Efficacy of non-chemical insecticides against *Hyalopterus pruni* (Hemiptera: Aphididae) on plum

Pavlin Vasilev[1], Radoslav Andreev[1], Nedyalka Palagacheva[1], Hristina Kutinkova[2], Desislava Stefanova[2]

ABSTRACT

The aim of the study was to establish the efficacy of nonchemical insecticides, from different groups, for control of *Hyalopterus pruni* on plum. The experiments were conducted under laboratory conditions. Three botanical insecticides with active ingredients pyrethrum (Pyretrum FS EC - 0.025%,0.05%,0.1%), nicotine (NicoTab - 1:1; 1:2; 1:3 with water) and azadirachtin (NeemAzal T/S – 0.1%; 0.3%; and 0.5%) were used, as well as two microbial products based on *Beauveria bassiana* (Naturalis^R - 2.3 x 10^7 spores/mL) and *Paecilomyces fumosoroseus* (PreFeRal WG - 2 x 10 9 CFU/g) in concentration 1%, 2%, 3%. All insecticides are registered in Bulgaria for other pest's control, except for NicoTab, which is in an ongoing registration process. Experiments have shown that microbial insecticides, based on *B. bassiana* (Naturalis^R) and *P. fumosoroseus* (PreFeRal WG) in concentration 2% and 3%, as well as botanical insecticides with active ingredients pyrethrum (Pyretrum FS EC in concentration 0.05% and 0.1%) and nicotine (NicoTab in a ratio of 1:1 and 1:2 with water) have high efficacy against *H. pruni*. They are suitable for pest control in organic orchards. The insecticides based on azadirachtin has low efficacy and are not suitable for control of this aphid.

Keywords: Plum aphid, Biological control, Botanical insecticides, Microbial insecticides, *Hyalopterus pruni.*

MS History: 09.09.2019 (Received)- 17.09.2019 (Revised)- 18.10.2019 (Accepted).

Citation: Pavlin Vasilev, Radoslav Andreev, Nedyalka Palagacheva, Hristina Kutinkova, Desislava Stefanova. 2019. Efficacy of non-chemical insecticides against *Hyalopterus pruni* (Hemiptera: Aphididae) on plum. *Journal of Biopesticides,* **12**(2): 157-163.

INTRODUCTION

Plum orchards take second place in Bulgaria, after the cherries, with an area of over 6700 ha. The number of organic orchards has also increased significantly. Plum is attacked by a number of pests and requires a well-organized system of measures for the protection of fruits, foliage and wood. The most economically important pests are: red plum maggot, plum sawfly, European fruit lecanium and some aphids (Lecheva *et al.*, 2006). Seven aphid species on plum in Bulgaria have been described in previous studies (Grigorov, 1980; Grigorov *et al.*, 2004). Until now it has been assumed that the most dangerous pests are: plum–thistle aphid *Brachycaudus cardui* (L.), mealy peach aphid *Hyalopterus amygdali* (Blanchard) and mealy plum aphid *Hyalopterus pruni* (Geoffroy) (Lecheva *et al*., 2006). *H. pruni* was found to be the most distributed aphid on plums in Central Southern Bulgaria (Vasilev and Andreev, 2013), but the significance of the other species must be assessed too. *Hyalopterus pruni* is a holocyclic facultative migratory species. The main hosts are *Prunus domestica*, *P. instititia, P. cerasifera* and *P. spinosa* (Grigorov, 1980; Grigorov *et al.*, 2006; CABI, 2018; HYPPZ, 2018). Secondary hosts of the species are: *Phragmites communis Calamagrostis, Elymus* and *Arundo donax* (Nevskii, 1929; Bodenheimer and Swirski, 1957; Blackman and Eastop, 2004; CABI, 2018; HYPPZ, 2018). The pest damages shoots during almost the entire growing season, significantly slowing their growth. Chemical insecticides are mainly used to control the aphids in Bulgaria – neonicotinoids, organophosphates and pyrethroids (Lecheva *et al*., 2006). The aim of this study is to establish the efficacy of nonchemical insecticides, from different groups, for effective control of mealy plum aphid.

MATERIALS AND METHODS

The experiments were conducted in a laboratory. Three botanical insecticides were used, with active ingredients pyrethrum (Pyretrum FS EC), nicotine (NikoTab) and azadirachtin (Neem Azal T/S), as well as two microbial products based on *Beauveria bassiana* (Naturalis[R]) and *Paecilomyces fumosoroseus* (PreFeRal WG) (Table 1). All insecticides are registered in Bulgaria (BFSA, 2018) for other pests, except for NicoTab, which is to be registered.

Table 1. Used test products for control of *Hyalopterus pruni* under laboratory conditions

Active ingredients	Trade name	Concentrations
Microbial insecticides		
Blastospores and mycelium of the fungus *Paecilomyces fumosoroseus,* strain Апорка 97; 2 x 10 9 CFU/g (CFU = Colony Forming Units)	PreFeRal WG	0.1%; 0.2%; 0.3%
Beauveria bassiana, strain ATCC 74040; 2.3 x 10^7 spores/ml	Naturalis[R]	0.1%; 0.2%; 0.3%
botanical insecticides		
1 % azadirachtin A+0,5% azadirachtin B, V, G, D + 2,5% neem tree substances – extracts from *Azadirachta indica*	NeemAzal T/S	0.1%; 0.3%; 0.5%
32 % pyrethrum (*Tanacetum/ Chrysanthemum cinerariifolium*) extract + 32 % sesame oil +36 % adhesives - soft potassium soaps	Pyretrum FS EC	0.025%; 0.05%; 0.1%
extract from *Nicotiana tabacum*	NikoTab	1:1; 1:2; 1:3

Table 2. Efficacy of Preferal WG (*Paecilomyces fumosoroseus*) against *Hyalopterus pruni*

concen-trations	1 day after treatment			3 days after treatment			5 days after treatment			7 days after treatment		
	mean ± m	Std. dev.	P	mean ± m	Std. dev.	P	mean ± m	Std. dev.	P	Mean ± m	Std. dev.	P
0.1%	5.46 ±1.17	2.49	0.010	27.74 ±2.58	5.79	0.0	55.94 ±1.76	3.82	0.00 0	90.44±0.90	1.84	0.000
0.2%	13.8 ±2.26	5.06	0.004	51.12 ±3.70	8.27	0.0	77.43 ±4.12	10.26	0.00 0	94.22±1.05	2.34	0.000
0.3%	16.48 ±3.17	7.09	0.007	62.20 ±7.31	16.43	0.0	83.68 ±3.15	7.04	0.00 0	95.88±1.52	3.41	0.000

RESULTS AND DISCUSSIONS

Both microbial insecticides had a delayed initial effect and high aphid mortality rate was observed after 3 days (Table 2 and 4). PreFeRal WG (*Paecilomyces fumosoroseus*) showed good results but even at higher concentrations (0.3%) the efficacy did not reach 100% (Table 2). However, on the seventh day, the efficacy was high enough (over 90%) so that this insecticide can be recommended for use in *H. pruni* control programs. In mathematical data processing, regression equations are derived. They determine the change in efficacy (Z) depending on concentration (Y) and number of days after treatment (X). They allow us to calculate the necessary concentration to achieve maximum effect after a certain number of days. The model for PreFeRal is adequate to the experimental data (P <0.0000) and can be used to optimize and predict its efficacy against this pest (Table 3). It is clear that with increasing concentration and number of days, the effectiveness of the preparation increases as well (Figure 1). For the first 3-4 days, the results are relatively poor but after 5 days the efficacy increases significantly. The conclusions are similar for the models seen with Pyretrum FS EC (Figure 3) and NeemAzal T/S (figure 5). Naturalis[R] showed the best results among the tested insecticides (Table 4). At a concentration of 0.3% and 0.2% on the third day the efficacy exceeds

95%, and on the fifth day exceeds 99%. The insecticide was very effective at its lowest concentration (0.1%) - efficacy over 90% on the third and 99.14% on the seventh day. The established efficacy values of the insecticide Naturalis^R at different concentrations are very similar. Therefore, the dependency in the calculated regression model expresses only the relationship between efficacy and the number of days after treatment (Figure 2).The model is adequate to the experimental data (*P* <0.0000) and can be used to optimize treatments for *H. pruni* (Table 5).

Table 3.Regression summary for dependent variable for efficacy of PreFeRal against H.pruni

R=0,98610964; Adjusted R^2=0,97078941; F(2,34)=599,21; p<0,0000; Std.Error of estimate: 11,105						
	Beta	**Std.Err.**	**B**	**Std.Err.**	**t(34)**	**p-level**
X	0,875265	0,040608	12,4099	0,57575	21,55416	0,000000
Y*Y	0,147854	0,040608	168,0818	46,16307	3,64104	0,000894

Fig. 1. Functional dependency of efficacy (Z) on concentration (Y) and number of days after treatment (X) in the experiment with the bioinsecticide PreFeRal (*Paecilomyces fumosoroseus*) against *H. pruni*

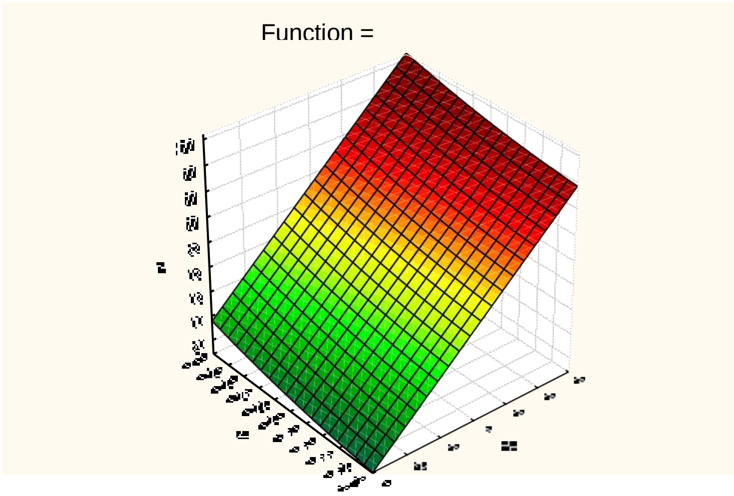


Table 4. Efficacy of naturalis^R (*Beauveria bassiana*) against *H. pruni*

	1 day after treatment			**3 days after treatment**			**5 days after treatment**			**7 days after treatment**		
concen-trations	mean ± m	Std. dev.	P	mean ± m	Std. dev.	P	mean ± m	Std. dev.	P	mean ± m	Std. dev.	P
0.1%	8.20 ±2.71	6.06	0.039	92.94 ±1.96	2.59	0.000	97.2 ±0.86	1.92	0.000	99.14 ±0.64	1.43	0.000
0.2%	8.74 ±1.34	3.00	0.003	95.36 ±0.30	0.86	0.000	99.56 ±0.27	0.61	0.000	99.80 ±0.20	0.45	0.000
0.3%	14.78 ±2.34	5.23	0.003	96.84 ±1.02	2.27	0.000	99.34 ±0.45	1.01	0.000	100	0.00	0.000

Table 5. Regression summary for dependent variable for efficacy of naturalis^R against *H. pruni*

R= 0, 98588004; Adjusted R^2= 0, 97031001; F(2,33)= 589,27; *P*<0,0000; Std.Error of estimate14.648						
	Beta	**Std.Err.**	**B**	**Std.Err.**	**t(33)**	**p-level**
X	3,26239	0,198968	35,2550	3,396754	16,3965	0,00000
X*X	-2,52728	0,198968	-3,0432	0,414362	-12,7019	0,00000

Among the insecticides based on plant extracts the best performer was Pyrethrum. At a concentration of 0.1% even on the 3rd day, the efficiency reached 99% and 100% on the fifth day. At 0.05% efficiency was also high and on the 7th day reached 98.42%. The effect of this insecticide at a concentration of 0.025% was significantly lowers (Table 6). The regression model for Pyretrum FS EC is adequate to the experimental data (Table 7) and shows what exactly is the change in efficiency depending on the concentration and the days after Treatment (fig.3). Excellent results were also found with nicotine-based insecticide NikoTab. At a dilution of 1:1 and 1:2 with water efficacy of third day was respectively 98.26% and 97.66%, and on the 7th day - 100% and 99.80%. Less was the efficacy at a ratio of 1:3 with water (tab. 8)

Fig 2. Functional dependency of efficacy (Y) on number of days after treatment (X) in the experiment with the bioinsecticide Naturalis[R] (*Beauveria bassiana*) against *H.pruni*

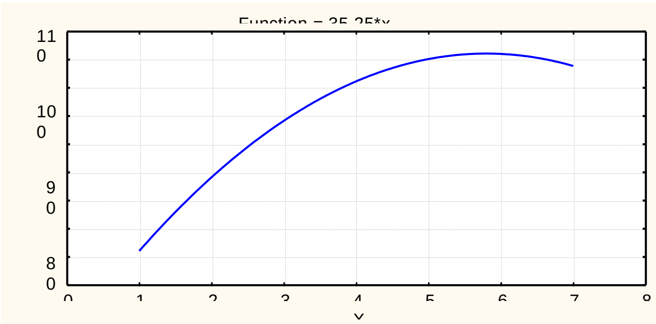


Table 6. Efficacy of Pyretrum FS EC (pyrethrum) against *H.pruni*

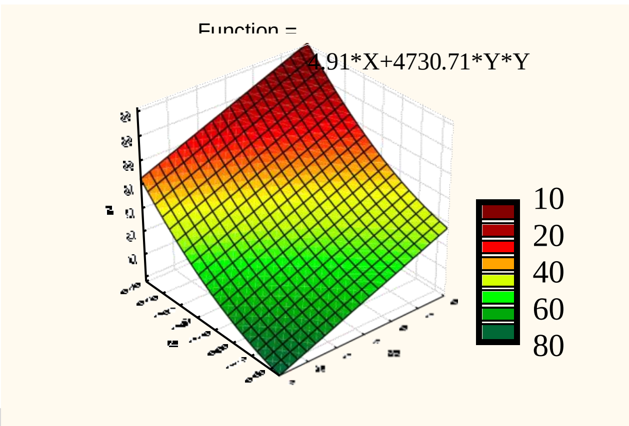
	1 day after treatment			3 days after treatment			5 days after treatment			7 days after treatment		
concen-trations	mean ± m	Std. dev.	P	mean ± m	Std. dev.	P	mean ± m	Std. dev.	P	mean ± m	Std. dev.	P
0.1%	73.26 ±2.75	6.15	0.000	99.18 ±0.50	1.12	0.000	99.38 ±0.41	0.93	0.000	100	0.00	0.000
0.05%	67.2 ±5.19	11.61	0.000	90.18 ±4.59	10.27	0.000	93.6 ±3.21	7.18	0.000	98.42 ±1.34	3.00	0.000
0.025%	32.48 ±7.98	17.73	0.015	59.78 ±8.00	17.89	0.002	65.46 ±7.24	16.19	0.001	77.3 ±5.63	12.59	0.000

Table 7. Regression summary for dependent variable for efficacy of pyretrum FS EC against *H.pruni*

R= 0,94886260; Adjusted R^2= 0,89447790; F(2,34)=153,58; p<0,00000 ; Std.Error of estimate: 15,743

	Beta	Std.Err.	B	Std.Err.	t(34)	p-level
X	0,464240	0,070500	4,910	0,7456	6,584969	0,000000
Y*Y	0,581989	0,070500	4730,711	573,0608	8,255164	0,000000

Figure 3. Functional dependence of efficacy (Z) on concentration (Y) and number of days after treatment (X) in the experiment with the bioinsecticide Pyretrum FS EC (pyrethrum) against *H.pruni*



The calculated model is adequate to the experimental data (tab. 9) and can be used to optimize treatments for *H.pruni*, but the established efficacy values at different concentrations are very similar (as with the insecticide Naturalis[R]) and the dependence expresses only the relationship between efficacy and the number of days after treatment(fig.4).

Table 8. Efficacy of nikoTab (extract from *Nicotiana tabacum*) against *H.pruni*

	1 day after treatment			3 day after treatment			5 day after treatment			7 day after treatment		
Ratio with water	**mean ± m**	**Std. dev.**	**P**	**mean ± m**	**Std. dev.**	**P**	**mean ± m**	**Std. dev.**	**P**	**mean ± m**	**Std. dev.**	**P**
1:1	47.00 ±4.47	9.99	.000	98.26 ±0.92	2.06	0.000	99.38 ±0.42	0.93	0.000	100	0.00	0.000
1:2	39.48 ±7.35	16.43	.006	97.66 ±1.12	2.51	0.000	99.40 ±0.40	0.89	0.000	99.80 ±0.20	0.45	0.000
1:3	28.74 ±3.98	8.78	.002	78.8 ±11.03	29.66	0.002	81.5 ±10.37	23.19	0.001	84.52 ±9.74	21.78	0.001

Figure 4. Functional dependence of efficacy (Y) on number of days after treatment (X) in the experiment with the bioinsecticide nikoTab (extract from *Nicotiana tabacum*) against *H.pruni*

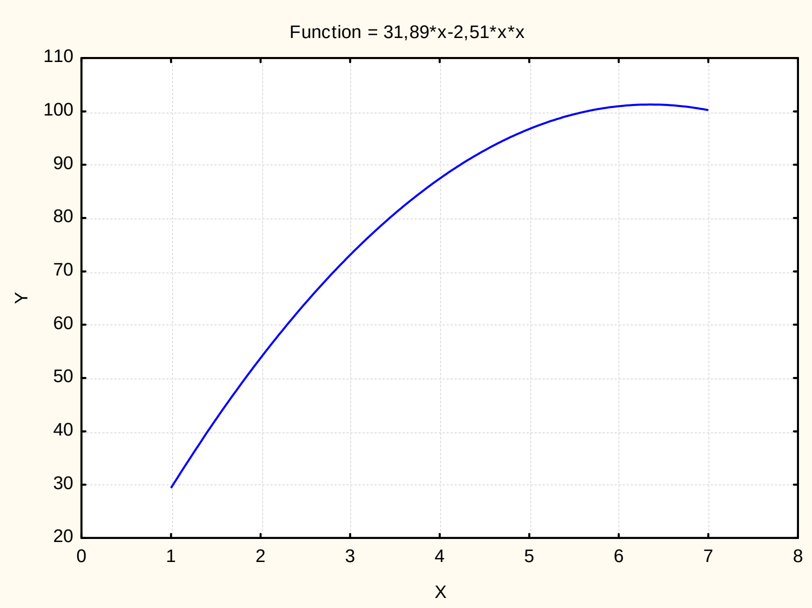


Table 9. Regression summary for dependent variable for efficacy of nikoTab against *H.pruni*

R=0,95961048; Adjusted R^2= 0,91619652; F(2,34)=197,79; *p*<0,0000; Std.Error of estimate: 23,872						
	Beta	**Std.Err.**	**B**	**Std.Err.**	**t(34)**	**p-level**
X	2,16102	0,200912	31,88661	3,615317	10,75607	0,000000
X*X	-1,29061	0,200912	-2,51098	0,594354	-6,42375	0,000000

Table 10. Efficacy of neemAzal T/S (azadirachtin) against *H.pruni*

	1 day after treatment			3 days after treatment			5 days after treatment			7 days after treatment		
concen-trations	mean ± m	Std. dev.	P	mean ± m	Std. dev.	P	mean ± m	Std. dev.	P	mean ± m	Std. dev.	P
0.5%	36.18 ±4.30	9.61	0.001	72.66 ±8.57	19.17	0.001	75.22 ±8.31	18.61	0.001	84.36 ±3.03	6.78	0.000
0.3%	20.30 ±7.53	16.83	0.054	26.98 ±8.23	18.40	0.031	32.18 ±7.14	15.97	0.011	53.46 ±4.58	10.25	0.000

0.1%	4.33 ±1.39	3.11	0.020	19.74 ±2.14	4.78	0.001	22.16 ±2.29	5.12	0.001	32.20 ±2.68	5.99	0.000

Figure 5. Functional dependence of efficacy (Z) on concentration (Y) and number of days after treatment (X) in the experiment with the bioinsecticide neemAzal T/S (azadirachtin) against *H.pruni*

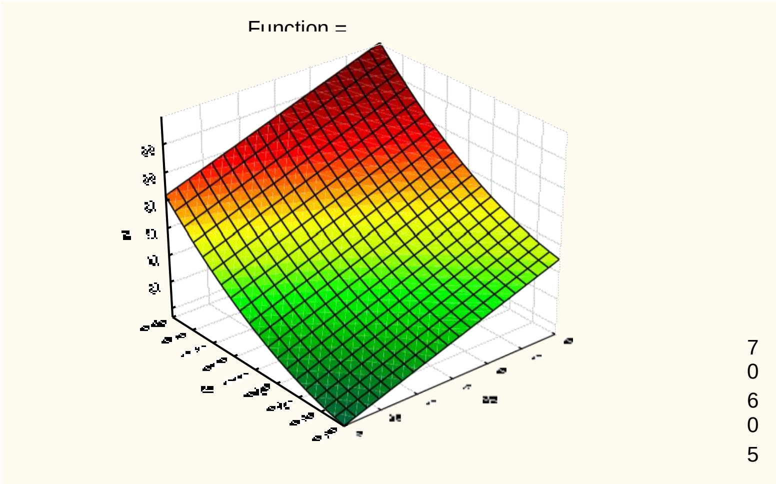


Table 11. Regression summary for dependent variable for efficacy of neemazal T/S against *H.pruni*

R= 0,94771767; Adjusted R^2= 0,89217871; F(2,34)=149,94; p<0,00000; Std.Error of estimate: 15,913						
	Beta	**Std.Err.**	**B**	**Std.Err.**	**t(34)**	**p-level**
X	0,442968	0,073135	4,6846	0,77344	6,056870	0,000001
Y^2	0,594013	0,073135	187,5250	23,08806	8,122163	0,000000

Unsatisfactory were the results for the botanical insecticide Neem Azal T/S (azadirachtin) against *H. pruni*. At the highest concentration the efficacy did not exceed 85% on the 7th day after treatment. At 0.3% and 0.1% the efficacy was even worse (Table 10). The calculated model is adequate to the experimental data (Table 11). It shows that efficacy above 80% is difficult to achieve with this insecticide (Fig. 5).

Microbial insecticides based on *B. bassiana* (Naturalis^R) and *P. fumosoroseus* (Preferal WG) as well as botanical insecticides with active ingredients pyrethrum (Pyretrum FS EC) and nicotine (NikoTab), in a suitable concentration have high efficacy against *H. pruni* and are suitable for their control in organic orchards. The insecticides based on azadirachtin have low efficacy and are not suitable for controlling the aphids.

ACKNOWLEDGMENTS

This study is supported by the National Scientific Fund of Bulgaria from the Project No. 16/4, 2017 **"C**ompetition for financial support for research projects – 2017**".**

REFERENCES

BFSA (Bulgarian Food Safety Agency). 2012/2018. List of authorized for marketing and use of plant protection products. Videnov and son. Sofia. 1000 **PP**.

Blackman, R. and Eastop V. 2004. Aphids on the World's Herbaceous Plants and Shrubs. *Journal of Wiley and Sons*, Chichester, 1439 **PP**.

Bodenheimer, F. and Swirski, E. 1957. The aphidoidea of the midlle east. Jerusalim, 378 PP.

CABI. 2018. Crop Protection Compendium. Wallingford, UK: CAB International. Online: https://www.cabi.org/cpc/

Grigorov, S. 1980. Aphids and their control. Zemizdat. Sofia. 285 **PP**.

Grigorov, S., Tashev, D. and Grigorov, P. 2004. Aphids (*Aphidoidea*, *Homoptera*) in Bulgaria and their control. Academic press at Agrivultural University, Plovdiv. 423 **PP**.

Henderson, C. F. and Tilton, E. W. 1955. Tests with acaricides against the brow wheat mite, Journal of Economic Entomology. **48**: 157-161.

Hyppz. 2018. Encyclopédie des ravageurs européens. INRA Online: http://www7.inra.fr/hyppz/species.htm

Lecheva, I., P. Petrov, M. Nakova, M. Borovinova, N. Velcheva, S. Simova, E. Staneva, L. Ivanova, V. Taseva, St. Kalinova, P. Nikolov, M. Tsenova. 2006. Good plant protection practices in orchards with stone fruits. In book "Rules of good plant protection practices in agriculture": *National services of Plant Protection*, Sofia. 379-415.

Martin, J. H. 1983. The identification of common aphid pests of tropical agriculture. *Tropical Pest Management*. **29**: 395-411.

Mikhailova, P., Straka F. and Apostolov, I. 1982. Plant-protection prognosis and signalization, Zemizdat, Sofia. 342 **PP**.

Nevskii, V. 1929. Aphids of Middle Asia, UOSTAZR, 16, Tashkent, 1-417.

Vasilev, P. and Andreev, R. 2013. Aphids on plums in the region of Plovdiv. *Acta Entomologica Bulgarica*, 1-2, 23-30.

Pavlin Vasilev[1], Radoslav Andreev[1], Nedyalka Palagacheva[1], Hristina Kutinkova[2], Desislava Stefanova[2]

[1]Agricultural University, 12 Mendeleev Blvd., Plovdiv- 4000, Bulgaria.

[2]Fruit Growing Institute, 12 Ostromila Str., Plovdiv- 4004, Bulgaria.

***Communication author:**

palagacheva@abv.bg