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EFFECTS OF TREATMENTS WITH BIOPESTICIDE CARBECOL AND FUNECOL ON TOMATO (*SOLANUM LYCOPERSICUM*. L) LATE BLIGHT

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Abstract

Tomato late blight (Phytophtora infestans) is a major disease of tomato (Solanum lycopersicum L.) in many agricultural regions, causing huge losses in vegetable production. A greenhouse experiment was conducted to investigate the efficacy of the new biofungicide Carbecol alone or in combination with treatments of the biofungicide Funecol in the control of late blight in tomato and their impact on crop productivity. Tomato plants were treated four times during the growing period with Carbecol alone or in combination with treatments of Funecol at different concentrations to control late blight of tomato. The experimental results revealed that foliar disease of late blight in tomato was significantly reduced by treatments applied in combinations of Carbecol and Funecol in comparison with untreated plant or Carbecol alone. However, the best results were reached in the variant with integrated application of Carbecol at a rate of 0.4% plus treatments with Funecol at a rate of 0.4%. The treatments had a beneficial effect on the tomato fruit production. The integrated application of Carbecol and Funecol gave the best effect and the yield increased by 16% in comparison with untreated plants.

Key words*: Biorational products, Carbecol, Funecol, Late blight, tomato.*

INTRODUCTION

Plant diseases are a major threat to agriculture and to food security. Today, organic agriculture is being promoted on a large scale and the market for organic products has grown significantly in many countries as well as in the Republic of Moldova (Fenibo et al., 2021; Suja et al., 2013). It is well documented that plant fungal diseases are the most destructive diseases, where the fungal pathogens attack many valuable crops, causing a significant yield loss (Šunjka & Mechora, 2022). Among them, tomato late blight, caused by the pathogen *Phytophtora infestans*, is the most common foliar disease of tomato, destroying all organs such as leaves, stems, stalks and fruits (Ivanov et al., 2021). Synthetic fungicides have a good efficacy to combat this disease. However, there are growing concerns about the use of synthetic fungicides in terms of environmental and food safety; hence, the need to explore other alternatives that are friendly to farmers, to consumers and to the environment is imperative for the sustainable development of organic vegetable production. In this regard, late blight also is a major constraint for tomato production in the Republic of Moldova. In order to minimize the use of chemical fungicides against late blight, attempts are being made to develop integrated approaches to the use of biorational protection products. According to EU regulations for the organic production of vegetable crops, there is a need to decrease the use of chemical fungicides in crop treatments and to increase the use of alternative biorational protection products (Commission Regulation No 1107/2009; La Torre et al., 2019; Marchand, 2016). Therefore, considering the agronomic and socioeconomic importance of late blight disease and the lack of information on the integrated use of biorational protection products, the aim of this study was to evaluate the efficacy of new biopesticide Carbecol and Funecol applied in different combinations, in controlling late blight disease of tomato.

MATERIALS AND METHODS

To fulfill the purpose of the study, a greenhouse experiment was conducted with tomato plants. A commercial susceptible tomato variety Tolstoy was used in the

experiment. The experiment was conducted at the Institute of Genetics, Physiology and Plant Protection, State University of Moldova. The soil used for the experiment was carbonated chernozem.

The trail was designed as a split-plot design with three replications. Treatments with Carbecol and Funecol are shown in Figure 1. Combined applications of Carbecol and Funecol were applied at the following stages of plant development: 1st - at 14 days after transplanting; 2nd - at the intensive growth stage; 3nd - at the flowering stage and the 4th - at the fruit development stage. Carbecol and Funecol were applied separately, in different concentrations.

The treatments were performed by spraying the solution on the tomato leaves. The usual cultural practices were followed during the growing season. In addition to late blight, other diseases, insects and weeds were monitored in the trial by regularly inspecting the plants. The severity of the late blight was determined using the disease severity index (DSI), calculated according to Pandey et al. (Pandey et al., 2003). The index of disease severity was recorded four times at ten days intervals after the last spray. At physiological maturity, tomato fruits from each variety were harvested (10 harvests were made) and weighed separately to determine fruit yield. The experimental data were analyzed using the STATISTIC 7 program.

RESULTS AND DISCUSSIONS

Tomato late blight disease has become one of the major constraints for successful organic cultivation of tomato in the Republic of Moldova. The efficacy of treatments with Carbecol alone or in combination with Funecol against late blight was examined on tomato leaves. The tomato plants were naturally infected with phytopathogen *P. infestans*. The effect of the biorational products Carbecol and Funecol on the percentage of disease severity during the first assessment of the late blight is shown in figure 1. The severity of late blight caused by pathogen *Phytophtora infestans* in the experimental plots was higher than we expected for untreated tomatoes. The experimental data showed that all the tested treatments significantly suppressed the attack of the phytopathogen *P. infestans* on leaves of tomato plants. Experimental results revealed that the disease severity index was minimal in the plots treated with the standard systemic fungicide Cooperon, WP (0.3%). It is known that the Cooperon, WP is a systemic fungicide that has been widely used to control late blight in tomato and other diseases of Solanaceae species caused by oomycetes fungi (Alexandersson et al., 2016; Shashidhara et al., 2009). The data show that there were favorable conditions for the fungus sporulation during vegetation period of tomato plants.

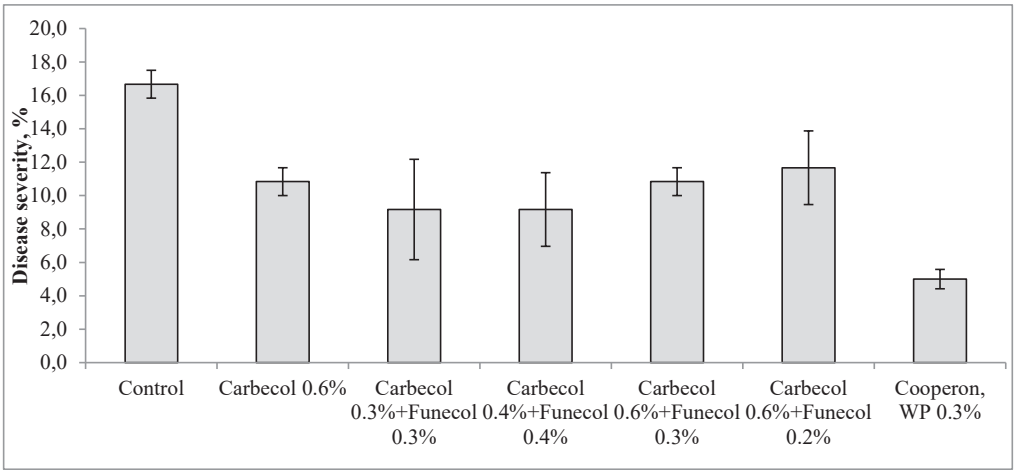

Figure 1. Effect of treatments with Carbecol alone or in combination with Funecol on late blight disease severity of tomato. Vertical bars show mean values and standard error (SE) (The first assessment of the disease index, 24.07.23).

Among the combinations of these two products, the lowest incidence of late blight occurred in the treatment of Carbecol 0.4% combined with Funecol 0.4% treatments (Figure 1). This variant also registered a better effect in controlling late blight in tomato in the next evaluations of disease severity. The results obtained at the second assessment of the disease (Figure 2) showed that all treatments applied had a significant positive effect on reducing the severity of late blight compared to the control. The experimental results showed that all treatments were significantly different from the untreated treatment of control.

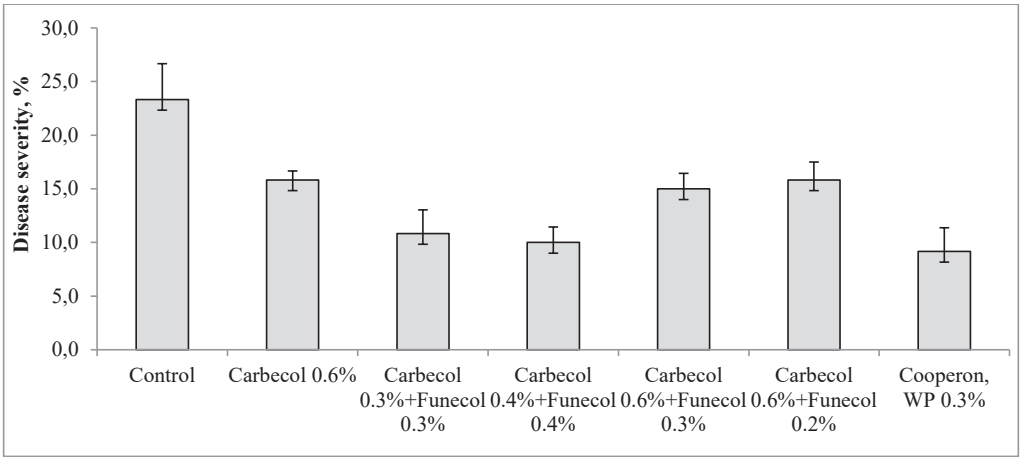

Figure 2. Effect of treatments with Carbecol alone or in combination with Funecol on late blight disease severity. Vertical bars show mean values and standard error (SE) (The second score of the disease index, 7.08.23).

Generally, the greenhouse experiment demonstrated that the application of Carbecol combined with Funecol was more effective in controlling tomato late blight disease than the application of Carbecol alone. It is necessary to note that differences between control plants and treated ones were observed even at the first evaluation of disease severity. Experimental data revealed that upon the first evidence of late blight incidence, the treatment of Carbecol+Funecol at a concentration of 0.4% for each product resulted in a disease severity of 9.2%, whereas in the control treatment, this value was 16.7%. The lowest infection of tomatoes by *P. infestans* was recorded in the variant treated with the chemical fungicide Cooperon, WP with an occurrence of 5%. Therefore, the research data indicated that the treatment of Carbecol 0.4% + Funecol 0.4% offered effective protection against the phytopathogen *P. infestans*. The results of the second score of disease severity of tomato leaves are presented in Figure 2. The best protection (60.7% efficacy) was obtained with the application of chemical fungicide Cooperon, WP, which was slightly better but not significantly different from the variant Carbecol 0.4% + Funecol 0.4% (57.1%). Biofungicide Carbecol applied alone provided the worst protection but significantly different from untreated control, with 32% efficacy (data are not shown). No phytotoxicity was observed on the tomato plants after spray application of the biorational protection products as well as in treatment with standard chemical fungicide. It is necessary to note that the disease severity index in all treatments increased during the vegetation growth of plants. The treatments suppressed the progression of the disease; however, the increase was less pronounced in the chemical treatment of Cooperon, WP. Likewise, a good protection effect was registered in the treatment Carbecol + Funecol at 0.4% concentration of each product in all scores of the index. Nonetheless, the phytopathogen *P. infestans* caused a higher disease severity on the tomato plants in the untreated control. We can suggest that the incidence of late blight, caused by the phytopathogen *P. infestans*, in the treatment

with the combined application of biorational products, exhibited the lowest values of disease severity index compared to the treatment with Carbecol alone. Such trend was observed at all evaluation dates for disease severity (Figures 1-4). The analysis of results at the second and third evaluations of disease severity revealed more pronounced differences between variants (Figures 2 and 3). The application of Carbecol alone at a concentration of 0.6% decreased the disease severity from 23.3%, as registered in the control variant, to 15.8%. However, the most significant reduction in disease severity was observed in the variant with the combined use of Carbecol and Funecol (variant 4). Thanks to integrated use of biofungicide Carbecol and Funecol, the late blight severity index was reduced compared to the control variant (untreated plants), indicating a reduction in infection by around 50%. Similarly, the application of Cooperon, WP significantly reduced the attack by pytopathogen *Phytophtora infestans*, resulting in a disease severity of 9.2% (Figure 2).

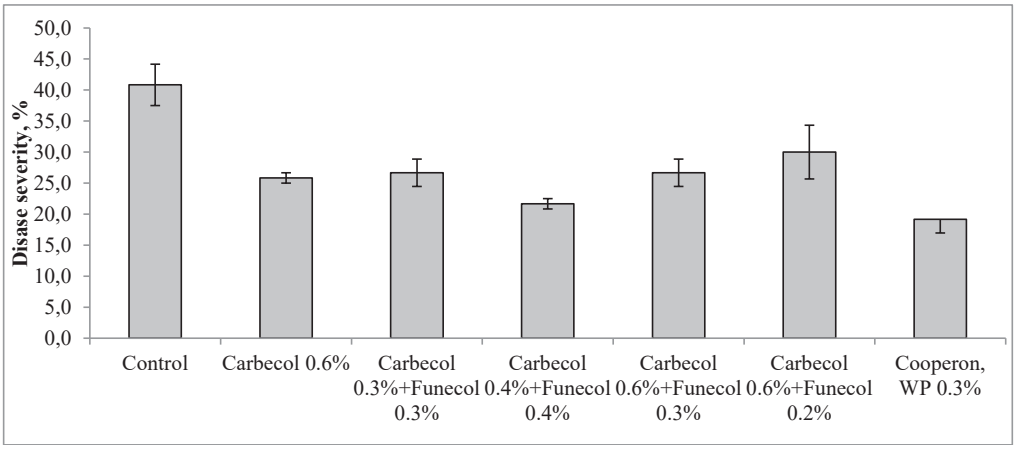

Figure 3. Effect of treatments with Carbecol alone or in combination with Funecol on late blight disease severity. Vertical bars show mean values and standard error (SE) (The third index assessment, 17.08.23).

In general, the lowest incidence of the disease caused by *P. infestans* was observed in tomato plants treated with systemic fungicide Cooperon, WP as well as in the treatment of integrated use of Carbecol and Funecol (variant Carbecol 0.4% + Funecol 0.4%). We stated that there were no significant differences in effectiveness among the biopesticide combination of Carbecol and Funecol and chemical fungicide Cooperon, WP.

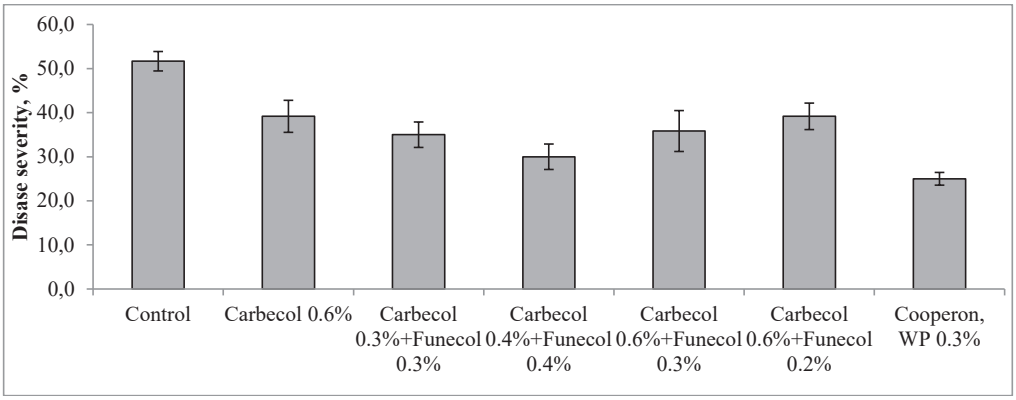

Figure 4. Effect of treatments with Carbecol alone or in combination with Funecol on late blight disease severity. Vertical bars show mean values and standard error (SE) (The fourth assessment index, 27.08.23).

As the growth of plants progressed, the disease incidence of late blight caused by *P. infestans* increased regardless of treatments. Figures 3 and 4 showed the mean percent of disease severity at the third and fourth scores of the index. The treatments with the lowest incidence of late blight at the third evidence of disease index were those of combined application of both biorational products and synthetic fungicide Cooperon, WP (Figure 3). Of course, the highest incidence of late blight was at fourth evidence of the disease index (on the end of august) especially in the untreated control variant. However, the integrated application of these two biorational products reduced significantly the severity of this disease also in august. In the treated plots, the disease progress in the plants was much slower and the severity of disease was much less than in control plots. It was revealed that the treatment of Cooperon, WP was most effective in controlling late blight and was not significantly different from the treatment of biorational products Carbecol 0.4% + Funecol 0.4%. Similar, as in the previously three assessments of the disease, the highest incidence of late blight was observed in the untreated variant with 40.8% (Figure 4).

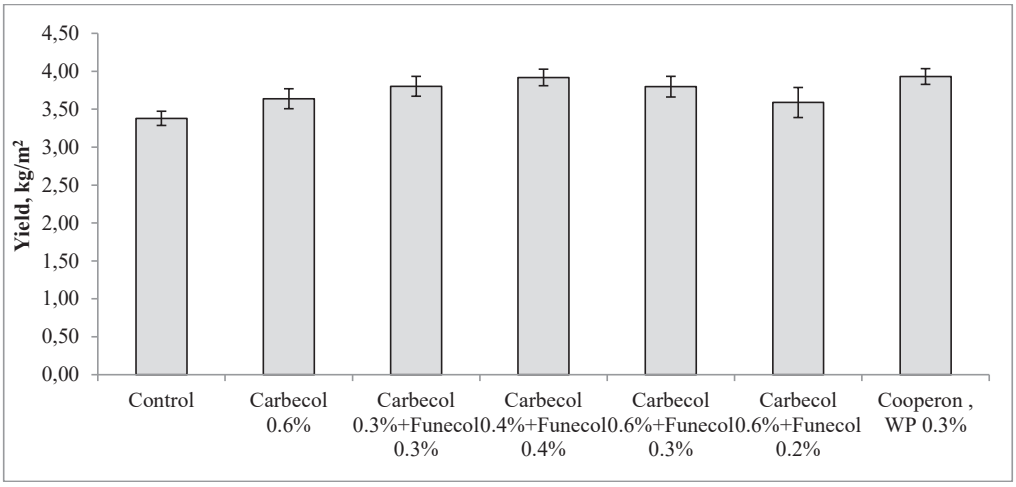

Figure 5. The effect of treatments with Carbecol alone or in combination with Funecol on the yield of tomato plants. Error bars represent SE at $p \leq 0.05$ of a mean pooled from three replications.

One of the objectives of the study was to determine the influence of treatments on fruits productivity of tomato plants. The application of different combinations of Carbecol and Funecol was also found to positively influence the fruit yield of tomato (Figure 5). For the untreated plants, control treatment recorded the lowest fruit weight compared to the other treatments. The effect of disease severity was negative on the yield of tomato fruits (Figure 5). Consequently, the mean yield in the untreated control was lower and different from the experimental treatments. Within the treatments, the total yield in Carbecol 0.4% + Funecol 0.4% treated plots was much higher and significantly different from other treatments at P = 0.05. For the plants with the integrated application of Carbecol and Funecol at a concentration of 0.4% for each biorational product, the highest fruit yield was recorded, resulting in a 16% increase in productivity compared to the control variant. It is necessary to note that Carbecol contains nitrogen and potassium nutrients which had a positive effect on growth and consequently the fruit yield of tomato plants increased. Similar observation was made by Abd-El-Kareem et al. (2012) who reported that the increase in yield of potato plants could also be due to application of products with bicarbonates during crop growth. Overall, the findings in this study could be useful for development of integrated disease management strategies of tomato cultivation. The protection products tested in this research offer new possibilities to enhance the capacity of tomato protection through the combined use

of these biorational products. This approach could potentially reduce the rates and frequencies of chemical applications, consequently mitigating the negative impact on the environment (Šunjka & Mechora, 2022). Hence, the results of the current research revealed that integrated application of Carbecol and Funecol demonstrate comparable efficacy in controlling late blight of tomatoes. The treatment combining Carbecol 0.4% and Funecol 0.4% exhibited the lowest disease severity index and resulted in better tomato yields. However, it is essential to underline that their application does not provide complete protection against late blight. This study is the first to demonstrate the potential of biorational products Carbecol and Funecol in managing tomato late blight under greenhouse conditions. Generally, in reducing the severity of late blight disease and improving tomato fruit yield, the integrated application of Carbecol and Funecol was found to be more efficient than the application of Carbecol alone. We consider that further testing of these biopesticides is needed to investigate their efficacy in field conditions.

CONCLUSIONS

Study results suggest that spraying biofungicide Carbecol and the biofungicide Funecol has the potential to control late blight of tomato plants. The integrated use of these products decreased the severity of late blight in tomato plants by 50%. The most effective combination of Carbecol and Funecol to control late blight of tomato was Carbecol 0.4% + Funecol 0.4%. The combined application of Carbecol and Funecol, each at a concentration of 0.4%, enhanced the yield of tomato by 16%. Thus, the integrated application of plant protection ecological products should be considered an effective biotechnological option for eco-friendly management of late blight disease.

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