CHANGES IN NUTRIENT STATUS AND PRODUCTIVITY OF TREATED CUCUMBER PLANTS WITH POTASIUM PHOSPHATES AND NEEM OIL EMULSION AGAINST POWDERY MILDEW

MODIFICARILE CONTINUTULUI DE NUTRIENTI SI ALE PRODUCTIVITĂȚII PLANTELOR DE CASTRAVETI TRATATE CU FOSFATI DE POTASIU SI EMULSIA ULEIULUI DE NEEM IMPOTRIVA FAINARII

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Abstract.
A greenhouse experiment was carried out to evaluate the changes in nutrient status and productivity of cucumber plants treated with monopotasium phosphate, dipotasium phosphate and neem oil applied against powdery mildew. All treatments resulted in different changes of nitrogen, phosphorus and potassium contents in leaves. The application of neem oil emulsion alone recorded the lowest influence on nutrient status of cucumber plants. The most significant increase of phosphorus and potassium concentrations in leaves was registered in treatment with integrated use of dipotassium phosphate (1%) and emulsion of neem oil (0.5%). There was significant negative correlation between the phosphorus concentration in leaves and disease severity of powdery mildew. Thus, this study revealed that the integrated use of potassium phosphates and emulsion of neem oil, applied against powdery mildew, changed the contents of nutrients in cucumber leaves and improved yield of cucumber plants.
Key words: cucumber, neem oil, nutrients, potassium phosphate.

Rezumat.
A fost realizat un experiment în seră pentru a evalua schimbările in statusul de nutrienti si productivitatea plantelor de castraveți tratate cu monopotasiu fosfat, dipotasiu fosfat și emulsia uleiului de neem, aplicate împotriva fainarii. Aplicarea tratamentelor a contribuit la modificări ale conținutului de azot, fosfor și potasiu din frunze. Administrarea emulsiei uleiului de neem aparte a înregistrat cea mai mică influență asupra statusului de nutrienți in frunzele plantelor. Creșterea mai evidentă a concentrației de fosfor și potasiu în plante a fost înregistrată în tratamentul cu utilizarea integrată a dipotasiului fosfat (1%) și a emulsiei uleiului de neem (0,5%). S-a stabilit o corelație negativă semnificativă dintre concentrația de fosfor din frunze și intensitatea făinării. Așadar, acest studiu a demonstrat că utilizarea integrată a fosfaților de potasiu și

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emulsiei uleiului de neem la plantele de castraveți, afectate de făinare, a modificat conținutul elementelor de nutriție și a majorat productivitatea plantelor.

Cuvinte cheie: castraveți, ulei de neem, nutrienți, fosfați de potasiu

INTRODUCTION

Vegetable crops production is limited by a range of biotic unfavourable factors which as a consequence significantly reduce crop yield and quality in many regions of the world, including in the Republic of Moldova [Lal et al., 2023]. Among the biotic factors, phytopathogens such as bacteria, fungi, nematodes have dangerous impacts on agricultural productivity and sustainability. Nowadays, there are a lot of ecological plant protection products as alternatives for chemical fungicides to combat crops diseases, in particular the powdery mildew in cucumber plants. It was confirmed that mineral nutrients have a range of biological activities improving the resilience of crops against phytopathogens [Dordas, 2008]. For instance, Reuveni and co-works (1994) revealed that potassium phosphates used as foliar spray, are the target agent for inducing resistance to powdery mildew disease in flax. Nevertheless, it is worth underlining that the application of chemical plant protection substances as well as natural essential oils affects different biological metabolic aspects of crops, especially the nutrients contents in plants.

Nitrogen, phosphorus and potassium are essential mineral nutrients for plant growth, health and productivity [Bhat et al., 2024]. There is a larger body of scientific data demonstrating that major nutrients are directly involved in plant protection as structural components and metabolic regulators [Huber and Graham, 1999]. As the primary line of defence, the plant's nutritional status can play a significant role in determining the plant's susceptibility or resistance to infection by phytopathogens [Tripathi et al., 2022]. Although, it is widely recognized that mineral nutrition can influence disease, much of the available information is contradictory, showing both disease suppression and disease stimulation [Walters, D.R. Bingham, 2007]. To our knowledge, in most investigations the focus was on determining the impact of protection products on disease control and their efficiency in reducing the damage caused by phytopathogens. Among essential oils *A. indica* L. oil is used primarily for its antifungal and insecticidal properties. However, it should be noted that the application of neem oil alone, in some cases, did not show sufficient efficacy to combat fungal diseases [Murugesan, 2024].

There are not sufficient experimental results regarding how ecological protection products influence the mineral nutrient status of crops, in particular in cucumber plants affected by powdery mildew. Therefore, the aim of this study was to evaluate the effect of monopotassium phosphate, dipotassium phosphate and emulsion of neem oil, used against cucumber powdery mildew, on nitrogen, phosphorus and potassium contents in leaves and on the productivity of plants.

MATERIALS AND METHOD

Cucumber variety Iulian used in the investigation is susceptible to the powdery mildew pathogen S*phaerotheca fuliginea*. The experimental design included six treatments with three replicates of each treatment. The applied treatments were as follows: 1. Control, untreated plants; 2. Monopotasium phosphate 1%; 3. Dipotassium phosphate 1%; 4. Neem oil 0.5%; 5. Monopotasium 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 four sprays were made at weekly intervals. Plants sprayed with water served as control. After the final, fourth treatment, for nitrogen, phosphorus, and potassium determinations in leaves, plant samples from each plot were dried at 70°C in a forced-air oven for 48h. The dried plant material was ground and subjected to chemical analysis. N, P, and K concentrations in the leaves were analysed after digestion with sulfuric acid and peroxide [Mineev, 1989]. Total N was determined using Kjeldahl method according to the procedure described by Mineev [1989]. The P content was determined spectrophotometrically. The potassium content in leaves was determined using flame photometer. Yield was estimated as fruits weight/m^2. To examine the relationship between the concentration of phosphorus concentration in leaves and disease severity, correlation coefficients were calculated. Statistical analysis was performed using Statistic 7 program.

RESULTS AND DISCUSSIONS

Plant nutrient status plays an important role not only in ensuring the quantity and quality of agricultural production, but it largely determines plant resilience to adverse abiotic and biotic factors.

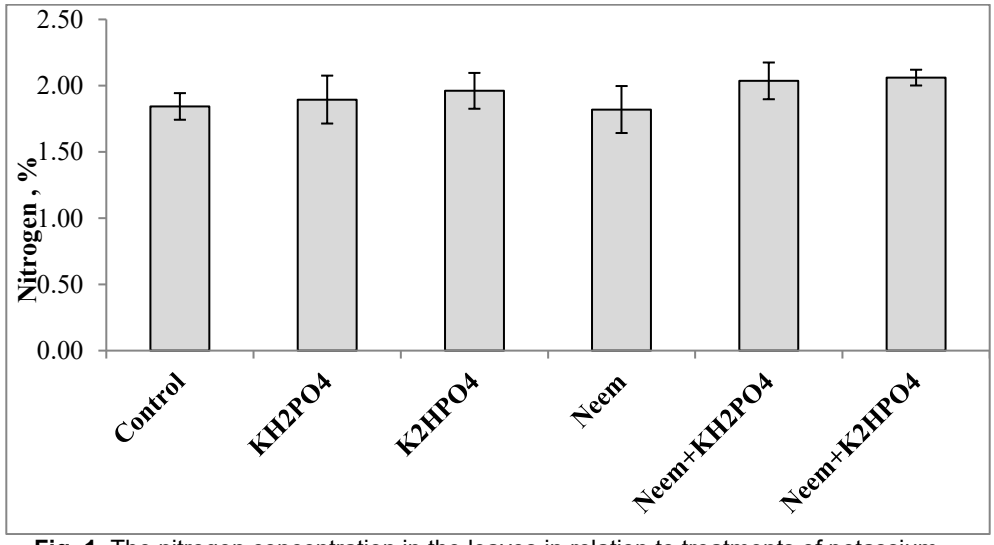

Fig. 1. The nitrogen concentration in the leaves in relation to treatments of potassium phosphates and neem oil emulsion applied alone or alternate. Data presented as the means of three replicates ± SD.

Usually, it is believed that high levels of nitrogen in plant tissues will increase the severity of diseases that are caused by obligate parasites [Bavaresco and Eibach, 1987]. The results of this study presented in Figure 1 show the changes of nitrogen concentrations in leaves in relation to treatments of cucumber plants. The experimental results showed that leaf nitrogen content did not change significantly under the influence of treatments with ecological products tested in this investigation (*Fig. 1*). However, it was observed that alternate applications of potassium phosphate and neem oil emulsion showed a slight improvement in plant nutrition with this major nutrient compared to the control and to the variant with neem oil emulsion applied alone. In the rest of the variants, there were no obvious effects of the treatments on changes in leaf nitrogen contents in leaves.

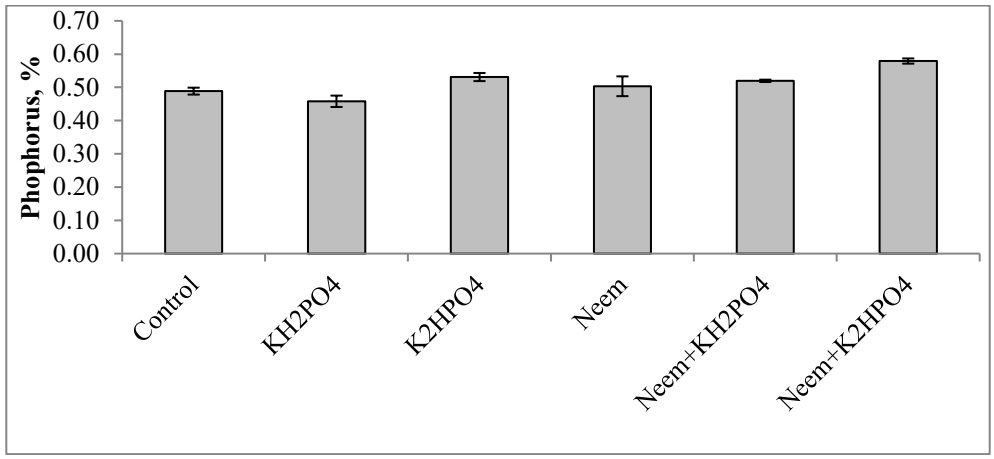

Fig. 2. The phosphorus concentration in the leaves in relation to treatments of potassium phosphates and neem oil emulsion applied alone or alternate. Data presented as the means of three replicates ± SD.

Previous studies have found that phosphorus supply affects disease levels differently in different species of plants. For example, Mustafa and co-works [2016] found that P inhibits wheat powdery mildew (*Blumeria graminis*), whereas Develash and Sugha [1997] found that P increases the severity of onion downy mildew (*Peronospora destructor*). There is a large body of scientific information confirming the fact that adequate phosphorus supply plays significant physiological role for realizing the potential of plant resistance to phytopathogen attack. Therefore, we decided to monitor the changes in the phosphorus content in plant tissues in relation to treatments of plant protection products. The changes in phosphorus content in plant leaves under the action of ecological treatments with potassium phosphates and neem oil are presented in *Figure 2*. The data of this investigation showed that the phosphorus content in the leaves underwent changes depending on the treatments applied. However, at the same time it can be stated with certainty that the beneficial effect of the treatments was detected in the case

of application of dipotassium phosphate used either separately or in an alternating way with neem oil emulsion where the phosphorus content in leaves increased by 10.3% of the leaf dry weight compared to the control variant. Similarly, the research conducted out by Reuveni and co-works [2000] have shown that improved phosphorus nutrition due to foliar potassium phosphate application significantly reduces phytopathogen attack on cucumber plants.

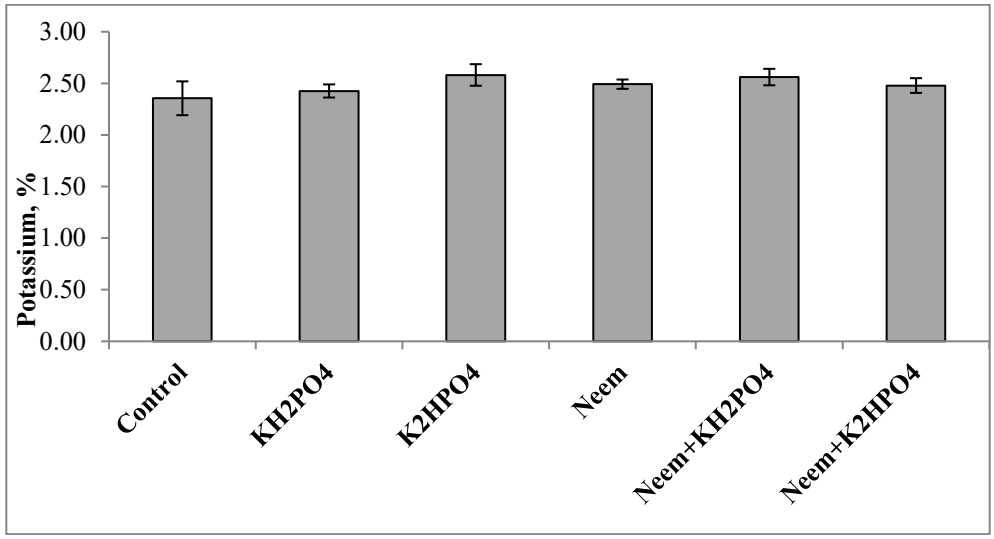

Fig. 3. The nitrogen concentration in the leaves in relation to treatments of potassium phosphates and neem oil emulsion applied alone or alternate. Data presented as the means of three replicates ± SD.

Potassium enrichment in cucumber reduced the natural incidence of powdery mildew [Elad et al., 2021]. According to the specialized literature, plants sufficiently supplied with potassium are more resistant and resilient to adverse abiotic and biotic environmental factors. The leaf potassium contents data registered in our experiment in relation to treatments are shown in *Figure 3*. It was revealed that the use of monopotassium phosphate alone had little influence on potassium content in leaves. However, in the variant where dipotassium phosphate was applied, an increase (by 15.2%) in this biological index was established compared to the untreated control plants (*Fig. 3*). Virtually the same beneficial effect on potassium content was observed in the variant where potassium phosphate salts and neem oil emulsion were applied together. Therefore, it can be stated that the use of biorational plant protection products improves the potassium nutrient status of cucumber plants. Likewise, a slight decrease in the intensity of leaf wilting was visually observed in plants better supplied with potassium. In this study we evaluated the relationships between cucumber powdery mildew severity and the concentrations of phosphorus in leaves (data not presented). Calculation of the correlation coefficient *r* between disease intensity and leaf phosphorus content

established a strong negative correlation. Thus, a coefficient between these parameters of r = -0.91 was established at the second estimation of disease severity, and at the third assessment of disease severity this correlation coefficient was r = -0.94. Therefore, it can be stated that a strong relationship was established between the powdery mildew severity and leaf phosphorus concentration in cucumber plants.

Alongside disease evaluation, agricultural producers as well as researchers have a particular interest in knowing the impact of plant protection treatments on crop yields, because this is a main objective in farming. Nitrogen, phosphorus, and potassium are essential nutrients for many physiological and metabolic processes, which determine plant productivity. There are results in the specialized literature that clearly demonstrate the beneficial effects of treatments with both potassium- and phosphorus containing salts on the growth, development, photosynthetic and metabolic activity, and productivity of crops. However, there is less data on the effect of plant protection treatments on the cucumber fruits yield. In the present study, the fruit productivity of cucumber plants was analysed according to the treatments with monopotassium phosphate, dipotassium phosphate, neem oil, applied either separately or alternately (*Fig. 4*).

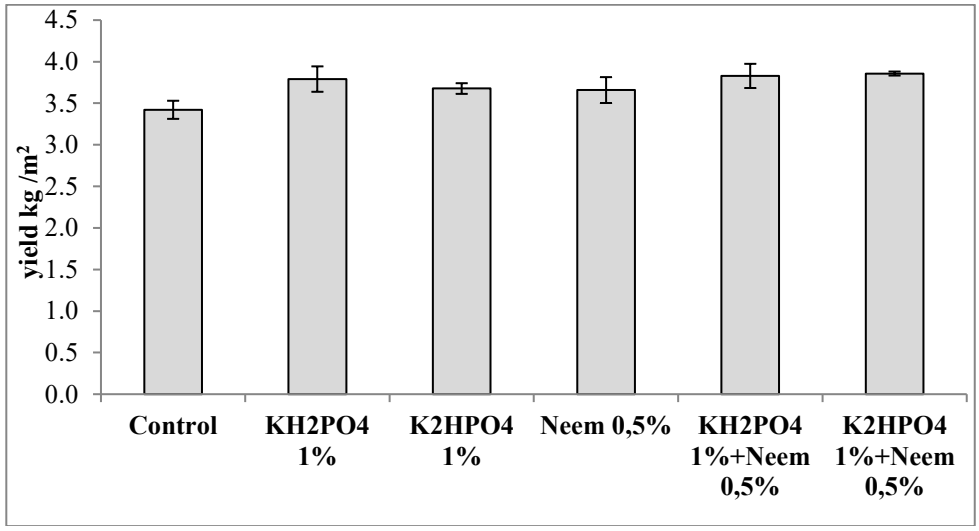

Fig. 4. Influence of potassium phosphates and neem oil on productivity of cucumber plants. Error bars represent LSD at $p \leq 0.05$ of a mean pooled from three replications

It was found that application of potassium phosphates in combination with neem oil emulsion treatments led to an increase in cucumber yield. Thus, experimental results demonstrated that integrated use of these two ecological plant protection products contributed not only to a reduction in the damage to the plants by powdery mildew, but also to an increase by 12.9% in productivity compared to

untreated plants. The experimental result are in concordance with those obtained by Tanaka and co-works [2017] who found that the biological treatments reduced powdery mildew disease and increased the cucumber yield. On the other hand, there was no positive effect in treatment with emulsion of neem oil on the fruits productivity. In our previous paper, it was shown that alternating applications of potassium salts and neem oil emulsion provided better powdery mildew control than their separate application [Rotaru and Todiraș, 2025]. Thus, we supposed that alternate application of mineral salts and emulsion of neem oil contributed to a certain extent to improve mineral nutrition, which undoubtedly had positive repercussions on the better plant growth and development. Future research should focus to identify the optimum ratios of potassium phosphate and neem oil, which would have a higher efficacy on inhibition of powdery mildew disease and on the other hand to stimulate crop productivity.

CONCLUSIONS

The application of ecological plant protection products of potassium phosphates salts and neem oil emulsion, used against cucumber powdery mildew, affected the contents of major mineral elements in leaves.

Treatments of cucumber plants with potassium phosphate and neem oil emulsion improved plant phosphorus and potassium status and did not alter significantly the nitrogen content in the leaves of cucumber plants. A strong negative correlation was established between phosphorus contents in the leaves and the severity of powdery mildew disease.

Alternate use of dipotassium phosphate and neem oil emulsion increased the fruit yield of cucumber plants by 12.9% compared to the control, untreated plants.

ACKNOWLEDGMENTS

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