

ECOLOGICAL CONTROL OF POWDERY MILDEW OF CUCUMBER BY POTASSIUM PHOSPHATE AND NEEM OIL AND THEIR EFFECTS ON CONTENTS OF CHLOROPHYLLS IN LEAVES

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Abstract

Powdery mildew, caused by Sphaerotheca fuliginea is a widespread disease affecting cucumber plants causing yield losses worldwide. A greenhouse experiment was carried out to evaluate the effects of the ecological plant protection products of monopotassium phosphate, dipotassium phosphate and Neem oil on powdery mildew disease severity. The study, also, evaluated the changes of photosynthetic pigments contents in leaves in relation to treatments. All treatments resulted in a significantly lower mildew infection development than untreated control plants (water spray). The application of Neem oil emulsion alone recorded the lowest efficacy rate. The most significant disease severity reduction was registered in the treatment with integrated use of dipotassium phosphate (1%) and Neem oil (0.5%) compared to the other treatments. The foliar application of the tested compounds improved the status of photosynthetic pigments in leaves and no phytotoxicity was observed on the plants. This research demonstrated that the integrated application of potassium phosphates and Neem oil had fungicidal activity against powdery mildew.

Key words: chlorophylls, cucumber, Neem oil, potassium phosphates, powdery mildew.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) plays a pivotal role in organic production of legumes. There is a body of information indicating that a major constraint of sustainable vegetable production is the high sensitivity of crops to different kinds of diseases. Among these diseases, powdery mildew of cucumber, caused by the fungus *Sphaerotheca fuliginea*, is a serious problem for both legume producers and researchers (Amtmann et al., 2008; Elad et al., 2021). This pathogen is widely spread in many countries, including the Republic of Moldova and it attacks cucurbit vegetable crops under both field and greenhouse conditions, significantly reducing crop quality and yield (Rur et al., 2018). Powdery mildew infects all organs in cucumber plants which have negative repercussions on the physiological and metabolic processes of the plants (Cheah et al., 1996). In particular, powdery mildew reduces photosynthetic parameters and chlorophylls content in leaves of melon (Tian et al., 2024). As a rule, conventional agricultural practices rely on synthetic fungicides to control plant diseases. However, the application of these

fungicides has raised concerns regarding human and environmental health for the long-term (Morishita et al., 2003). Likewise, public awareness has increased regarding the contamination of the natural resources and vegetables food products with pesticides. In organic production of vegetables, various ecological products are used to protect against fungus disease. However, their efficacy to control powdery mildew in legume crops is low. Therefore, it is necessary to look for more effective ecological plant protection products and find out new approaches of their application in order to sustainably manage powdery mildew in crops, especially cucumber plants. One of these compounds with antifungal activity is mineral salts and essential oils of different plants. It has been demonstrated that applications of potassium phosphates (Reuveni et al., 1995; Deliopoulos et al., 2010) as well as neem oil (Mostafa et al., 2021; Raveau et al., 2020; Viradiya & Gangwar, 2022) have a potential in controlling plant diseases, particularly cucumber powdery mildew. Many researchers revealed that separate use of these ecological products does not provide sufficient

efficiency to combat the powdery mildew (El-Sharkaway et al., 2014; Rur et al., 2018).

The purpose of this research was to evaluate the efficacy of monopotassium phosphate, dipotassium phosphate applied alone or in combination with emulsion of Neem oil to control powdery mildew disease of cucumber. In addition, in this study we examined the treatments effects on chlorophylls contents in cucumber leaves.

MATERIALS AND METHODS

Cucumber plants were grown from seed sown in soil under greenhouse conditions. A cucumber cultivar Iulian was used in this study. This cucumber variety has moderate susceptibility to the powdery mildew pathogen *Sphaerotheca fuliginea*. The experimental design included six treatments with three replicates of each treatment. The applied treatments were as follows: 1. Control, untreated plants; 2. Monopotassium phosphate 1%; 3. Dipotassium phosphate 1%; 4. Neem oil 0.5%; 5. Monopotassium phosphate 1% + Neem oil 0.5%; 6. Dipotassium phosphate 1% + Neem oil 0.5%. The plants to be treated had five fully expanded leaves at 4 weeks after transplanting, and sprays were made at weekly intervals. Plants sprayed with water served as control. The grown plants were artificially inoculated by shaking naturally infected cucumber leaves three days after the first spraying with the tested compounds. Disease

severity was assessed three times after the second spray. A powdery mildew severity scale from 0 to 5 A powdery mildew severity scale from 0 to 5 according to Paulus et al. (1969) was used to assess the disease. The percentage of treatment efficiency in the reduction of powdery mildew severity was calculated according to the method published in the literature of specialty (Viradiya & Gangwar, 2022). The chlorophyll content in leaves was determined according to the method proposed by Arnon (1949). The contents of Chl. *a* and *b* were measured by absorption using a spectrophotometer at 663nm and 645nm. The data were analyzed using Statistic Program 7. Means were compared by least significant differences (LSD) at $p \leq 0.05$.

RESULTS AND DISCUSSIONS

In organic farming, the application of ecological plant protection products has been increasingly accepted, particularly for vegetables such as cucumber. Unfortunately, limited studies have compared the influence of potassium phosphates and Neem oil applied individually or alternately on powdery mildew development in cucumber. Our study's results showed that the application of monopotassium phosphate, dipotassium phosphate and Neem oil individually or in alternation, reduced the disease severity of powdery mildew. The data of the first evaluation of the disease severity are presented in Figure 1.

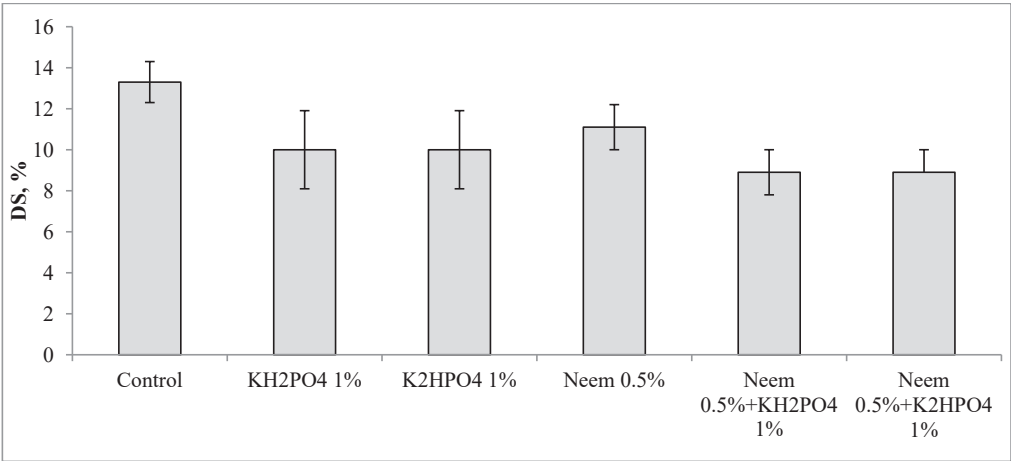


Figure 1. Effect of treatments of potassium salts and Neem oil on powdery mildew disease severity (DS, %) of cucumber plants. Data presented as the means of three replicates ±SE. (1st disease rate 28.06.2024)

The highest disease development was observed on leaves of control plants receiving four weekly applications of water. The treatments displayed different levels of effectiveness in reducing disease severity. According to experimental results, the most effective treatment was the alternate use of dipotassium phosphate (1%) and Neem oil (0.5%). In general, the tested products applied alone or in alternation, reduced the disease severity of powdery mildew under greenhouse conditions in all disease evaluations (Figures 1, 2 and 3). Therefore, the results recorded at the first evaluation of the disease severity found that the intensity of the powdery mildew in the control variant was the highest and constituted 13%. However, the application of potassium phosphates salts decreased the disease severity. It has been observed that the application of monopotassium phosphate and dipotassium phosphate separately had the same effect on the spread of the disease (first disease assessment). On the other hand, the plant treatments with emulsion of Neem oil alone had a low effect

compared to the application of other treatments. The lowest intensity of the disease was registered in the treatment of combined application of potassium phosphate and Neem oil. It is important to note that no significant difference was established between treatments of monopotassium phosphate+Neem oil (variant 5) and dipotassium phosphate+Neem oil (variant 6) at the first assessment of disease severity (Figure 1). Experimental data revealed that disease severity in these variants reached lower indices, being 31% lower than the value registered in control variant. This suggests that monopotassium phosphate, dipotassium phosphate, and Neem oil exhibit fungicidal properties, whether applied separately or together, in managing powdery mildew. However, these treatments had different grades of powdery mildew disease suppression. The use of these ecological protection products to manage powdery mildew was moderately effective in minimizing the danger of this disease at second and third evaluation of the disease severity (Figures 2 and 3).

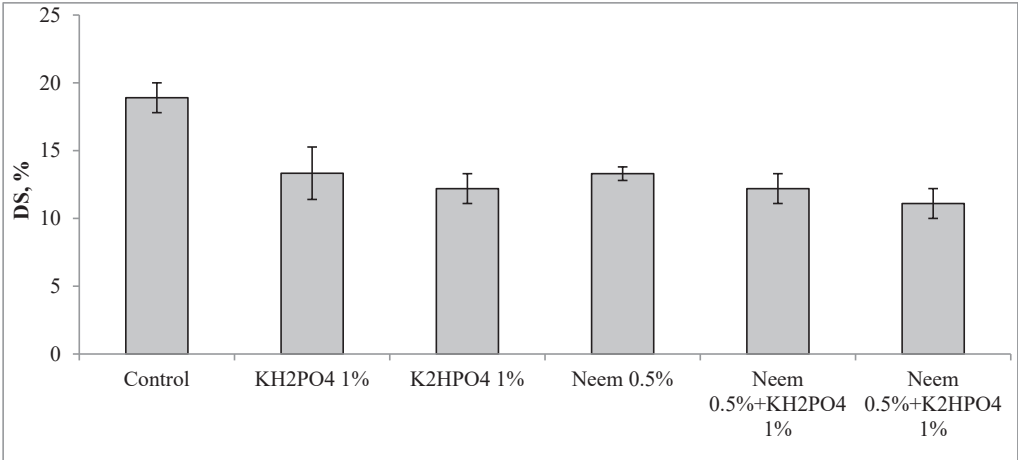


Figure 2. Effect of treatments of potassium salts and Neem oil on powdery mildew disease severity (DS, %) of cucumber plants. Data presented as the means of three replicates ± SE (II-nd rate 5.07.2024)

This study observed that as cucumber plants progressed in their growth cycle, powdery mildew severity increased in all variants, including treated plants. Analysis of these data demonstrates that the separate application of potassium phosphate and Neem oil had a beneficial effect in reducing the spread of the cucumber powdery mildew. From the

experimental results of second assessment of disease severity (Figure 2) it can be observed that the application of dipotassium phosphate showed a better effect than the variant with the use of Neem oil alone, in terms of reducing the severity of powdery mildew. Nevertheless, the integrated application of Neem oil and dipotassium phosphate ensured the best

biological efficacy in combating powdery mildew compared to the other experimental variants. Treatments with alternate use of dipotassium phosphate and Neem oil resulted in the highest decrease of in the powdery mildew with a disease severity of 11%. The effects of treatments with potassium phosphate

and emulsion of Neem oil at the third evaluation of the disease severity rate highlighted increased differences between the control variant (untreated plants) and the treatments with biorational protection products (Figure 3).

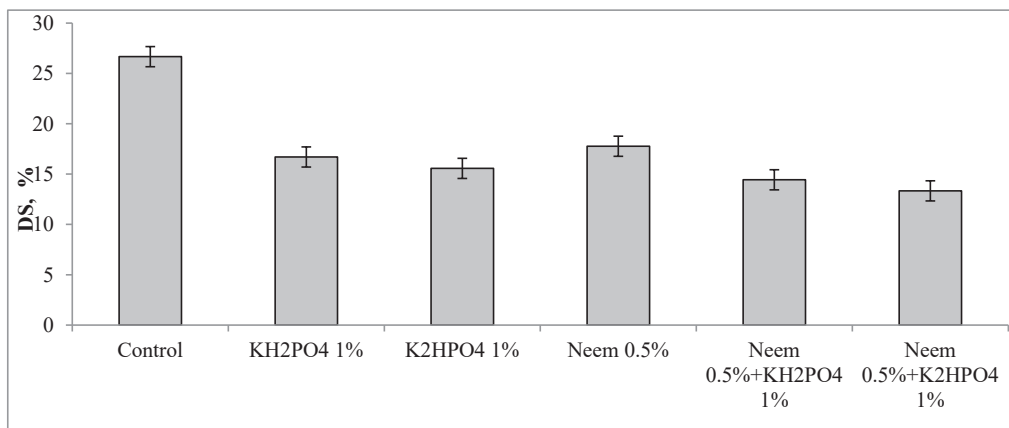


Figure 3. Effect of treatments of potassium salts and Neem oil on powdery mildew disease severity (DS, %) of cucumber plants. Data presented as the means of three replicates ± SE (III-rd rate 12.07.2024)

Similar to the previous two estimations of the disease development the highest severity of powdery mildew disease was established in the control variant where this value registered the level of 27%, and the lowest intensity was observed in the sixth variant, where treatments were made with dipotassium phosphate and Neem oil (the disease severity recorded 13.3%). Therefore, the disease development at this growth stage of cucumber reached lower indices due to the applied four treatments. Hence, the disease severity was almost two times lower than those recorded in the control. Perhaps, the obtained results could be explained by an increased resistance of plants against powdery mildew due to higher activity of enzymes and accumulation of antioxidants. In this respect researchers Irving & Kuc (1990) found out that induced resistance in cucumber plants with dipotassium phosphate increased the activity of peroxidase and chitinase enzymes.

One of the most crucial metabolic processes in crops is photosynthesis. The foliage treatments have a direct impact on the chlorophylls status

of crop leaves. Besides evaluating the disease severity of cucumber, we examined the effects of monopotassium phosphate, dipotassium phosphate and Neem oil applied individually or alternately on changes in contents of chlorophylls *a* and *b* in leaves. Experimental data revealed that powdery mildew infection reduced chlorophylls (Chl.) contents in leaves. Results showed that treatments alleviate the adverse effect of powdery mildew on chlorophylls status in cucumber leaves.

In the present study, there was a moderate increase in the content of Chl. *a* and Chl. *b* in leaves due to the application of the dipotassium phosphate alone or in conjunction with Neem oil compared to the untreated plants (Figure 4 and 5). Determination of chlorophylls revealed that the concentration of Chl. *a* was low ($1.17 \text{ mg} \cdot \text{g}^{-1} \text{ FW}$) in the control variant and this parameter increased with dipotassium phosphate and Neem oil to $1.35 \text{ mg} \cdot \text{g}^{-1} \text{ FW}$. We suggest that plants treated with mineral salts and Neem oil have a protective effect on chlorophylls against pathogen attack in cucumber leaves.

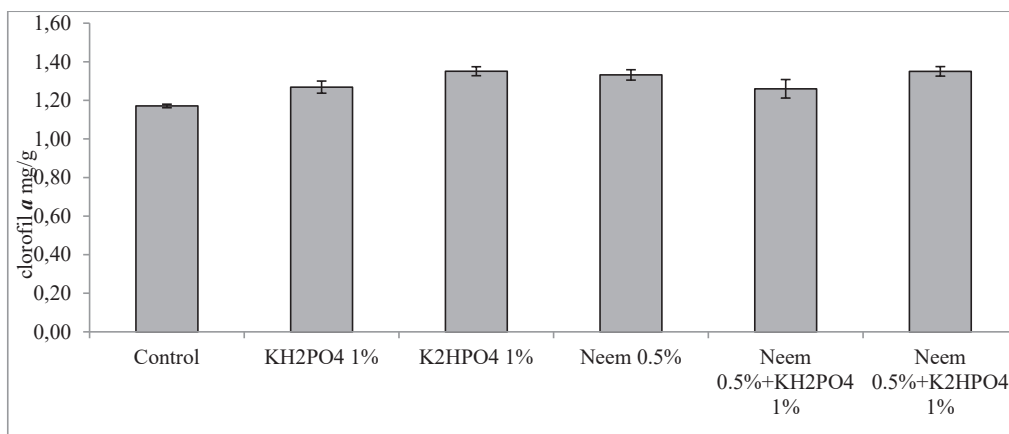


Figure 4. Effect of potassium phosphates and Neem oil on chlorophyll *a* contents (mg/g of fresh weight) in the cucumber leaves. Mean $\pm$ standard error (n = 3)

Figure 5 demonstrates the changes in Chl. *b* in leaves after four treatments. The data revealed that the chlorophyll content significantly changed in relation to application of dipotassium phosphate alone or in combination with Neem oil. The lowest value of Chl. *b* has established in the control variant. Meanwhile, the highest value of Chl. *b* content was registered ($0.58 \text{ mg} \cdot \text{g}^{-1} \text{ FW}$) as a result of the combined application of dipotassium phosphate

and Neem oil. The untreated plants showed the lowest concentration of the photosynthetic pigment of Chl. *b* ($0.49 \text{ mg} \cdot \text{g}^{-1} \text{ FW}$). Therefore, results of the study showed that pathogen infection decreased the photosynthetic pigments concentrations in cucumber plants, but this adverse effect was at some level attenuated by the integrated use of potassium phosphates and Neem oil emulsion.

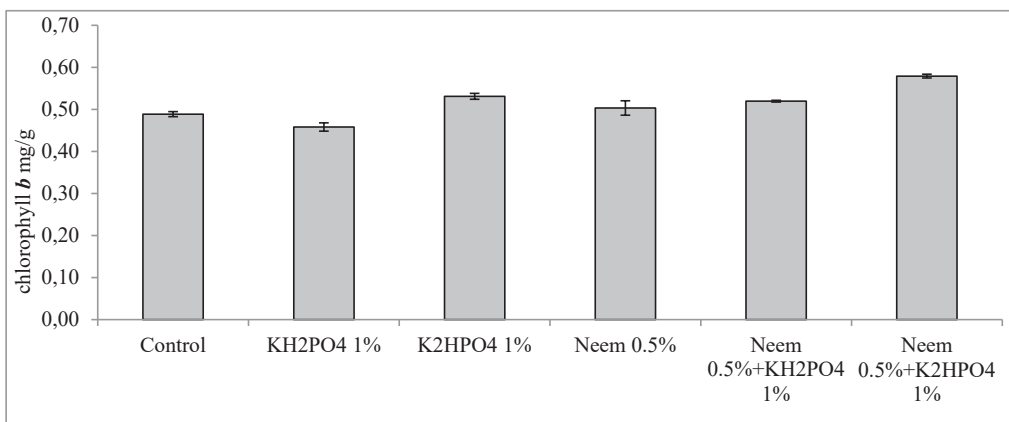


Figure 5. Effect of potassium phosphates and Neem oil on chlorophyll *b* contents (mg/g of fresh weight) in the cucumber leaves. Vertical bars represent the mean of three replicates $\pm$ standard error. Mean $\pm$ standard error

On the other hand, it is worth noting that four treatments with these mineral salts of potassium phosphates of course contributed to a certain extent to the improvement of mineral nutrition of cucumber plants, increasing the photosynthetic activity, which undoubtedly had

positive repercussions on the improved development of plants and the increase in fruit productivity. Hence, our study showed that all treatments led to an increase in the content of Chl. *a*, and had less impact on Chl. *b* modifications. These findings are consistent

with those of Ahmed et al. (2021), who found that celery treated with biological control agents showed a significant increase in chlorophylls and carotenoids pigments in leaves of celery. Overall, the results of the current research indicate that treatments with potassium phosphate in conjunction with Neem oil application had a beneficial impact on pathogen tolerance, protecting the functions of the photosynthetic apparatus by improving the status of chlorophylls in cucumber leaves. Hence, based on the experimental findings we can suggest that the integrated use of the tested biorational products could offer an ecologically alternative to the use of synthetic fungicides in suppressing powdery mildew in cucumber plants.

CONCLUSIONS

Results of the study demonstrated that application of monopotassium phosphate and dipotassium phosphate, applied alone or alternated with the Neem oil displayed fungicidal activity against cucumber powdery mildew.

The alternate use of dipotassium phosphate and Neem oil was the most effective for controlling powdery mildew disease compared to individual treatments. The concentrations of photosynthetic pigments increased after treatments with potassium phosphate in combination with treatments of Neem oil emulsion.

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