**-28.1**
9	b	87.7 b	-25.4	318.2 ab	-20.1	392.5 b	-29.0	266.1 c	-25.3
Pyrethrum+Biofa	b+f	62.7 c	-49.7	247.0 ab	-40.3	247.0 b	-54.0	185.6 c	-48.2
	Mean	**75.2**	**-37.9**	**282.6**	**-30.4**	**319.8**	**-41.4**	**225.8**	**-36.8**
10.	b	95.7 bcd	-18.6	365.2 de	-8.3	451.6 cd	-18.4	304.2 e	-14.6
NeemAzal+Polyversum	b+f	78.4 e	-37.1	348.0 ef	-15.8	337.8 de	-37.2	254.7 f	-28.9
	Mean	**87.0**	**-28.1**	**356.6**	**-12.1**	**394.7**	**-27.6**	**279.4**	**-21.8**
11.	b	90.8 bc	-22.7	321.2 ab	-19.3	420.8 bc	-23.9	277.6 cd	-22.1
Pyrethrum+Polyversum	b+f	67.9 cd	-45.5	263.5 bc	-36.3	287.0 c	-46.6	206.1 d	-42.5
	Mean	**79.4**	**-34.4**	**292.4**	**-28.0**	**353.9**	**-35.1**	**241.9**	**-32.3**
12.	b	69.3 a	-41.0	294.8 a	-26.0	306.3 a	-44.6	223.5 a	-37.3
Nurelle D+Flordimex	b+f	37.5 a	-69.9	207.4 a	-49.8	144.9 a	-73.0	129.9 a	-63.8
	Mean	**53.4**	**-55.9**	**251.1**	**-38.1**	**225.6**	**-58.6**	**176.7**	**-50.6**
$LSD_{0.05}$	b	**9.918**		**36.116**		**39.294**		**19.141**	
$LSD_{0.05}$	b+f	**8.502**		**40.779**		**29.165**		**19.951**	

b – stage of budding, b+f – stages of budding and flowering
[a]Means in each column followed by the same letter are not significantly different ($P > 0.05$) at budding.
[b]Means in each column followed by the same letter are not significantly different ($P > 0.05$) at budding and flowering.

All tested insecticides reduced aphid numbers at budding, and at budding and flowering stages over the years of trial. Statistically significant differences were detected between the insecticide-treated variants and variants without insecticides, including the control.

In the group of biological insecticides assessed at the budding stage, the density of *Acyrthosyphon pisum* was lowest after the combined use of Pyrethrum and Biofa, which reduced aphid numbers by 25.3 % on the average for the period. The difference between the combined and individual use of Pyrethrum was statistically significant. More substantial reduction in aphid density of 22.1 and 20.4% was found in plots treated with Pyrethrum+Polyversum and NeemAzal+Biofa, respectively. Statistically significant decrease was also observed after treatments with NeemAzal and NeemAzal+Biofa. NeemAzal had the slightest protective effect and decreased aphid numbers only by 10.6%.

The protective effect of insecticides applied at budding and flowering stages was stronger and *A. pisum* numbers were considerably lower compared to their numbers after a single treatment. The interaction of Pyrethrum with Biofa was the most efficient variant among the tested biological products, reaching a reduction in aphid density of 48.2%. Statistically significant differences were observed between Pyrethrum+Biofa and other bioinsecticide-treated variants. The combination Pyrethrum+Polyversum significantly decreased aphid numbers by 42.5%, and it was followed by Pyrethrum and NeemAzal+Biofa reductions of 36.2 and 35.7%, respectively. The combined use of Pyrethrum with Polyversum and Biofa, and NeemAzal with Biofa resulted in statistically higher decreases in aphid numbers than their individual application. Statistically the lowest decrease was detected for NeemAzal.

The biological products NeemAzal and Pyrethrum, applied individually and in combination, had significantly lower effects on aphid numbers than the synthetic insecticide Nurelle D and its combination after single and double treatments.

In the group of biological insecticides, Pyrethrum and its combinations with organic products showed higher efficacy than NeemAzal applied alone and in combination with Polyversum in 2011 (Table 3).

The combination of Pyrethrum and Biofa achieved the highest efficacy of 93.5, 83.3 and 72.2% one, three and five days after treatment, respectively, while the combination of Pyrethrum and Polyversum reached 85.6, 76.1 and 60.3% efficacy. Differences between Pyrethrum+Biofa and the other bioinsecticide variants were statistically significant over the five-day period, except Pyrethrum+Polyversum on the third and NeemAzal+Biofa on the fifth day after treatment. Seven days after pea treatment with the combination of NeemAzal and Biofa, aphid mortality was the highest (74.9%), followed by Pyrethrum+Polyversum (68.6%). NeemAzal applied individually and in combination with Polyversum had the lowest efficacy for the reporting period. Compared to the synthetic insecticide Nurelle D (applied alone and in combination with Flordimex), the biological insecticides demonstrated efficacy that was significantly lower, except Pyrethrum+Biofa whose efficacy was close to that of the standard insecticide.

Table 3. Efficacy of insecticides applied individually and in combination with other products against *Acyrthosyphon pisum* (at budding and flowering stages), 2011

Variants	1 DAT		3 DAT		5 DAT		7 DAT	
	E, %	Sd	E, %	Sd	E, %	Sd	E, %	Sd
5. NeemAzal	53.6 a	1.98	56.6 a	3.39	60.0 a	2.82	62.4 ab	2.26
6. Pyrethrum	75.3 b	3.82	67.1 b	2.96	61.5 a	2.12	56.2 a	3.11
7. Nurelle D	95.7 de	1.84	85.4 d	3.67	82.0 c	2.89	76.1 d	4.10
8. NeemAzal+Biofa	56.2 a	3.11	64.5 b	3.53	70.0 b	4.17	74.9 cd	1.55
9. Pyrethrum+Biofa	93.5 d	2.12	83.3 cd	3.25	72.7 b	1.83	68.6 bc	3.39
10. NeemAzal+Polyversum	53.9 a	2.97	59.4 ab	3.39	60.2 a	3.95	66.0 b	4.24
11. Pyrethrum+Polyversum	85.6 c	3.68	76.1 c	2.96	60.3 a	3.81	58.2 a	3.11
12. Nurelle D+Flordimex	100 e	0.0	90.5 d	3.53	82.5 c	3.53	77.7 d	3.32
$LSD_{0.05}$	6.231		7.725		7.747		7.484	

Means in columns followed by the same letter are not significantly different (p>0.05)
1DAT – one day after treatment; 3DAT – three days after treatment; 5DAT – five days after treatment; 7DAT – seven days after treatment; Sd – standard deviation; E - efficacy

In 2012, the efficacy of the tested bioinsecticides ranged from 41.2 to 79.7% one day after treatment, and the efficacy of Pyrethrum+Biofa was highest (79.7%), approaching that of Nurelle D (Table 4). The trend of leading efficacy of Pyrethrum+Biofa extended until the fifth day and the differences from the other variants with organic products were statistically significant. Seven days after treatment, NeemAzal+Biofa had the highest efficacy (61.1%), and it was followed by Pyrethrum+Biofa (56.1%). NeemAzal exhibited the lowest efficacy for the reporting period.

Nurelle D applied in combination with Flordimex showed the highest efficacy from the first to the seventh day after treatment, followed by its individual use. In the group of biological insecticides, only Pyrethrum +Biofa demonstrated a protective effect that was close to that of the standard insecticide.

Fast initial activity and 100.0% efficacy was achieved one day after treatment of peas with Pyrethrum+Biofa, Nurelle D and Nurelle D+Flordimex in 2013 (Table 5). The efficacy of Pyrethrum+Biofa slightly exceeded that of Nurelle D and approached that of Nurelle D+Flordimex on the third and fifth days after treatment. In that interval, the combination Pyrethrum+Biofa had a statistically highest efficacy in the group of biological insecticides, ranging from 80.6 to 88.3%. On the seventh day after treatment, the trend was different. NeemAzal+Biofa showed the highest efficacy (80.4%) of all variants with organic products and almost reached that of the synthetic variants.

Table 4. Efficacy of insecticides applied individually and in combination with other products against *Acyrthosyphon pisum* (at budding and flowering stages), 2012

Variant	1 DAT		3 DAT		5 DAT		7 DAT	
	E, %	Sd	E, %	Sd	E, %	Sd	E, %	Sd
5. NeemAzal	41.2 a	3.95	45.2 a	5.37	50.5 a	3.53	52.0 bc	2.82
6. Pyrethrum	63.6 b	3.39	55.4 bc	4.80	50.9 a	1.55	43.5 a	3.53
7. Nurelle D	83.3 d	4.66	72.0 de	2.82	68.7 cd	2.68	62.3 de	3.25
8. NeemAzal+Biofa	46.1 a	4.38	56.6 bc	4.24	58.7 b	0.42	61.1 de	4.10
9. Pyrethrum+Biofa	79.7 cd	4.66	75.0 e	2.82	64.3 c	1.27	56.1 cd	3.53
10. NeemAzal+Polyversum	44.4 a	6.22	48.7 ab	4.38	51.3 a	2.40	55.0 bcd	2.82
11. Pyrethrum+Polyversum	71.6 bc	1.97	64.8 cd	4.52	53.1 a	2.41	47.5 ab	3.53
12. Nurelle D+Flordimex	85.2 d	5.37	78.6 e	3.39	70.0 d	1.41	66.3 e	3.25
$LSD_{0.05}$	10.361		9.550		4.993		7.797	

Means in columns followed by the same letter are not significantly different (p>0.05)
1DAT – one day after treatment; 3DAT – three days after treatment; 5DAT – five days after treatment; 7DAT – seven days after treatment; Sd – standard deviation; E - efficacy

Table 5. Efficacy of insecticides applied individually and in combination with other products against *Acyrthosyphon pisum* (at budding and flowering stages), 2013

Variant	1 DAT		3 DAT		5 DAT		7 DAT	
	E, %	Sd	E, %	Sd	E, %	Sd	E, %	Sd
5. NeemAzal	57.5 a	3.25	61.5 a	2.69	63.2 a	3.11	67.3 ab	3.81
6. Pyrethrum	83.1 b	2.69	72.2 bc	3.95	66.4 ab	2.54	61.5 a	3.53
7. Nurelle D	100.0 d	0.07	87.8 d	3.11	80.0 cd	2.82	81.6 de	2.62
8. NeemAzal+Biofa	62.7 a	3.25	68.9 abc	2.96	73.0 bc	2.98	80.4 de	3.39
9. Pyrethrum+Biofa	100.0 d	0.0	88.3 d	2.40	80.6 d	2.54	74.7 cd	3.25
10. NeemAzal+Polyversum	61.4 a	3.39	66.0 ab	4.24	66.6 ab	3.67	70.3 bc	2.40
11. Pyrethrum+Polyversum	89.5 c	2.68	75.1 c	5.51	64.0 a	2.80	62.2 a	2.54
12. Nurelle D+Flordimex	100.0 d	0.07	94.4 d	4.52	85.1 d	4.10	82.5 e	3.53
$LSD_{0.05}$	5.597		8.784		7.153		7.249	

Means in columns followed by the same letter are not significantly different (p>0.05)
1DAT – one day after treatment; 3DAT – three days after treatment; 5DAT – five days after treatment; 7DAT – seven days after treatment; Sd – standard deviation; E - efficacy

DISCUSSION

Source literature on comparative biological efficacy of Pyrethrum and NeemAzal, applied in combination with different organic products against *Acyrthosyphon pisum*, is scarce and the results presented in this study are therefore valuable for the plant protection science.

Botanical insecticides consist of mixtures of biologically active substances. They do not allow resistance evolution by pests and pathogens, and have minimal residual effects.

Pyrethrum and NeemAzal have different mechanisms of action and manifestation of toxicity. Initial effects of Pyrethrum include paralysis followed by death (Pavela, 2009). Other studies have shown „knock-down" effects of Pyrethrum too (Chanda et al., 2010). In our study it had a fast initial activity and long after-action. Unlike Pyrethrum, treatment with NeemAzal ceases the development of larvae, they become less mobile, stop eating and die within a few days (Mordue & Blackwell, 1993), which explains the later toxicity exhibited by that biological insecticide, primarily seven days after treatment. Schmutterer (1990) concluded that foliar spray application of most commercial neem formulations persisted for 5-7 days under field conditions. Our present findings support observations of a reduction in pest density after treatment with NeemAzal. Since biological products with the active substance azadirachtin are unstable under illumination, have rapid photo degradation under UV radiation, and are susceptible to low temperatures and rainfall (Schmutterer, 1990; Pavela, 2009), NeemAzal exhibited a lower efficacy than Pyrethrum in our study.

Our comparative analysis of individual application of these biological insecticides showed that Pyrethrum had a better protective effect. Pyrethrum applied at budding, and at budding and flowering stages resulted in a more substantial aphid density reduction of 6.3 and 16.3%, respectively, compared to NeemAzal. The mortality of pea aphids over the seven-day period was 6.9% (2011), 6.1% (2012) and 8.4% (2013) higher on the average than it was after treatment with NeemAzal.

Similar results had been reported by other authors about some harmful thrips and flies (Barry et al., 2005; Chanda et al., 2010).

Data from other similar studies in our country had also indicated a higher level of efficacy of Pyrethrum than NeemAzal against bean weevil adults under laboratory conditions (Yankova, 2010). In another study, Yankova and Todorova (2011) found the phytopesticides Piros and Pyrethrum to demonstrate high effectiveness against peach leaf aphid up to five days after treatment, while the efficacy of NeemAzal was significantly lower. However, NeemAzal showed a very good effectiveness in the study against cotton bollworms that reached 77% seven days after treatment.

Andreev et al. (2012) found in a study that there were differences in susceptibility between rosy apple aphids (*Dysaphis plantaginea* Pass.) and spiraea aphids (*Aphis spiraecola* Patch.) in relation to these insecticides. The authors reported that NeemAzal and Pyrethrum were ineffective against spiraea aphids, while Pyrethrum showed flash action and resulted in a better control than NeemAzal and other botanical insecticides tested against rosy apple aphids as its efficacy was 100% on the first day after treatment. The action of NeemAzal was delayed and a good effect was reached three days after treatment.

Some authors have recommended that azadirachtin and Pyrethrum should be combined with plant oils in order to be more effective (Schulz et al., 1997; Liu et al., 2014).

In this study the combined application of NeemAzal and Pyrethrum with Biofa and Polyversum was found to increase the efficacy of insecticides, enhance natural resistance of plants to biotic stress and provide better protection against aphids. The combination of biological insecticides with organic products resulted in a more substantial reduction of aphid density than the insecticides achieved individually. The trend was significantly more pronounced after two treatments (at budding and flowering stages) as all differences in aphid numbers between the individual bioinsecticides and their combinations were statistically significant except for NeemAzal+Polyversum.

The protective action of these biological insecticides was significantly stronger in combination with Biofa, which contributed to better natural resistance of plants to aphids than Polyversum. It is important to note that the expressed synergism and increased biological efficacy of the biological insecticides in combination with the natural leaf fertilizer Biofa was due to an additional effect of its algal extract. It exhibited a strong protective effect on the foliage by forming a thin coating (microfilm). This coating contributed to a better hold of the insecticides on leaf surface and improved their effect. As a result of high contents of macro-and micronutrients, natural plant hormones, etc., Biofa enhanced the natural immune response of plants and contributed more to their better natural resistance against pests than Polyversum

(manufacturer's data). The positive synergism and good interaction between Pyrethrum and Biofa was stronger than that of NeemAzal and Biofa. Pyrethrum+Biofa was considerably more effective than the insecticide's individual treatment, i.e. 14.5% (2011), 15.4% (2012) and 15.1% (2013) on the average, while the efficacy of NeemAzal+Biofa was increased by the average 8.3 and 8.4% compared to individual treatment. The combined use of biological insecticides and Polyversum increased their efficacy slightly.

In the group of biological insecticides Pyrethrum combined with Biofa showed the highest efficacy and reduction in aphid density, followed by Pyrethrum+ Polyversum and NeemAzal+Biofa.

The efficacy of the biological insecticides (applied individually and in combinations) during the reported period was significantly lower than that of the standard Nurelle D (applied individually and in combination with Flordimex), except the combination of Pyrethrum with Biofa, whose efficacy was close to that of the synthetic insecticide.

CONCLUSION

The protective effects of Pyrethrum and NeemAzal were stronger in combinations with other organic products and *A. pisum* numbers were considerably lower than they were after the application of individual bioinsecticides. The interaction of Pyrethrum with Biofa was the most efficient variant among all biological products tested, reaching a reduction in aphid density of 48.2% after two treatments, and it was followed by Pyrethrum+Polyversum (42.5%).

The highest efficacy and synergism were demonstrated by the combined application of Pyrethrum and Biofa, whose efficacy was close to that of the synthetic insecticide.

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Uticaj bioloških insekticida NeemAzal T/S i Pyrethrum FS EC i njihova interakcija sa organskim proizvodima u tretmanima *Acyrthosiphon pisum* (Harris) (Hemiptera:Aphididae) na *Pisum sativum* (L.)

REZIME

Upoređivana je efikasnost i interakcija bioloških insekticida NeemAzal T/S i Pyrethrum FS EC u suzbijanju *Acyrthosyphon pisum* u organskoj proizvodnji *Pisum sativum* tokom tri godine. Insekticidi su primenjeni pojedinačno i u kombinaciji sa Polyversum (biološki regulator rasta i fungicid) i Biofa (organsko folijarno đubrivo). Nurelle D (sintetički insekticid) primenjen je kao standard pojedinačno i u kombinaciji sa Flordimex 420 (sintetički regulator rasta). Prskanje je sprovedeno jednom (u fazi pupoljka) i dva puta (u fazama pupoljka i cvetanja). Ispitane su 24 varijante. Najefikasnija varijanta među organskim proizvodima bila je interakcija Pyrethrum+Biofa, gde je smanjenje gustine vašiju dostiglo 48.2% u dvokratnom prskanju, dok je sledeća bila Pyrethrum+Polyversum (42.5 %). Najveću efikasnost i sinergizam pokazala je kombinacija Pyrethrum+Biofa, čija je efikasnost bila bliska insekticidu Nurelle D.

Ključne reči: Stočni grašak; Acyrthosiphon; biopesticidi; insekticidi