POTATO LATE BLIGHT CONTROL WITH DIFFERENT COPPER FUNGICIDES

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Abstract. *Potato culture is very sensitive to the pathogen attack. Of these, the most frequently reported is Phytophthora infestans. Late blight can cause in favorable years a 40-50% loss of the harvest if the control measures are not applied. In our country, Potato late blight is frequent and dangerous in the area of cultivation, especially in the rainy years, when the production losses can reach 50% or more. The evolution of the attack degree in 2017 is explosive, after 20 days of the first reading. If the first two readings in July show a level below 3%, in the third decay of the month, the average attack exceeded 20%. One of the oldest substances used to control these pathogens is copper. This substance is still valid and still accepted in organic farming. Climatic conditions strongly influence the efficiency of copper fungicides. Also, previous studies claim that there are differences in efficacy between the three chemical formulations of copper. This paper aims to determine the effectiveness of different formulations of this substance. Thus, copper sulfate, copper hydroxide, and copper oxychloride were tested on three varieties of potatoes (red, white, and purple). For control of downy mildew, the most efficient was the oxychloride followed by copper hydroxide. In the variant treated with copper sulfate, the average attack rate exceeded 30%. The highest levels of the attack were recorded in the variants treated with CuSO4 in both the Sante and Red Fantasy varieties. The differences between these two variants and all others are significant. Comparing the varieties is observed that the least attacked by the Phytophthora infestans is the purple variety, the differences between this variety and the others are covered statistically. The most sensitive to the late blight attack was found to be the Sante variety. Of the fungicides tested, the highest efficiency we noted at the copper oxychloride.*

Keywords*: potato, Phytophthora infestans, copper, fungicide*

INTRODUCTION

Obtaining healthy production is the desire of any farmer. One of the quality indicators is pesticide residue content. Thus, in this paperwork, we present some data related to the efficiency of some fungicides used in the control of potato late blight. The present work aims to establish, if appropriate, the best copper formulation of fungicides. The efficiency of copper fungicides is strongly influenced by climatic conditions (TÖFOLI ET AL., 2014; SCHILDER, 2010; HERMEZIU, 2014). Also, Large in 2008 states that there are differences in efficacy between the three chemical formulations of copper.

Late blight can cause, in favorable years, a 40-50% threshold of the harvest if no control measures are applied (STEVENSON ET AL., 2008). In our country, the potato late blight is frequent and dangerous in the main area of cultivation, especially in the rainy years, when the losses can reap 50% or more (BOȚOMAN, 2005; HATMAN ET AL., 1989; LAZĂR ET AL., 1977).

All aerial and underground organs of plants can be attacked, except for the roots. The most common form of attack is on the leaves. These, as a result of the infection, have brown spots with a diffuse contour, located mainly at the edge or tip of the leaflets. Over time, the tissue near the spots becomes necrotic, and around them, a yellowish area is observed. On the underside of the leaves, on the edge of the spots towards the healthy tissue, in wet weather or in the mornings on the dew, there is a delicate whitish puff made up of the sporangia and the sporangiophores of the pseudofungi (PÂRVU M., 2010; POPESCU GH., 1999; ULEA, 2003).

Figure 1 Late blight on the leaves and tubers - *Phytophthora infestans*

On the stems and petioles of the leaves, the disease appears in the form of elongated brown spots, which can produce browning and drying.

From the stems, the disease passes through stolons on the tubers. The tubers can also be infected directly from the sporangia which falling from the leaves on the ground they are driven with rainwater up to 6-8 cm, where they meet the potato tubers and infect them. The tubers can also be infected by direct contact with the sick ones. In the early stages, the tubers attacked do not differ on the outside from the healthy ones; in a more advanced stage, on the surface of the tubercles appear brown-leaden sunken spots, which correspond inward with areas of brown tissue. (HATMAN ET AL., 1989; PUIA, 2005).

Copper products can control, or slow down, potato late blight epidemics. Copper products have no therapeutic activity (MANEA ET AL., 2017). Therefore, they need to be applied to all plant surfaces before infection (STONE, 2019). They must be applied so that all plant surfaces are covered, including the undersides of leaves where *Phytophthora infestans* sporulates (STEVENSON ET AL., 2008 FLORIAN ET AL., 2012).

MATERIAL AND METHODS

The purpose of the paper is to establish the efficiency of some copper fungicides in control of potato late blight.

In order to achieve the objective, an experimental field was placed in the village Petreștii de Jos, Cluj County. The experimental field was established on April 18, 2017, with a length of 18.5 m and a width of 4.5 m using three potato varieties: Red Fantasy (red potato), Sante (white potato), and Albastru de Gălănești (purple potato). Each plot comprises two rows of 1.5 m in length.

The treatments were differentiated with products based on copper: Bordeaux Mint (copper sulfate), Champ (copper hydroxide), and Flowbrix (copper oxychloride). The doses used are those recommended by the manufacturer (Manea et al., 2017). Alternative treatments with the following products have been performed to combat the Colorado (Leptinotarsa decemlineata): Calypso, Actara, and Mospilan

The first of the four treatments was performed on June 27, 2017, the second on July 7, 2017, the third on July 18, 2017, and the last on July 27, 2017. After each treatment, at an

interval of approximately 7-10 days, we performed the notations in the experimental field regarding the efficiency of fungicide used.

RESULTS AND DISCUSSIONS

As mentioned above, climatic conditions have an influence on the behavior of the pathogen *Phytophthora infestans*. We can see that in the first two readings, the attack level is very low; most of the variants registering an attack degree of less than 1%. In 04.07.2017, on purple variety, no attack was observed in the variants treated with oxychloride and hydroxide copper (Table 1).

Table 1

The efficiency of copper fungicides, in late blight control (04.07.2017)

Variety	Treatment	Attack degree	Duncan significance
White **Sante**	**Average**	0.64^{Mt}	
	Zeamă Bordeleză $CuSO_4$	0.23	A
	Flowbrix $Cu_2(OH_3)Cl$	1.00	A
	Champ CuOH	0.68	A
Red **Red Fantasy**	**Average**	0.25^{Mt}	A
	Zeamă Bordeleză $CuSO_4$	0.16	A
	Flowbrix $Cu_2(OH_3)Cl$	0.53	A
	Champ CuOH	0.07	A
Purple **Albastru de Gălănești**	**Average**	0.63^{Mt}	A
	Zeamă Bordeleză $CuSO_4$	1.87	A
	Flowbrix $Cu_2(OH_3)Cl$	0.00	A
	Champ CuOH	0.00	A
Mt-control		LSD (p 5%) – 2.10 DL (p 1%)- 2.95 DL (p 0,1%)- 4.17	DS 2.10

Ten days after the first observation (table 2), the degree of attack increases, revealing the varieties treated with copper sulfate for the purple variety and the Sante variety. These variants registered the highest attack value of over 3%, the differences between them, and the other variants being statistically covered.

At 20 days after the first reading, the situation of the attack degree changes dramatically. The level of this attack reaching, on average, the Red Fantasy variety at 17.21%, and the Sante variety up to 15.74% (table 3). This fact is due to the climatic conditions that have been characterized by alternating short rains with warm periods. Again we note the purple variety with the lowest degree of attack, below 3% (table 3).

The highest levels of the attack were recorded in the variants treated with CuSO4 (over 20%) in both varieties: Sante and Red Fantasy. The differences between these two variants are significant. If in the Red Fantasy variety, there are no significant differences between the plots treated with copper hydroxide or oxychloride, in the purple variety, there are no significant differences between the three treatment variants.

Table 2

The efficiency of copper fungicides, in late blight control (14.07.2017)

Variety	Treatment	Attack degree	Duncan significance
White **Sante**	**Media**	1.83^{Mt}	
	Zeamă Bordeleză $CuSO_4$	3.74*	B
	Flowbrix $Cu_2(OH_3)Cl$	0.47	A
	Champ CuOH	1.28	A
Red **Red Fantasy**	**Media**	0.85^{Mt}	
	Zeamă Bordeleză $CuSO_4$	0.40	A
	Flowbrix $Cu_2(OH_3)Cl$	0.65	A
	Champ CuOH	1.50	A
Purple **Albastru de Gălănești**	**Media**	1.36^{Mt}	
	Zeamă Bordeleză $CuSO_4$	3.67**	B
	Flowbrix $Cu_2(OH_3)Cl$	0.26	A
	Champ CuOH	0.15	A
Mt-control		LSD (p 5%) – 1.39 DL (p 1%)- 1.95 DL (p 0.1%)- 2.75	DS 1.38

Table 3

The efficiency of copper fungicides, in late blight control (24.07.2017)

Variety	Treatment	Attack degree	Duncan significance
White **Sante**	**Media**	15.74^{Mt}	
	Zeamă Bordeleză $CuSO_4$	21.53***	E
	Flowbrix $Cu_2(OH_3)Cl$	8.28^{ooo}	B
	Champ CuOH	17.41	D
Red **Red Fantasy**	**Media**	17.21^{Mt}	
	Zeamă Bordeleză $CuSO_4$	21.30**	E
	Flowbrix $Cu_2(OH_3)Cl$	14.43^{o}	C
	Champ CuOH	15.89	CD
Purple **Albastru de Gălănești**	**Media**	1.65^{Mt}	
	Zeamă Bordeleză $CuSO_4$	1.79	A
	Flowbrix $Cu_2(OH_3)Cl$	0.50	A
	Champ CuOH	2.66	A
Mt-control		LSD (p 5%) – 2.71 DL (p 1%)- 3.81 DL (p 0.1%)- 5.38	DS 2.71

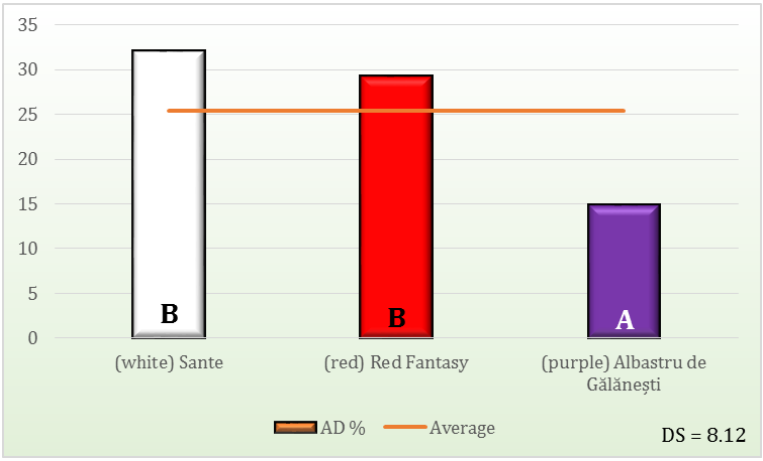

Figure 2. Late blight attack degree

Comparing the varieties, we observe that the least attacked by the *Phytophthora infestans* is the purple variety, with an attack degree below 15% (Figure 2). The difference between this variety and the others is statistically covered. The most sensitive to the late blight attack was found to be the Sante variety.

Figure 3 shows a comparison of the efficacy of the treatments. It is also recognized this time as the most efficient the copper oxychloride, the differences from the other two formulations, in terms of efficiency, being significant.

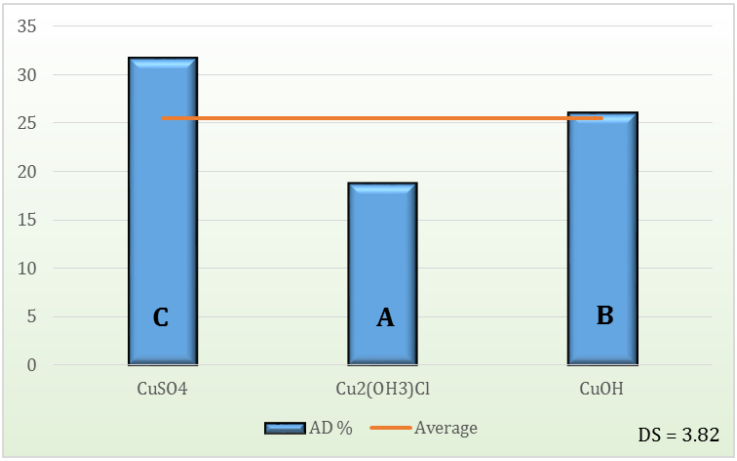

Figure 3. Efficacy of copper fungicides

On the last date of reading the degree of attack and comparing the interaction between varieties and treatments regarding the late blight (Table 4), we can say that the purple variety behaved best in the variant to which copper oxychloride was applied. The least resistant to the late blight proved to be white variety, which in the variant treated with copper sulfate noted an attack degree of 37.75%.

Table 4

The efficiency of copper fungicides, in late blight control (05.08.2017)

Variety	Treatment	Attack degree	Duncan significance
White **Sante**	**Media**	32.12^{Mt}	
	Zeamă Bordeleză $CuSO_4$	37.75	E
	Flowbrix $Cu_2(OH_3)Cl$	27.22	CD
	Champ CuOH	31.38	DE
Red **Red Fantasy**	**Media**	29.33^{Mt}	
	Zeamă Bordeleză $CuSO_4$	36.55*	E
	Flowbrix $Cu_2(OH_3)Cl$	19.94^{oo}	B
	Champ CuOH	31.50	DE
Purple **Albastru de Gălănești**	**Media**	14.94^{Mt}	
	Zeamă Bordeleză $CuSO_4$	20.62	BC
	Flowbrix $Cu_2(OH_3)Cl$	8.95	A
	Champ CuOH	15.26	AB
Mt-control		LSD (p 5%) – 6.61 DL (p 1%)- 9.28 DL (p 0.1%)- 13.10	DS 6.61

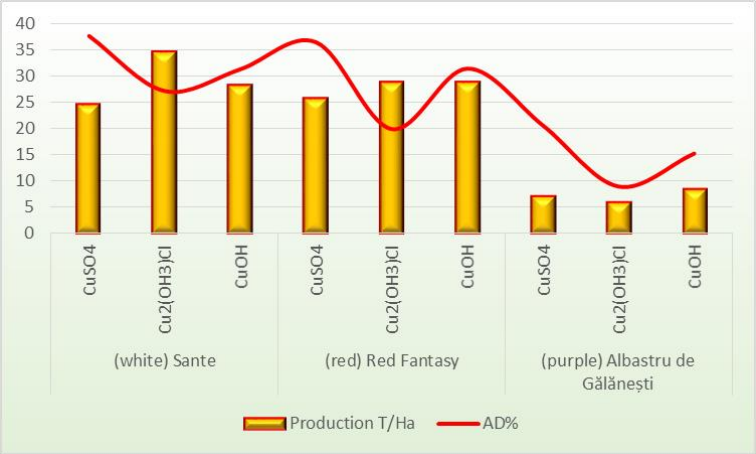

Figure 4 The relation between the production and late blight attack degree

As expected, production is influenced by the degree of attack of this dangerous pathogen, but especially by the productive potential of the tested variety (Figure 4). In all the plots cultivated with the variety Sante or Red Fantasy, the productions exceeded 25 t/ha. The variants treated with copper oxychloride generally had high yields, except for the purple variety where it seems that this treatment inhibited the development of plants, the yields being for this variant below 6 t/ha, with 1 and 2 tons per hectare smaller than the other variants.

CONCLUSIONS

Among the varieties tested, the most resistant to late blight attack in the conditions of 2017 was the purple variety (local population). Of the fungicides tested, the highest efficiency was noted to the one based on copper oxychloride. Copper treatments are still a viable alternative in the control of potato late blight. Under the conditions of organic farming, we recommend the application of any copper-based product for the first two treatments, and the next one's treatments fungicides based on copper oxychloride. Research on the effectiveness of treatments should be continued in the following year to eliminate the influence of climatic conditions on their efficiency.

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