

Chemical Protection of Potato Late Blight and Resistance of Varieties Toward Pathogen

Ismajl Cacaj^a, Bakir Kelmendi^a, Nexhdet Shala^a, Defrime Berisha^a, Burim Rexhaj^a and Bekri Xhemali^b

^aDepartment of Crop Production, Faculty of Agribusiness, University “Haxhi Zeka”, Pejë, Kosovo

^bLaboratory of Plant Protection, Kosovo Institute of Agriculture – KIA, Pejë, Kosovo

Corresponding author: Ismajl Cacaj

Abstract

The aim of this two years study was the research of efficiency in plant protection products and resistance of potato varieties against late blight (*Phytophthora infestans*). Three potato varieties (Rudolph, Zafira and Arnova) have been tested in experimental fields of Kosovo Institute of Agriculture – KIA in Peja and the research was conducted during 2014-2015. These fungicides were used: Ridomil (Metalaxil) 0.35%, Consento (Propamokarb dihidrolid + Fenamidon) 0.20%, Dithan M-45 (Mankozeb) 0.25% and copper compounds 1.5%. During vegetation has been made three treatments, first treatment was done when length of potato was 30 cm, second treatment was done 12-15 days after first treatment and the third treatment was done 12-15 days after second treatment, so that three disease assessment were made. Obtained results were elaborated according the index of Mc Kinney. Elaborated results showed that high efficacy of chemicals were in combination of Ridomil and Consento (variant B5) as well as combination of Ridomil and Dithan M-45 (variant B1) in two years of experiment. While, regarding the resistance of potato varieties against blight, Arnova variety has shown high resistance toward the pathogen where disease index in two years was lower in all variants including control. In comparison with two other varieties, Rudolph has been more susceptible variety where disease index in two years was higher in all variants.

KEYWORDS: potato blight, treatments efficacy, varieties, fungicides, Mc Kinney index

INTRODUCTION

According official data of 2013, potato in Kosovo was cultivated in 7184 ha. Potato is being attacked by several diseases while most important potato diseases are: late blight (*Phytophthora infestans*), early blight (*Alternaria solani*), potato wart (*Synchytrium endobioticum*), some other bacterial diseases and viruses. Fungus that causes late blight in potato is originated from South America where for the first time was found in 1830, meanwhile up to 1845 it was widespread in all countries of North and Western Europe (Balaž, F. 2010). In the beginning, the disease has caused lack of food and the death of people. Except potato, the pathogen affects also tomato and is prevalent in all countries of the world where potato and tomato are cultivated (Balaž, F. 2010).

Potato late blight appears with different intensity depending on the agro-climatic conditions which prevail during vegetation. The disease affects leaves, stems, flowers and sometimes even tubers of potatoes. The first symptoms appear on lower leaves near the ground and stained yellow, after then become brown. When the weather is wet, stains

increased and become necrosis. Pathogen penetrates through the tail of the stalk and leaves sometimes can dry up the stem. In the lower side of leaves during wet weather appear gray mold layer which represents conidia of the pathogen conidiophores (Susuri, L. 2004). While during dry conditions, infected leaves curl and take the dark color. Meanwhile in tubers appear dark colored spots, where the internal tissue is softened and rot. Moreover, blight pathogen overwinter in the form of mycelium in potato tuber and the optimal temperature for the development of the pathogen is 17-21°C. When there is light infection, the mycelium enters inside potato tissues which have not yet come on the surface of the soil. Then later, mycelium covers upper part of potato and forms new conidia and conidiophores which cause new infections (Susuri, L. 2004).

MATERIALS AND METHODS

Potato protection and the research in resistance of potato varieties against potato late blight were carried out during 2014-2015. The study was performed in three potato varieties: Rudolph, Zafira and Arnova. The experimental field was located in Arbnes of Peja, in the field of Kosovo Institute of Agriculture. For the protection of potato against blight were used these fungicides: Ridomil (Metalaxil) 0.35%, Consento (Propamokarb dihidrolid + Fenamidon) 0.20%, Dithan M-45 (Mankozeb) 0.25% and copper compounds 1.5%. These fungicides were used in six variants, such as:

1. Ridomil + Dithan M-45, exchangeable application
2. Consento + Dithan M-45, exchangeable application
3. Ridomil + copper compounds, exchangeable application
4. Consento + copper compounds, exchangeable application
5. Ridomil + Consento, exchangeable application
6. Dithan M-45 + copper compounds, exchangeable application
7. Control

For the chemical treatments has been used the motor pump with a tank of 10 liters, while during vegetation have been done three treatments (the first treatment has been done when potato plants reached the size of 30 cm, the second treatment has been done 12-15 days after the first treatment, and the third treatment has been done 12-15 days after the second treatment).

The experiment has been established under the block system, as case method. Each variant has been placed in the testing plots in size (3 x 4 m – 12 m²) in two repetition. The evaluation of the disease has been done three times in potato leaves (first evaluation was done after the first treatment, the second evaluation after the second treatment and the last evaluation after the third treatment). These estimates have been made by checking – rate of 100 leaves for each variant. The class of assessment that is used has been of five classes (class 0 - no infection, class 1 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) (Josifovic 1956). The details of these observations are processed for each variant according to Mc Kinney index (Index Mc) (Josifovic 1956). The formula for determining the percentage of infection by Mc Kinney index is:

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

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.

RESULTS AND DISCUSSIONS

1. Results of the year 2014

From the results obtained during the evaluation of disease in 2014 has been seen that from seven variants used to protect potato late blight on leaves, in cultivar Rudolph to variant B5 (8.16%) the average percentage of the disease was lower in the case of using Ridomil and Consento, hence, these chemicals have showed very high efficiency against the disease. Afterwards, for the efficacy, after variant B5, combining Ridomil and Dithan M-45 ranked in percentage of infection in variant B1 (11.40%). Whereas, less efficient has shown combinations in variant B2 (13.63%) which were used Consento and Dithan M-45, then variant B3 (17.43%) which were used cooper compounds and Ridomil, then variant B4 (19.06 %) which were used Consento and copper compounds and B6 (21.36%) which were used Dithan M-45 and copper compounds. While, in examination the average percentage of infection has been B7 (35.66%).

But in terms of cultivar Zafira higher efficiency against the pathogen was in variant B5 with the average percentage of the disease B5 (6.06%) which was used combination of Ridomil and Consento. High efficiency also showed combination Ridomil and Dithan M-45 in variant B1 (9.40%). Less effective were shown combinations in variant B2 (11.00%) which were used Consento and Dithan M-45, then variant B3 (14.33%) which were used copper compounds and Ridomil, then variant B4 (16.13%) which were used Consento and copper compounds variant B6 (18.80%) which were used Dithan M-45 and copper compounds. While, in examination the average percentage of infection has B7 (30.93%).

Regarding cultivar Arnova, the average percentage of infection was lowest in variant B5 (3.53%) which was used Consento and Ridomil, therefore this combination has shown more successful in protection of potato blight. High efficiency has shown also the combination of Ridomil and Dithan M-45 variant B1 (5.93%). Also it has shown good efficiency the combination of Consento and Dithan M-45% in variant B2 (7.16%). Whereas, less efficient has shown combinations in variant B3 (10.60%) which were used Ridomil and copper compounds, then variant B4 (11.86%) which were used Consento and cooper compounds, then variant B6 (14.63%) which were used Dithan M-45 and copper compounds. While, in examination the average percentage of infection has been B7 (23.33%).

Table 1. Demonstration of the infection percentage of blight on potato leaves during 2014

Cultivar Factor (A)	Chemicals Factor (B)	Evaluation of disease Factor (C)			- X
		C1	C2	C3	
Rudolph	B1	10.00	13.10	11.10	11.40
	B2	12.30	15.10	13.50	13.63
	B3	17.10	19.20	16.00	17.43
	B4	18.80	20.90	17.50	19.06

	B5	7.25	9.80	8.80	8.16
	B6	20.30	22.60	21.20	21.36
	B7	28.60	36.50	41.90	35.66
Zafira	B1	8.10	10.50	9.60	9.40
	B2	10.00	12.20	10.80	11.00
	B3	14.20	15.30	13.50	14.33
	B4	15.80	17.90	14.70	16.13
	B5	5.10	7.20	5.90	6.06
	B6	17.50	20.10	18.80	18.80
	B7	25.10	30.90	36.80	30.93
Arnova	B1	5.20	6.50	6.10	5.93
	B2	6.00	8.30	7.20	7.16
	B3	10.10	12.50	9.20	10.60
	B4	11.60	13.80	10.20	11.86
	B5	2.80	4.30	3.50	3.53
	B6	13.50	16.20	14.20	14.63
	B7	18.10	22.90	29.00	23.33

2. Results of the year 2015

In assessing the leaf blight disease for 2015, it appears that from seven variants used in cultivar Rudolph, in variant B5 (6.83%) the average percentage of the disease was lowest where chemicals used were Consento and Ridomil, therefore these chemicals have shown very high efficacy against the pathogen. Moreover, for efficiency after variants B5 ranked combination of Ridomil and Dithan M-45 with percentage of infection in variant B1 (10.50%). Whereas, less efficient has shown combinations in variant B2 (12.26%) which were used Consento and Dithan M-45, then variant B3 (15.66%) which were used cooper compounds and Ridomil, then variant B4 (16.86 %) which were used Consento and copper compounds and B6 (19.93%) which were used Dithan M-45 and copper compounds. While, in examination the average percentage of infection has been B7 (33.40%).

Regarding cultivar Zafira higher efficiency against the disease has been in variant B5 (5.43%) with the average of infection which was used combination Ridomil and Consento. High efficacy has shown also combination of Ridomil and Dithan M-45 in variant B1 (7.83%). Whereas, less efficient has shown combinations in variant B2 (9.26%) which were used Consento and Dithan M-45, then variant B3 (11.73%) which were used cooper compounds and Ridomil, then variant B4 (13.50 %) which were used Consento and copper compounds and B6 (15.43%) which were used Dithan M-45 and copper compounds. While, in examination the average percentage of infection has been B7 (29.70%).

Regarding cultivar Arnova, the average percentage of infection was lowest in variant B5 (3.03%) which was used Consento and Ridomil, therefore this combination has shown more successful in protection of potato blight. High efficiency has shown also the combination of Ridomil and Dithan M-45 variant B1 (5.13%). Also it has shown good efficiency the combination of Consento and Dithan M-45% in variant B2 (5.93%). Whereas, less efficient has shown combinations in variant B3 (8.56%) which were used Ridomil and copper compounds, then variant B4 (9.50%) which were used Consento and

cooper compounds, then variant B6 (11.13%) which were used Dithan M-45 and copper compounds. While, in examination the average percentage of infection has been B7 (22.20%).

Table 2. Demonstration of the infection percentage of blight on potato leaves during 2015

Cultivar Factor (A)	Chemicals Factor (B)	Evaluation of disease Factor (C)			X
		C1	C2	C3	
Rudolph	B1	9.20	12.20	10.30	10.50
	B2	11.10	13.90	11.80	12.26
	B3	15.20	17.30	14.50	15.66
	B4	16.30	18.30	16.00	16.86
	B5	6.00	7.50	7.00	6.83
	B6	18.10	20.30	19.60	19.33
	B7	27.50	33.90	38.80	33.40
Zafira	B1	7.00	8.70	7.80	7.83
	B2	8.80	10.10	8.90	9.26
	B3	11.10	13.20	10.90	11.73
	B4	13.20	14.50	12.80	13.50
	B5	4.80	6.50	5.00	5.43
	B6	13.20	17.50	15.60	15.43
	B7	26.00	28.10	35.00	29.70
Arnova	B1	4.80	5.60	5.00	5.13
	B2	5.10	6.90	5.80	5.93
	B3	8.00	10.30	7.40	8.56
	B4	9.50	10.80	8.20	9.50
	B5	2.50	3.80	2.80	3.03
	B6	10.80	12.10	10.50	11.13
	B7	20.00	21.00	25.60	22.20

3. Discussion of the results

From the results obtained during the two years of research is obvious that the most effective chemicals to combat the leaf blight of potato (to the three cultivars) have been: Ridomil in combination with Consento (variants B5) and the combination of Ridomil and Dithan M45 (variants B1). Respectively, Consento in combination with Dithan M-45 (variants B2) and Ridomil in combination with copper compounds (B3 variants) have shown average efficacy in combating the potato blight pathogen. Whereas, Consento in combination with copper compounds (variants B4) and Dithan M-45 in combination with copper compounds (variants B6) gave less efficient results in the protection of potato from blight pathogen.

While regarding the cultivars investigated during two years of study, the cultivar Arnova has showed the highest efficacy against potato blight (which is evidenced by the lowest rate of infection) to all variants including variant B7 compared to the cultivars Zafira and

Rudolph. The cultivar Rudolph has shown lower efficacy (with the highest percentage of infection) to all variants including the variant B7.

According to Aslam, K. et al (2003) good results in the protection of potatoes against late blight on leaves have given these fungicides: Metalaxil + Mankozeb, Ridomil Gold and Acrobat when the infection has been high, while if treatment is done in intervals of 15 days. Even in our research, combination of Mankozeb + Metalaxil has given good results, while treatments were done every 12 to 15 days depending on weather conditions.

Balaž, F. (2010), for combating the late blight of potato has been used chemicals with these active ingredients: copper, mankozeb, mankozeb + dimetomorf, propamokarb dihlorid + fenamidon, cimoksasil + famoksadon, azoksistrobin, mankozeb + metalaksil, hlortalonil, cijazofamid. Even we have been used approximately the same active ingredients (metalaksil, propamokarb dihlorid + fenamidon, mankozeb and copper) against blight in potato.

According to Bici, I. (2011), for combating blight in potato these chemicals should be successfully used: metalaksil, propamokarb dihlorid, mankozeb, copper and many others by contact or systemic. In general we can say that in our experimental fields most chemicals that we have used against blight gave good results.

Eremnev, V. et al (2006), in the experimental fields for potato protection against blight, have made three treatments during vegetation in 2003 and four treatments during 2004. Even in our research fields of potatoes we have done three treatments during two years of study.

Hu, T. et al (2014) cite that when the treatment is initiated two weeks after the appearance of the first symptoms of blight, the effect of fungicide protection of potatoes has not been very good. For this reason we have been spraying when potato reached size of 30 cm and the effect of fungicides has been good.

According to Josifović, M. (1956), the rate of pathogen infection is done by dividing the assessment of infection in five categories. Even we made the same estimate approximately with some changes (Josifović, M., 1956 and Ruci, Th. 2004).

According to Kišpatič, J. (1986), systemic fungicides enter and remain for a certain time in plants and can be transformed into new relationships respectfully can change the metabolism of the plant, for this reason can be eventually toxic and can create resistant strains of the pathogens. Even in protection program against potato blight we have used two fungicides with systemic action only in one variant (B5) and the effect of the action has been very good. Moreover, is essential to take care and to do not be used for many years because they can create resistant strains of the pathogen and eventually can be toxic.

According to Miller, J. et al (2006), treatments against blight of potato should begin when potato plants begin to close the orders, while other treatments after every 10 days when weather conditions are favorable for the development of the pathogen. While chemicals that provided good results are Ridomil gold and Mankozeb. Even in our research we have begun when the potato plants reached size of 30 cm (when it starts closing orders), while in terms of efficiency of fungicide, combination of Ridomil and Dithan M-45 (Mankozeb) have given good results.

Susuri, L. (2004), to protect potato against blight should be used fungicides based on copper and ditiocarbamate. Even we used approximately the same fungicides. According to the same author, first treatment should be done when the potato plants reach the height of

15-25 cm, while we made first treatment when potato plants have reached the height of 30 cm.

Stein, J. and Kirk, W. (2002), for combating blight in potato, have used Azoxistrobin WDG, Chlorothalonil + Propamocarb, Mankozeb + Copper - OHDF, Mankozeb + Cymocanil DF and other fungicides where their effect has resulted in 30-50% of reduction in development of blight. Even in our research we have achieved approximately the same results compared the control with treated variants.

CONCLUSIONS AND RECOMMENDATIONS

From the research conducted and on the basis of the results obtained through the evaluations that are made during the survey (2014 and 2015) can be concluded that:

- Cultivar Arnova owns a lower vulnerability against potato blight; therefore, it is resistant against the pathogen compared to the cultivars Zafira and Rudolph.
- Cultivar Zafira has average vulnerability against potato blight, while cultivar Rudolph has high vulnerability to the pathogen.
- To combat the blight in potato leaves (to cultivars that are tested) high efficiency chemical combination showed Ridomil and Consento during two years of research where the disease index was very low (B5 variant).
- High efficiency against potato blight on the leaves has shown the combination of Ridomil dhe Dithan M-45 (B1 variant).
- Less effective in combating pathogen was combination of Dithan M-45 and copper compounds (B6 variant).

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

- The green mass to be maintained under control during vegetative season with regular treatments especially to susceptible cultivars.
- For regular protection against potato blight on leaves should be used systemic chemicals but in combination with organic ones in order to do not appear subspecies of the resistant pathogen.
- To be careful during mineral fertilization (especially nitrogen fertilizers) in the cases of high doses of these fertilizers potato cultivars are more sensitive to the pathogen.
- For planting potato to be chosen cultivars which are more resistant against the blight pathogen.

References

1. Aslam Khan, M., Rashid, A., Ullah, O., and Iqbal, M., J., (2003): Control of Late Blight of Potato by Foliar Application of Fungicides. *International Journal of Agriculture & Biology*, Chiniot, Pakistan: pp. 540-542.
2. Balaž, F., Balaž J., Tošič, M. (2010): Late blight of potato and tomato, *Fitopatologija*, Novi Sad, Serbia: pp. 62-65.
3. Bici, I. (2011): Manual i produkteve për mbrojtjen e bimëve. Tiranë, Shqipëri: pp. 38-39, 109-110, 166-174, 185-187.
4. Eremmev, V., Lohmus, A., Joudu., J. (2006): NegFry – DSS for the chemical control of potato late blight – results of validation trails in Tartu.. *Agronomy Research 4 (Special issue)*, Tartu, Estonia: pp. 167-170.

5. Hu, T., Zhao, Zh., Zhou, D., Zhu, J., Cao, K. (2014): Chemical Control Strategy of Potato Late Blight Based on the DSS `China-blight`. Fourteenth euroblight Workshop, PPO-Special report No 16-2014, Limassol – Cyprus 12-15 May 2013: pp. 139-144.
6. Josifovič, M. (1956): Procena štete nanete od biljnih bolesti, Poljoprivredna Fitopatologija, Beograd, Serbia: pp.43-46
7. Kišpatič, J. (1986): Fungicidi, Zagreb, Hrvatska: 149.
8. Miller, J., Nolte, Ph., Olsen, N., Miller, T., Bohl, B., Thornton, M. (2006): Sprout and disease control of potatoes in storage. University of Idaho, College of Agricultural and Life Sciences, CIS 1132, 8, USA.
9. Stein, J., Kirk, W. (2002): Crop Protection, Michigan State University, USA: pp. 21, 575, 582.
10. Susuri, L. (2004): Fitopatologija, Prishtinë, Kosovë: pp. 108-112.