SIPARUNTON
International Journal of
Interdisciplinary Research

ISSN 2337-0556 (Print)
ISSN 2337-0572 (Online)
Vol 1, Issue 5, October 2015

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Chemical protection of apple against leaf powdery mildew and sustainability to pathogen cultivars according to EU standards

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Abstract

The main goal of this research has been to investigate the efficiency of chemical preparations and their sustainability of apple cultivars against powdery mildew pathogen (Podosphaera leucotricha) .Three cultivars of apple (Jonathan, Idared and Vizajka-native cultivars) have been tested in experimental fields (in the municipality of Peja, Kosovo) during the two years of research (2013 - 2014) .Fungicides that are used were: Webeton (triadimefon), Rubigan (fenarimol), Karathan EC (dinocap) and Kossan WG (sulfur). During the vegetation has been made eight spraying, three spraying before the blossoming and five spraying after the blossoming, within a period of 10-15 days between spraying and sprinkling. After that, there have been done three evaluations of the disease and the results obtained have been processed according to Mc Kinney index. Through the processed results has been seen that higher efficiency of chemical preparations has been in the Webeton and Karathan combination EC (variant - B2) and in Rubigan and Karathan combination EC (variant - B1), during the two years of the research. Whereas, regarding the suitability of cultivars to pathogen, cultivar "Vizajka" (native cultivar) showed the highest sustainability against disease pathogen, where, the index in the first and

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second year of the research has been lower in all variants as well as to control compared to two other cultivars. While, the most sensitive cultivar against powdery mildew pathogen was Jonathan with the higher disease index compared with two other cultivars.

Key words: powdery mildew of apple, spraying efficiency, cultivars, fungicides, Mc Kinney index

1. Introduction

Kosovo has 2,024 hectares of cultivated terrestrial surface with apples. The apple as an orchard culture is affected by a large number of diseases, of which, the most important are: Kroma, powdery mildew of apple, bacterial burned, maturation, etc. The fungus that causes the apple powdery mildew (Podosphaera leucotricha) originates from North America, has been found found as early as 1871, afterwards, it has been widespread in Europe and on all other continents.This pathogen infects plants of the Rosaceae family, but the greatest damage is causedto apples. Except the apples, it also infects peaches, quince and almonds.

This pathogen appears to apple for every year with different intensity depending on the agro-climatic conditions that prevails during the certain years. The cause of apple powdery mildew generates even without the presence of moisture and touches apple cultivars which are grown in bright places and less humidity. The disease affects leaves, flowers, and fruit saplings of apples. On the leaves appear gray layer which represents the fungus bodies (mycelium with conidia), affected leaves grow very slowly, vibrates, when the infestation is high can also befaded away/die away. Whereas, in the infected fruits is formed the mold net as necrotic ring, consequently, fruits remain small and have less commercial value. The infected flowers are covered with a white layer of mycelium, pthen, take the brown color and remain sterile. While, in the infected seedlings buds and flowers are not formed.

A Dimeron mildew fungus appears in two forms: in the form of **mycelium** in the bud and as **kleistotec** in leaves and seedlings. Infections by this pathogen appear in April and May during the time of fresh and moist, but also are caused infections in high temperatures and dry weather. The optimum temperature for the development of pathogen is 20-22 º C with relative air humidity above 35%, in these conditions conidia can sprout very quickly.

2. Research Methodology

The study protection against apple powdery mildew and the investigation of sustainability of cultivars against pathogen has been conducted during two years (2013 and 2014). The subject of research has been three apple cultivars: Jonathan, Idared, and Vizajka (native cultivar).

The experiment has been located in the village Broliq - Municipality of Peja. For apple protection against mildew has been used these chemicals (fungicides) :, Rubigan (Fenarimol) at 0.04% concentration, Webeton (Triadimefon) at 0.1% concentration, Karathan EC (Dinocap) at a concentration of 0.12% and Kossan WG (Squlfur) at 0.3% concentration. These chemicals are used in six variants, such as:

1.Rubigan + Karathan, exchangeable/convertable application
2.Webeton + Karathan, exchangeable application
3.Webeton + Kossan WG, exchangeable application
4.Kubigan + Kossan WG, exchangeable application,
5.Karathan + Kossan WG, exchangeable application
6.Kossan WG
7. Examination/Control

For spraying has been used the motor pump with tank of 10 liters, while in vegetation have been eight spraying in total (three spraying have been done before blooming and five spraying after blooming) within 10-15 days between each spraying.

The experiment has been established under the block system so called the case method. Each variant has been set at five apple bodies and has been aplied twice (repeated twice).The evaluation of the disease has been done three times in the leaves of apple (first evaluation was done after three spraying, respectively, before fourth spraying, while second evaluation after the sixth or spray before starting the seventh and third evaluation was done after the last spray).

These estimates are made by check - rate of 100 leaves for each variant. The class of assessment that is used has been of five classes (class O no- infection, class1 to 10% poor infection, class 2 with 11-20% average infection, class 3 to 21-50% with high infection and class 4 over 50% too high infection), the bibliographic sources (Josifović 1956 Ruçi 2004) .The details of these observations are processed for each variant according to Mc Kinney index (Index Mc) . The formula for determining the percentage of infection by Mc Kinney index is:

$$I = \frac{\sum (n \times k)}{N \times K} \cdot 100$$

I - the index of the disease, n - the number of assessments for each class, k - the

value of the particular classes;
N - number of all assessed classes, K - value of the highest class.

3. Findings and Discussion

3.1. Results (findings) for year 2013

From the results obtained during the evaluation of disease has been seen that the seven variants used to resist and combat powdery mildew on leaves in Jonathan variety to variant B2 (10.90%) the average percentage of the disease was lower in the case of using Webeton and Karathan EC, hence, these chemicals have showed very high efficiency against the disease. Afterwards, for the efficacy, after combining Rubigan has been ranked B2 variants and Karathan EC with the average percentage of infection in variant B1 (13.70%). Whereas, less efficient has shown combinations in vaiant B3 (16.18%), which have been used Webeton and Kossan WG. In variant B4 (20.30%) have been used Rubigan and Kossan WG, in variant B5 (21.88%) Karathan EC and WG Kossan, and in variant B6 (23, 24%) has been used only Kossan WG. While, in examination the average percentage of infection has been B7 (46.23%).

Regarding cultivar Idared, the higher efficacy against the disease has been B2 variant to an average desease percentage, B2 (7:03%), and the combination Webeton and Karathan EC has been used in that variant. Also, the combination Rubigan and Karathan EC has shown high efficiency in version B1 (9.58%). Whereas, Less effective were the combinations shown in version B3 (12.70%) which were used Webeton and Kossan WG, after that, the variant B4 (15.33%) used Rubigan and Kossan WG, B5 variant (17 , 58%) used Karathan and Kossan WG and B6 variant (19.85%) which used only Kossani WG. While, in examination the average percentage of infection has been B7 (30.40%).

In the case of cultivar Vizajka, the average percentage of infection was lower in variant B2 (3.27%), in which was used the combination of Karathan EC Webeton and therefore, this combination has shown very high efficiency against powdery mildew. Besides that, high efficiency has also shown the combination of Rubigan and Karathan EC in variant B1 (5.16%).

Also, the combination of Kossan WG Webeton in variant B3 (6.40%) has shown good efficiency. While, less effective in fighting pathogen has been the combination Rubigan and Kossan WG in variant B4 (7.80%), variant B5 (9.69%) the combination of Karathan EC and WG Kossan and B6 variant (11.50%) that used only Kossan WG . While, in examination the average percentage of infection has been B7 (17.46%).

Chart.1 The chart below shows the demonstration of the infection percentage of

powdery mildew on apple leaves during 2013

Cultivar Fak.(A)	Chemicals Fak.(B)	Evaluation of disease Fak.(C)			-
		C_1	C_2	C_3	X
Jonathan	B_1	12,00	15,60	13,50	13,70
	B_2	9,30	12,90	10,50	10,90
	B_3	14,25	18,00	16,30	16,18
	B_4	19,00	21,90	20,00	20,30
	B_5	20,90	23,25	21,50	21,88
	B_6	22,00	24,90	22,90	23,26
	B_7	31,20	42,20	65,30	46,23
Idared	B_1	9,00	11,25	8,50	9,58
	B_2	6,20	8,00	6,90	7,03
	B_3	10,22	14,90	13,00	12,70
	B_4	13,90	17,30	14,80	15,33
	B_5	16,25	19,20	17,30	17,58
	B_6	18,20	21,55	19,80	19,85
	B_7	26,20	31,00	34,00	30,40
Vizajka	B_1	4,28	6,20	5,00	5,16
	B_2	2,30	4,53	3,00	3,27
	B_3	4,95	8,00	6,25	6,40
	B_4	6,20	9,90	7,30	7,80
	B_5	9,00	10,90	10,00	9,96
	B_6	10,80	12,20	11,50	11,50
	B_7	14,5	17,00	20,90	17,46

3. 3. Results and Findings for year 2014

From the results obtained in the second year of research to resist and combat powdery mildew on leaves to Jonathan cultivar, to variant B2 (13.23%), the average percentage of the disease was lower, where has been used Webeton and Karathan EC combination, these chemicals have showed a very high efficiency against powdery mildew. After variant B2, for the efficiency of resisting and combating the pathogen is ranked the combination of Rubigan and Karathan EC with the average percentage of infection in variant B1 (15.80%). Whereas, less efficient have been shown the combinations in variant B3 (19.66%) where have been used Webeton and Kossan WG, pafterwards, variant B4 (23.10%) with the comination of Rubigan and Kossan WG, and variant B5 (15.30%) the comination of WG Kossan EC and Karathan, variant B6 (26.20%) that has been used only Kossan WG. Thus, the average percentage of infection in examination or control has been B7 (51.85%).

Furthermore, to Idared cultivar, the highest efficiency against the pathogen has been in variant B2 (9.96%) where, it has been used the combination of Webeton and Karathan EC. Good efficiency has also shown the combination of Karathan and Rubigan EC in version B1 (13.70%). Less effective have been shown the combinations in variant B3 (15.45%) where, it used Webeton and Kossan WG, subsequently, the variant B4 (18.00%) that has been used Rubigan and Kossan WG, variant B5 (20.46%) with Karathan EC and WG Kossan and B6 variant (22.60) which was used only Kossan WG. Consequently, the average percentage of infection in control has been B7 (35.03%).

But to cultivar Vizajka the average percentage of infection was lower in variant B2 (5.23%) the combination Karathan EC Webeton and therefore, this combination has shown very high efficiency against apple powdery mildew. High efficiency has also shown the combination of Rubigan and Karathan EC in variant B1 (8.66%). Less effective in protecting apple against powedery mildew pathogen have shown the combinations Webeton and Kossan WG in variant B3 (11.00%), then, variant B4 (14.13 %) with the combination of Rubigan and Kossan WG, B5 variant (15.03%) with Karathan EC and WG Kossan and B6 variant (16.53%) that was used only Kossan WG. As a result, the average percentage of infection has been B7 (20.41%).

Chart. 2 The chart below shows the demonstration of the infection percentage of powdery mildew on apple leaves during 2014

Cultivar Fak.(A)	Chemicals Fak.(B)	The evaluation of the disease Fak.(C)			-
		C_1	C_2	C_3	X
Jonathan	B_1	14,30	18,20	14,90	15,80
	B_2	11,55	15,30	12,90	13,23
	B_3	17,20	22,30	19,50	19,66
	B_4	21,90	25,20	22,20	23,10
	B_5	23,80	27,20	24,90	25,30
	B_6	24,50	28,10	26,00	26,20
	B_7	38,30	48,25	69,00	51,58
Idared	B_1	12,00	15,20	13,90	13,70
	B_2	8,90	11,80	9,20	9,96
	B_3	13,90	17,80	14,90	15,40
	B_4	16,20	19,90	17,90	18,00
	B_5	19,00	23,20	19,00	20,46
	B_6	20,90	25,00	22,10	22,66

	B_7	29,90	35,20	40,00	35,03
	B_1	7,20	11,30	7,50	8,66
	B_2	4,00	6,80	4,90	5,23
Vizajka	B_3	9,80	13,20	10,00	11,00
	B_4	12,20	17,30	12,90	14,13
	B_5	13,20	17,90	14,00	15,03
	B_6	14,90	19,20	15,50	16,53
	B_7	17,25	20,00	24,00	20,41

3.3. Discussion of the Results

From the results obtained during the two years of research is obvious that the most effective preparations to combat the leaf powedery mildew of apple (to the three cultivars) have been: Webeton in combination with Karathan EC (B2 variants) and preparation Rubigan in combination with Karathan EC (variant B1). Respectively, Webeton in combination with WG Kossan and Kossan in combination with Rubigan WG (B4 variants) have shown average efficacy in combating the pathogen. Whereas, Karathan EC in combination with Kossanin WG (variants B5) and variants B6 where, it has been used only Kossan WG gave less efficient results in the protection of apples from powdery mildew pathogen.

While regarding the cultivars investigated during two years of study, the cultivar "Vizajka" has showed the highest sustainability againt the apple powdery mildew (which is evidenced by the lowest rate of infection) to all variants including variant B7 compared to the cultivars Idared and Jonathan. The cultivar "Jonathan" has shown lower sustainability (with the highest percentage of infection) to all variants including the variant B7.

Author **Butt** states that the infection of apple by conidia during the summer in England could be caused even under the presence of humidity. During our research as well, the infection has been present ceaselessly even if there was moisture, especially, in the second year of research.

According to the researcher **Ciglar**, the protection against apple powdery mildew is made with the use of these chemical preparations: Bayleton, Rubigan and Sulfur. This complies with our research because we have used such preparations for the protection of apple against powdery mildew pathogen.

Moreover, **Gupta and Sharma** have used fungicides to control the powdery mildew in apples: hexaconazol (0.05%), miclobutanil (0.05%) and fluquiconazol (0.03%) which fungicides have reached to control/examine the disease 100%. Even in our research the fungicides used: triadimefon in combination with dinocap and fenarimol in combination with dinocap have reached to control the disease 90-95%.

According to **Josifović** the rate of the disease evaluation is done by dividing the assessment of infection in five categories, in our research, it has been made approximately the same estimate with some minor changes (Josifović Ruçi 1956 & 2004).

Another researcher, **Kišpatic** states that systemic fungicides enter and remain for a certain time in the vegetation, which can be converted in new connections, respectively, can change the plant metabolism and could be eventually toxic. Therefore, in the program of apple protection against powdery mildew have not been used only systemic fungicides but there have been combined using the organic and contact ones.

The same author notes that more powdery mildew occurs during the warm weather and the lack of rain. This provided the same consistent as our research, where, over the past two years the index of the disease has been higher during the second and third evaluation and, in comparison with the evaluation of the first where the disease index was lower.

Marine, spraying with sulfur preparations do not have a good effect in protecting apple against the pathogen. The data of this study complies with our research , where, Kossan WG (Sulfur) did not give proper efficiency against powdery mildew pathogen to the cultivars Jonathan and Idared.

In addition, **Susuri** states that for apple protection against powdery mildew should have been done three spraying before blooming and three spraying after it, and this can be done using fungicides such as: triadimefon, fenarimol and pirazofos. In this study have been used approximately the same preparations (triadimefon, fenarimol, dinocap and sulfur), while during the vegetation we have done three spraying before blooming and five spraying after it, because the pathogen infects apple even at high temperatures and less moisture/humidity.

According to **Wurms**, the treatment of apple leaves against powdery mildew using anhydrous milk fat and soybean oil has lower leaf infection in 12% compared to plants that have not been sprayed. Our research approximately compiles with these results, where the infection was lowest in B2 variant (the first year of research B2-10, 90% the second year B2-13,23%) to Jonathan cultivar where we used the combination of Webeton and Karathan EC.

4. Conclusions and recommendations

From the research done on the basis of the results obtained through the evaluations that are made during the survey (2013 and 2014) can beconcluded that:

* Cultivar Vizajka owns a lower vulnerability against leaf powdery mildew;

therefore, it is resistant against the pathogen compared to the cultivars Jonathan and Idared.

* Cultivar Idared has average vulnerability against leaf powdery mildew, while cultivar Jonathan has high vulnerablility to the pathogen.
* To combat the powdery mildew in apple leaves (to cultivars that are explored) high efficiency combination preparations showed Karathan EC Webeton and during two years of research where the disease index was very low (B2 variants).
* Also high efficiency against apple powdery mildew on the leaves has shown the combination of the preparations Rubigan and Karathan EC (B1variant)
* Less effective in fighting pathogen combination preparations have shown Karathan EC and Kossan WG (to variants B5) and variants B6 which has been used only Kossan WG preparation.
* Hence, the most successful variants are shown the variants where has been used the systemic and organic preparation –such as variants B2 and B1, while less successful have been shown such variants where have been used in combination an organic preparation and a contact -variants B5 and variants B6 that was used only sulfur.

Based on the conclusions made above on can be given these recommendations:

***** The green mass to be maintained under control during vegetative season with regular spraying and appropriate pruning.
* For regular protection against leaf powdersy mildew, to be used systemic preparations but in combination with organic ones in order not to appear sub-species that are resistant to the pathogen.
* To be careful during composting with mineral fertilizer (especially nitrogen fertilizers) in the cases of high doses of these fertilizers apple cultivars are more sensitive against the pathogen.
* With the establishment of new apple orchards to be chosen cultivars which are more resistant against the pathogen.

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