EFFECTS OF BIOLOGICALS AND PLANT GROWTH REGULATORS ON THE SOWING QUALITY OF EGGPLANT SEEDS

Shchetyna S.V.1, Kichihina O.O.2, Ulianych O.I.1

1Uman National University of Horticulture, 1 Instytutska Str., Uman, Cherkaska Oblast, 20300, Ukraine
E-mail: sv_shetina@ukr.net, olena.ivanivna@gmail.com

2Institute of Agroecology and Nature Management of NAAS, 12 Metrolohichna Str., Kyiv, 03143, Ukraine
E-mail: seednlen@ukr.net

https://doi.org/10.3271/0131-0062-2024-75-59-71

Purpose. To investigate effects of biologicals with fungicidal and stimulating activities and natural and synthetic plant growth regulators on the sowing quality of seeds of various eggplant hybrids. Methods. Laboratory methods in compliance with DSTU 4138:2002. Results. Soaking of seeds of various eggplant hybrids in Phytocid, Mycosan-B, PhytoHelp, MycoHelp, Azotophyt, Vympel, Humisol, Ivin, and Emistim C solutions had positive effects on the sowing quality of seed: the germination energy increased on average by 1–34% and the laboratory germinability – by 2–28%. Regardless of the hybrid, soaking of seeds in Phytocid, PhytoHelp, and MycoHelp solutions significantly increased the germination energy by 34.2%, 32.5%, and 32.5%, respectively, compared to the control and the laboratory germinability of seeds by 27.6%, 27, 4% and 27.4%, respectively. When plant growth regulators Azotophyt, Ivin, and Emistim C were applied, the germination energy and laboratory germinability increased on average by 18–28% and 15–24%, respectively, compared to the control. With Mycosan-B, Vympel, and Humisol, the germinability and germination energy of seeds did not differ from the control levels. Soaking of eggplant seeds in solutions of the studied formulations positively affected the seedling length: there was on average a 1.24- to 1.94-fold elongation of seedlings. It was found that seeds of the investigated eggplant hybrids were contaminated with phytopathogenic micromycetes and, depending on damage degree, the hybrids were ranked in the following order: 'Sapfir' > 'Sharapova', 'Samurai' > 'Leire' > 'Night Lady', 'Fabina' > 'Destan'. Mycosan-B, Vympel, and Humisol were little effective (2.5–6.3%) against phytopathogens in comparison with the other formulations. Phytocid, PhytoHelp, and MycoHelp exerted potent fungicidal effects, which varied on different hybrids: 42.5–68.8%, 30.0–65.6%, and 32.5–65.6%, respectively. The fungicidal effectiveness of Ivin and Emistim C was 20.3% and 18.8%, respectively. Conclusions. Soaking of eggplant seeds in solutions of biologicals (Phytocid, PhytoHelp, and MycoHelp) and synthetic and natural plant growth regulators (Ivin and Emistim C, respectively) was shown to beneficially affect the sowing quality of seeds and suppress fungal phytopathogens. The greatest stimulatory effects of Phytocid, PhytoHelp, MycoHelp, Ivin, and Emistim C on the sowing quality of seeds were seen on hybs. 'Destan', 'Leire', and 'Fabina', 51–58% suppression of phytopathogens was achieved when eggplant seeds were soaked in Phytocid, PhytoHelp, and MycoHelp; Ivin and Emistim C resulted in 19–20% suppression. The greatest suppression of phytopathogens on eggplant seeds was observed on hybs. 'Destan', 'Leire', 'Night Lady', and 'Fabina'.

Key words: Solanum melongena L., hybrids, laboratory germinability, germination energy, phytopathogens.

Introduction. In current technologies for growing crops, including vegetables, biologicals and plant growth regulators (PGRs) become important (Kuts et al., 2020; Volkohon & Moskalenko, 2021; Sosnowski et al., 2023). This is related both to the transition to sustainable agriculture methods and the implementation of the Global Good Agricultural Practices (GLOBALGAP) policy to reduce the negative impact on the environment and obtain top-quality and safe products and to the objective of increasing the tolerance of plants to stressors associated with climate changes, pollution of the natural environment, and enhanced harmful effects of phytophages and phytopathogens (Oberč, Schnell, 2020).

Review of Recent Studies and Publications. The agricultural sector is constantly developing; this results in new technologies and innovations aimed at solving the problems of food security, minimizing climate changes and reducing their
negative impact on agricultural production, as well as at mitigating other environmental problems to achieve the Goals of Sustainable Development.

Unfortunately, the current situation in Ukraine is aggravated by the full-scale invasion of the Russian Federation; the current state of the domestic agribusiness, including the economic situation in the vegetable cultivation, does not allow for the full implementation of highly effective innovative agricultural technologies. Therefore, there is a need to find and introduce into production alternative farming techniques using soil-protective technologies, green manure crops, biological and organic fertilizers, biologicals, PGRs in the plant protection algorithms, etc.

Improvement of crop rotations, reduction in pesticide loads, creation of new cultivars and hybrids that will be resistant to biotic and abiotic factors, and application of alternative environmentally friendly ways of fertilization and protection against pests and diseases are pre-requisites for the production of ecologically clean vegetables (Rud et al., 2022).

Currently, the maximum fulfillment of the genetic potentials of crops, the harvest of high yields, manufacturing of top-quality and safe products, and reduction in the negative anthropogenic impact on agrophytocenoses are urgent challenges in vegetable cultivation technologies. After all, the excessive and unjustified application of pesticides and agrochemicals in intensive technologies negatively affects the environment, natural resources, and biodiversity and poses a direct threat to human health (Tudi et al., 2021). Therefore, there is an urgent need for a gradual transition from intensive technologies for growing vegetables to adaptive ones. Such cultivation systems, on the one hand, are transitional to organic; on the other hand, they are an alternative to intensive technologies (Vitanov et al., 2019). The transitional period from traditional to organic technology primarily involves ecologization of vegetable growing, which can be achieved through the use of biologicals and PGRs, alternative fertilizers, etc. and significantly reduce the application of mineral fertilizers and chemical agents for plant protection (Brust, 2019; Klimczuk & Klimczuk-Kocharinska, 2020; Kowalska & Matysiak, 2023).

Biologicals, including biologicals for plant protection against pests and pathogens, are an important, integral component of the protection algorithm in crop production in EU countries, which care about ecological and biological safety (The Future of Crop Protection in Europe, 2021). In particular, the Farm to Fork Strategy, as a central component of the European Green Deal, declares a 50% reduction in the total use and risk of chemical pesticides and a 50% reduction in the application of the most dangerous pesticides by 2030. At the same time, the need for wider use of safe alternative methods of protecting crops against harmful organisms and for a reduction in nutrient losses by at least 50% in plant fertilization was outlined (European Commission Communication COM/2020/381, 2020).

Biologicals based on agronomically useful species of microorganisms occupy an important place in organic technologies for growing vegetables (Fernández et al., 2022). However, in Ukraine unfortunately, biologicals are not widely used in agriculture. This is partially caused by underestimation of their beneficial properties and insufficient development of the plant protection biologicals market, which are serious obstacles to using safe, effective, and inexpensive biologicals by agricultural enterprises, farms, and owners of homesteads (Krutiaikova et al., 2023).

The priority of achieving the soonest maximum effect is still decisive in the selection of fertilizers, stimulants, and plant protection products. This is evidenced by analysis of the usage of biologicals and biomethods in Ukraine, which indicated a sharp reduction and an extremely rare application of biomethods in agriculture in recent decades: 4–5% of the total amount of plant protection, and the share of agricultural areas protected against harmful organisms with biologicals was 2.9–8.5% of the total cultivated area (Tkalenko et al., 2020; Krutiaikova et al., 2023).

The introduction of biologicals based on agronomically useful strains of microorganisms and into agrophytocenoses improves the phytosanitary condition due to a significant reduction in the pesticide load and a boost of beneficial microbiota. This contributes to an increase in the profitability of vegetable growing via extending the fruiting period, which helps to increase yields and obtain top-quality ecologically clean products that are competitive in the Ukrainian and European markets (Tkatenko et al., 2020).

Microorganisms, which are the basis of biologicals, have a complex of useful properties: they stimulate the growth and development of plants, inhibit the development of phytopathogenic microorganisms both in agrophytocenoses and during storage of products, and improve the mineral nutri-
tion of plants (Volkohon & Moskalenko, 2021; Pizik, 2021).

Over the past twenty years, a lot of fertilizing and protective biologicals have been developed in Ukraine. Comprehensive studies have been conducted on various agricultural crops, including vegetables. For example, Phosphobacterin, Mycoptil, Polymyxobacterin, and Albobacterin contribute to the transformation of soil phosphates into a form available for plants, thereby improving plant nutrition (Makukha, 2020; Volkohon & Moskalenko, 2021). Positive effects on the growth and development, yield and biochemical indicators of the quality of table root crops (carrots, beets) were recorded for such biologicals as HelpRost and HelpRost + PhytoHelp (Ulyanych & Shchetyna, 2021). The effectiveness of Avercom, Biophosphorin, Gaupsin, and Planriz on vegetables in terms of suppressing the germination of spores of micromycetes Alternaria solani and Phytophthora infestans was proven (Borzykh et al., 2022). In addition, the effectiveness of the combined application of biologicals (Azotobacterin (based on Azotobacter chroococcum IMV B-7171), Biophosphorin (based on Bacillus megaterium IMV B-7168) and fungicides (Acrrobat MC, Quadris 250 SC, Ridomil Gold MZ 68 WG, Infinito 61 SC) on tomatoes and white cabbage against phytopathogenic micromycetes of the genera Alternaria, Pseudoperonospora and Fusarium was demonstrated. It was revealed that such combinations decreased the pesticide load on agrocenoses by 17–33% (Tytova & Serhiienko, 2018).

The line of biologicals for crop production includes formulations based on metabolites of microorganisms and streptomycetes – antibiotic substances. Such biologicals are used to control the causative agents of mycoses and bacteriosis. For example, the antibiotic trichothecin is obtained from the culture material of the fungus Trichothecium roseum (Zhu et al., 2022), phytobacteriomyacin – from Streptomyces griseus or S. lavendulae (Komaki, 2023).

Application of highly effective PGRs of the new generation, along with breeding-genetic and biotechnological methods, is a way to fulfill the biological yield potential (Thakur, 2022; Sosnowski et al., 2023; Wu et al., 2023). Research into and application of PGRs are considered key measures to achieve "super production" in agriculture of the 21st century and to strengthen the global agricultural production by mitigating environmental factors and optimizing yields (de Andrade et al., 2023). This is evidenced by growing volumes of PGR sales on world markets, reflecting the constant demand for this type of agroproducts (Report, 2023). PGRs are a promising measure for improving the sowing qualities of seeds and managing the plant performance upon pre-sowing treatment of seeds and spraying of plants during the seedling period; they make it possible to obtain top-quality seedlings, accelerate growth, development, and ripening of fruits, and to increase yields (Mykhalska et al., 2013; Kuts et al., 2021; Shah et al., 2023).

The range of their positive effects is quite wide: increased yields (a gain in yields of 10–15 million t/year worldwide), improved quality of grown products, strengthened tolerance of plants to adverse environmental factors, reduced doses of chemical protectors upon combined application with growth regulators, etc. (Report, 2023; Shah et al., 2023). This is evidenced by data of many research institutions and numerous scientific and industrial verifications. In addition, PGRs are now widely used in agriculture as important elements of environmentally friendly resource-saving technologies (Spolidorio & Lollato, 2019), which are also economically beneficial. Regulation of growth and morphogenesis processes by PGRs depends on the plant species, phase and method of treatment, concentrations and chemical structure of agents, and physiological effects (Rogach et al., 2021).

According to current conceptions, PGRs are understood as natural or synthetic organic substances that have significant biological activities and, in small doses, change physiological and biochemical processes, growth, development, and yield formation in crops, without causing toxicities (Wu et al., 2021; Gan et al., 2022; Kuts et al., 2021). Analysis of the use of biologically active substances showed that rather synthetic PGRs than endogenous compounds were used in large areas around the world (Report, 2023). Natural PGRs include phytohormones such as auxins, gibberellins, cytokinins, abscisic and succinic acids, ethylene, brassinolides, etc. (Hrytsaenko et al., 2008). Formulations based on humic and fulvic acids were also highly efficient (Savarese et al., 2022; Ampong et al., 2022).

Among their various functions, PGRs affect plant growth and performance. In particular, growth processes are intensified due to exogenous growth regulators, including native endogenous hormones, which change plant morphometric parameters and the leaf apparatus structure (Wu et al., 2023).
It was demonstrated that the treatment of plants with exogenous growth regulators (1-naphthyl acetic acid (1-NAA), gibberellic acid-3 (GA-3), 6-benzylaminopurine (6-BAP)) in the budding phase increased the linear dimensions of plants, the numbers and biomass of leaves, stems and roots in sweet pepper (Rogach et al., 2021).

Currently, in Ukraine, comprehensive scientific research is being carried out to develop new generation PGRs (synthetic and natural), starting with the initial screening of these substances and comprehensive studies of their physico-chemical, physiological, and toxicological properties before their introduction into agricultural production. In particular, several studies were conducted to investigate mechanisms of the physiological action of PGRs upon both seed treatment and spraying of plants grown indoors and outdoors. It was shown that major physiological and biological processes in plants were activated due to high biological activities of PGRs (Hrytsaienko et al., 2008; Rogach et al., 2021).

Of the Ukrainian PGRs of the new generation, agrarians most often use Biosil, Biolan, Vympel, Radostim, Emistim C, Ivin, and others, the effectiveness of which was confirmed by long-term field trials under various pedo-climatic conditions. Thus, the application of Epin-N and Vympel on various kohlrabi cultivars resulted in a faster emergence of seedlings (on average by 1–2 days), the subsequent phases of vegetation also came 3–4 days earlier, and the yield was increased by 0.5–1.0 kg/m² (Kovtuniuk, 2015). The application of Energy M shortened the growing period in table beet by 3–4 days (Kuts et al., 2020).

Scientists of the Institute of Vegetable and Melon Growing of NAAS studied 15 of the most common PGRs and found that these agents acted as inducers of resistance to common diseases, but with low biological efficiency (42–56% against root rot and 26–38% against downy mildew of cucumber) (Kuts et al., 2020).

Positive effects of soaking of seeds in PGR solutions on the sowing quality of seeds and of spraying of plants during the seedling period to obtain top-quality seedlings, accelerate the growth, development, and ripening of fruits, and increase their yield were observed (Kuts et al., 2021).

Treatment of seeds with a natural stimulator based on 60% water-ethyl extract from the aerial part of Verbascum densiflorum Bertol. improved the seed germination, intensified the growth and development, and increased yields of tomatoes, onions, and white cabbages. Treatment of seeds with 0.01% solutions of the formulations had a complex positive effect: increased the germination energy and germinability of seeds, promoted the emergence of even and uniform seedlings, optimized the plant density, accelerated growth of the assimilation surface of leaves, increased the yield and output of marketable products (Kuts et al., 2021).

In studies to determine the effectiveness of Krezacin, Silacin, and Energy M, positive stimulating effects on the growth of Solanaceae plants were demonstrated: sweet peppers yielded by 19.1–24.7% more, tomatoes – by 17.5–30.9% more, and eggplants – by 16.4% more (Kuts et al., 2020).

Therefore, in Ukraine, different biologicals and PGRs are rather extensively studied on vegetables, both to evaluate the effect of a formulation on physiological and biological processes in plants and to develop and implement environmentally friendly technologies. However, the ever-growing assortment of biological and PGRs as well as insufficient data on the effects of these formulations on eggplant (Solanum melongena L.) require more attention from scientists and agrarians.

Our purpose was to investigate the effects of fungicidal-stimulating biological (Phytocid, Mycosan-B, PhytoHelp, MycoHelp) and natural and synthetic PGRs (Azotophyt, Vympel, Humisol, Ivin, Emistim C) on the sowing quality of seeds of different eggplant hybrids.

Materials and Methods. The study was conducted at the Independent Laboratory of Seed Ecology of the IAP NAAS, the effects of the fungicidal-stimulating biological (Phytocid, Mycosan-B, PhytoHelp, MycoHelp) and natural and synthetic PGRs (Azotophyt, Vympel, Humisol, Ivin, Emistim C) on the sowing quality of seeds of different eggplant hybrids were evaluated and the efficacy against phytopathogens on seeds was estimated. Eggplant seeds were soaked in working solutions.
of the studied formulations in the concentrations recommended by the manufacturer: Azotophyt – 20 mL of concentrate was diluted in 0.7 L of water per 1 kg of seeds, Phytocid – 20 mL of concentrate was diluted in 0.7 L of water per 1 kg of seeds, Mycosan-B – 100 mL of concentrate was diluted in 1.0 L of water per 1 kg of seeds; PhytoHelp – 10 mL of concentrate was diluted in 0.7 L of water per 1 kg of seeds; MycoHelp – 10 mL of concentrate was diluted in 0.7 L of water per 1 kg of seeds; Ivin – 200 mL of concentrate was diluted in 2.0 L of water per 1 kg of seeds; Emistim C – 1 mL of concentrate was diluted in 10 L of water according to the recommended dose of 10 mL of concentrate per 1 t of seeds; Vympel – 10 mL of concentrate was diluted in 0.5 L of water according to the recommended dose of 0.3 kg per 1 t of seeds; Humisol – 80 mL of concentrate was diluted in 2.0 L of water per 1 kg of seeds. The germination of eggplant seeds per the requirements of DSTU 4138:2002 was taken as the control (DSTU 4138:2002).

Eggplant hybrids with various ripening periods, ‘Destan’, ‘Sharapova’, ‘Leire’, ‘Samurai’, ‘Sapfir’, ‘Night Lady’, and ‘Fabina’ were tested. These hybrids are in the State Register of Plant Varieties Suitable for Dissemination in Ukraine. The seeds were germinated in Petri dishes at 20–30°C. The seed germination energy was recorded on day 7; the laboratory germinability was determined on day 14 in accordance with the requirements of the current standard (DSTU 4138:2002). The eggplant seedling length was measured on day 14 (n= 5).

The technical efficiency of the biologicals and PGRs against phytopathogens was calculated according to the following formula:

$$E = 100 \times (A - B) / A,$$

where

- $E$ – effectiveness of a formulation;
- $A$ – the number of affected seeds in the control;
- $B$ – the number of affected seeds that were treated with a formulation.

The experimental data were statistically processed in Microsoft Office Excel.

**Results.** It was found that soaking of seeds in solutions of the studied formulations positively affected the sowing quality of seeds of different eggplant hybrids; it was manifested as a 2–28% increase in the seed germinability and a 1–34% increase in the germination energy (Table 1).

**Table 1** Sowing quality of seeds of different eggplant hybrids soaked in solutions of the biologicals and PGRs, %

<table>
<thead>
<tr>
<th>Variant</th>
<th>Hybrid</th>
<th>Early-ripening</th>
<th>Medium-early</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Destan</td>
<td>Sharapova</td>
<td>Leire</td>
</tr>
<tr>
<td>Control</td>
<td>75/68</td>
<td>71/64</td>
<td>74/66</td>
</tr>
<tr>
<td>Azotophyt</td>
<td>88/82</td>
<td>84/78</td>
<td>85/79</td>
</tr>
<tr>
<td>Phytocid</td>
<td>99/94</td>
<td>93/88</td>
<td>97/93</td>
</tr>
<tr>
<td>Mycosan-B</td>
<td>78/72</td>
<td>75/68</td>
<td>75/69</td>
</tr>
<tr>
<td>PhytoHelp</td>
<td>99/94</td>
<td>90/85</td>
<td>96/90</td>
</tr>
<tr>
<td>MycoHelp</td>
<td>98/93</td>
<td>92/86</td>
<td>96/90</td>
</tr>
<tr>
<td>Ivin</td>
<td>94/89</td>
<td>88/83</td>
<td>95/89</td>
</tr>
<tr>
<td>Emistim C</td>
<td>96/89</td>
<td>89/82</td>
<td>96/89</td>
</tr>
<tr>
<td>Vympel</td>
<td>75/68</td>
<td>73/63</td>
<td>76/68</td>
</tr>
<tr>
<td>Humisol</td>
<td>79/73</td>
<td>74/68</td>
<td>75/70</td>
</tr>
</tbody>
</table>

LSD$_{05}$                             4.2/3.9

**Note:** numerator - germinability; denominator - germination energy.
In general, all investigated eggplant hybrids positively responded to seed treatment with biologicals. However, the effect of Mycosan-B on the sowing quality of seeds was rather weak and the studied parameters were very similar to the control values.

Regardless of the hybrid, soaking of seeds in Phytocid, PhytoHelp, and MycoHelp solutions significantly increased the germination energy (by 34.2%, 32.5%, and 32.5%, respectively) and the laboratory germinability of seeds (by 27.6%, 27.4%, and 27.4%, respectively) compared to the control. The highest laboratory germinability and germination energy of seeds treated with these agents were recorded for hybs. 'Destan', 'Leire', 'Night Lady', and 'Fabina' (Fig. 1). In these experimental variants, there was a 1.28- to 1.32-fold increase in the germinability and 1.32- to 1.41-fold increase in the germination energy compared to the control.

**Fig. 1.** Effect of biologicals (Phytocid, PhytoHelp, and MycoHelp) on the seed germinability of different eggplant hybrids, day 14
By seed germinability, the greatest positive effect was recorded for hyb. 'Destan' after the seed treatments with Phytocid, PhytoHelp, and MycoHelp. By germination energy, the greatest positive effect was noted for hybs. 'Destan' and 'Leire' after the seed treatment with Phytocid and for hyb. 'Destan' after the seed treatments with PhytoHelp and MycoHelp.

In addition, there was a significant increase in the sowing quality after the treatments of seeds with PGRs, Azotophyt, Ivin, and Emistim C: the germination energy and laboratory germinability of seeds increased on average by 18–28% and 15–24%, respectively, compared to the control (see Table 1).

The treatment of seeds with Vympel or Humisol had no significant effect on the germination of eggplant seeds of different hybrids. By germinability and germination energy of seeds, the effectiveness of these formulations was at the control level.

Synthetic (Ivin) and natural (Emistim C) agents were more effective growth regulators for the parameters of eggplant seeds of different hybrids. We observed an increase in the laboratory germinability of seeds treated with Ivin in hybs. 'Samurai' and 'Sapfir' (by 15–16%), hybs. 'Sharapova', 'Destan', and 'Night Lady' (by 24–25%), and hybs. 'Fabina' and 'Leire' (by 27–28%) compared to the control. Accordingly, the germination energy of treated seeds increased: by 20–23% in hybs. 'Samurai' and 'Sapfir', by 28–31% in hybs. 'Knight Lady', 'Fabina', 'Sharapova', and 'Destan', and by 35% in hyb. Leire'.

Somewhat better laboratory germinability of seeds was achieved with natural PHR, Emistim S: by 30% in hyb. 'Leire', by 28% in hybs. 'Destan', 'Night Lady', and 'Fabina', by 25% in hyb. 'Sharapova', and by 14% in hybs. 'Samurai' and 'Sapfir' compared to the control. In these experimental variants, the germination energy increased by 35%, 29–31%, 28%, 13–14%, respectively, compared to the control.

Soaking of eggplant seeds in solutions of the studied formulations positively affected the seedling length (Table 2).

**Table 2.** Eggplant seedlings length after soaking of seeds in solutions of biologicals and PGRs, cm, day 14

<table>
<thead>
<tr>
<th>Variant</th>
<th>Early-ripening</th>
<th>Medium-early</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Destan</td>
<td>Sharapova</td>
</tr>
<tr>
<td>Control</td>
<td>5.29</td>
<td>5.09</td>
</tr>
<tr>
<td>Mycosan-B</td>
<td>5.27</td>
<td>5.08</td>
</tr>
<tr>
<td>PhytoHelp</td>
<td>10.22</td>
<td>8.98</td>
</tr>
<tr>
<td>MycoHelp</td>
<td>10.21</td>
<td>8.74</td>
</tr>
<tr>
<td>Ivin</td>
<td>9.43</td>
<td>7.84</td>
</tr>
<tr>
<td>Emistim C</td>
<td>8.95</td>
<td>6.98</td>
</tr>
<tr>
<td>Vympel</td>
<td>7.16</td>
<td>5.43</td>
</tr>
<tr>
<td>Humisol</td>
<td>7.18</td>
<td>5.45</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;05&lt;/sub&gt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Eight out of the nine studied agents increased the eggplant seedling length on average by 1.24–1.94 times, regardless of the hybrid. In the Mycosan-B experiment, no stimulating effect on seed-
lings was noted; the seedling length was within the control limits in all seven eggplant hybrids. The strongest stimulating effect on eggplant seedlings was observed in the Azotophyt and Phytocid experiments: seedlings of all hybrids became longer on average by 94% and 90%, respectively. MycoHelp and PhytoHelp also made seedlings longer: by 84% and 82%, respectively. The mean stimulating effects of Ivin, Emistim C, Humisol, and Vympel on eggplant hybrids were 63%, 49%, 28% and 24%, respectively.

The greatest elongation (1.7-fold on average) of sprouts compared to the control was recorded for hybs. 'Destan', 'Night Lady', and 'Fabina', indicating the suitability of most of the studied formulations for these hybrids.

The results showed that seeds of all investigated eggplant hybrids were contaminated with phytopathogenic micromycetes (on average 30-40%, depending on the hybrid). This indicates their high potential capacity for biological pollution of agro-ecosystems and aggravation of the phytosanitary condition, if appropriate disinfection measures are not taken for seeds.

The highest percentage of seeds infected with fungal pathogens was detected in hybs. 'Sapfir' (40%), 'Sharapova' (36%), and 'Samurai' (36%) (Table 3). Hyb. 'Destan' had the lowest percentage of affected seeds (30%). Based on the phytopathological data, the investigated eggplant hybrids were ranked depending on the contamination degree by phytopathogenic micromycetes in the following order: 'Sapfir' > 'Sharapova', 'Samurai' > 'Leire' > 'Night Lady', 'Fabina' > 'Destan'.

The data in Table 3 show that most of the studied agents exerted a fungicidal effect against pathogens on seeds, but their effectiveness depended on both the formulation and the hybrid. Mycosan-B, Vympel, and Humisol were little effective against phytopathogens compared to the other agents: 2.8–5.9%, 2.5–5.6%, and 2.8–6.3%, respectively, depending on the hybrid.

Mycosan-B was ineffective against phytopathogens on hyb. 'Samurai'; Vympel – on hybs. 'Destan', 'Leire', and 'Fabina'; Humisol – on hybs. 'Destan' and 'Leire' (Fig. 2).

**Table 3. Percentage of infected eggplant seeds using different drugs, %, day 14**

<table>
<thead>
<tr>
<th>Variant</th>
<th>Early-ripening</th>
<th>Medium-early</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Destan</td>
<td>Sharapova</td>
</tr>
<tr>
<td>Control</td>
<td>30</td>
<td>36</td>
</tr>
<tr>
<td>Azotophyt</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>Phytocid</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>Mycosan-B</td>
<td>29</td>
<td>35</td>
</tr>
<tr>
<td>PhytoHelp</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>MycoHelp</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>Ivin</td>
<td>22</td>
<td>27</td>
</tr>
<tr>
<td>Emistim C</td>
<td>21</td>
<td>28</td>
</tr>
<tr>
<td>Vympel</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>Humisol</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
High fungicidal effects against pathogenic microbiota on seeds were exerted by Phytocid, PhytoHelp, and MycoHelp: 42.5–68.8%, 30.0–65.6%, and 32.5–65.6%, respectively, depending on the hybrid. These biologicals contain active strains of the bacterium *Bacillus subtilis* and other microorganisms producing various antibiotics and lytic enzymes (*Tokmakova & Shevchenko*, 2023), which explains their high fungicidal effects. The data in Table 3 show that there was a 1.3- to 1.5-fold suppression of phytopathogens caused by Phytocid, 1.5- to 2.0-fold suppression caused by PhytoHelp, and 1.6-to 1.8-fold suppression caused by MycoHelp in hybs. ‘Samurai’ and 'Sapfir'. The studied hybrids were ranked according to the effectiveness of Phytocid, PhytoHelp, and MycoHelp against phytopathogenic microorganisms on seeds as follows: 'Night Lady', 'Fabina' > 'Destan' > 'Leire'.

In the Ivin and Emistim C experiments, the suppression of phytopathogenic microbiota on eggplant seeds was almost twice as low as in the experiments with biological fungicides: the mean effectiveness was 20.3% and 18.8%, respectively. The effects of these growth regulators also varied from hybrid to hybrid. In particular, the lowest effectiveness of Ivin was recorded for hybs. 'Leire' (11.8%) and 'Samurai' (13.9%); Emistim C had the lowest effectiveness on hybs. 'Samurai' (11.1%), 'Leire' (11.8%), and 'Sapfir' (12.5%), which was 1.7–2.0 times lower compared to other hybrids.

**Discussion.** The use of environmentally friendly biologicals and PGRs to stimulate physiological and biochemical processes at the initial stages of plant development is considered an effective measure to improve the sowing quality of seeds and induce tolerance of plants to various factors at subsequent stages of organogenesis (*Kuts et al.*, 2021; *Shah et al.*, 2023). However, a positive effect can be only achieved by using high-quality formulations, strict adherence to the manufacturer’s recommendations, optimal dosage (concentration of the working fluid), and formulation-crop (cultivar/hybrid) compatibility, which requires comprehensive research into each crop. At the same time, the effects of biologicals and PGRs on solanaceous vegetables have been studied fragmentarily (*Rogach et al.*, 2020). Most of the studies, in particular by Ukrainian scientists, were focused on the evaluation of the impact of biologicals and PGRs on the growth, development, and performance of vegetables.

Our study demonstrated that most of the studied biologicals with fungicidal-stimulating activities positively affected the sowing quality of eggplant seeds of different hybrids, increasing the germination energy by 5–34% and germinability by 3–28%. Similar results were obtained in studies with biofungicide MycoHelp applied on seeds of cucumbers, tomatoes, sweet peppers, white cabbages, and onions (*Kuts et al.*, 2021; *Shah et al.*, 2023). The Mycohelp dosage was determined, which allowed for a significant improvement of the sowing quality of vegetable seeds, in particular, onions (20–100 mL/kg increased the germination energy by 31.7–46.3% related to the absolute control value) and sweet peppers (20–40 mL/kg – by 9.5–17.6%). Seed treatment with Vympel Maxi (0.4–2.0% solution) increased the germination energy of tomatoes by 2.6–8.0%, the germinability of seeds – by 1.3–7.0%, and the root length – by 0.68–3.75
cm. On cucumbers, the results were as follows: the germination energy was increased by 8–11%, the germinability of seeds – by 4–5%, and the root length – by 0.4–1.1 cm (Kuts et al., 2021). Testing Vympel K and Vympel K2 in concentrations of 2%, 3%, and 5%, researchers noted stimulating effects on the germination of carrot and onion seeds; however, for white cabbage seeds, a decline or a negative trend in the germination energy, germinability of seeds and seedling weight was recorded (Kuts et al., 2020). Similar results were obtained in our experiments: soaking of eggplant seeds in Vymipel solution had no significant effect on the germinability and germination energy of seeds, while Azotophyt, Ivin, and Emistim C were more effective in improving the sowing quality of eggplant seeds.

In several studies, the effectiveness of presowing seed treatment and foliar treatment of vegetables with exogenous growth regulators was also demonstrated (Rogach et al., 2020; Rogach et al., 2021; Kuts et al., 2020). Thus, treatments of carrot seeds with fusicoxacin, symbiont-1, and cytokinin solutions (Bisofset, Adefim, Adenophos) ensured a 6–20% increase in the germination energy of seeds (Kuts et al., 2020).

Currently, vegetable agrocenoses are characterized by high numbers of phytopathogenic microorganisms, negatively affecting plant growth, development, and performance as well as product quality. It is known that seeds of most agricultural crops are contaminated with pathogenic microorganisms, which, when they get into soil, increase environmental risks and create an additional infectious burden on the agrophytocenosis (Beznosko et al., 2020). Therefore, to form safe agrocenoses of vegetables, it is important to minimize the phytopathogenic background, including by sowing seeds with the smallest populations of phytopathogens (or the numbers of infectious structures). This can be achieved via treating seeds with biologicals and PGRs with fungicidal activities. The effectiveness of PGRs containing humic acids, biologically active substances, and microfertilizer CompleMet as inducers of resistance of cucumber plants to diseases was proven (Onyschenko & Chaiuk, 2019). Similar results were obtained in our study, specifically soaking of eggplant seeds in solutions of biologicals (Phytocid, PhytoHelp, and MycoHelp) and PGRs (Ivin and Emistim C) reduced the contamination of seeds with phytopathogenic mycobiota by 30–66% and 19–20%, respectively, depending on the formulation and hybrid.

**Conclusions.** Soaking of eggplant seeds in solutions of biologicals (Phytocid, PhytoHelp, and MycoHelp) and synthetic and natural PGRs (Ivin and Emistim C, respectively) positively affected the sowing quality of seeds of most of the studied hybrids due to the action of growth substances—phytohormones – auxins, cytokinins, and gibberellins. The greatest stimulatory effects of Phytocid, PhytoHelp, and MycoHelp on the sowing quality of seeds were recorded for hybs. 'Destan', 'Leire', and 'Fabina'. The greatest positive effects of Ivin and Emistim C on the sowing quality of eggplant seeds were noted for hybs. 'Leire', 'Fabina', 'Night Lady', and 'Destan'. The strong fungicidal effects (on average 51-58%) were observed when eggplant seeds were soaked in Phytocid, PhytoHelp, and MycoHelp solutions. In the Ivin and Emistim C experiments, the fungicidal effects were 19–20%. The greatest phytopathogen-suppressing effects exerted by these agents on eggplant seeds were detected on hybs. 'Destan', 'Leire', 'Night Lady', and 'Fabina'.

**Acknowledgments:** None.

**Conflict of interest.** The authors declare no conflict of interest.

**References**


УДК 635.646:631.53.01

ВПЛИВ БІОЛОГІЧНИХ ПРЕПАРАТІВ І РЕГУЛЯТОРІВ РОСТУ РОСЛИН НА ПОСІВНІ ЯКОСТИ НАСІННЯ БАКЛАЖАНА

Щетина С.В.1, Кічігіна О.О.2, Улянич О.І.1
Уманський національний університет садівництва, вул. Інститутська, 1, м. Умань, Черкаська обл., 20300, Україна
E-mail: sv_shetina@ukr.net, olena ivanivna@gmail.com
Інститут агроекології і природокористування НААН, вул. Метрологічна, 12, м. Київ, 03143, Україна
E-mail: seednlen@ukr.net

https://doi.org/10.32717/0131-0062-2024-75-59-71

Мета. Дослідити дію біологічних препаратів із фунгіцидною і стимулювальною дією і регуляторів росту рослин біологічної і хімічної природи на посівні якості насіння різних гібридів баклажана.

Методи. Лабораторні методи згідно з ДСТУ 4138:2002. Результати. Намочування насіння баклажана різних гібридів в розчинах препаратів Фітоцид, Мікосан «В», ФІТОХЕЛП, MycoHelp, Азотофіт, Вимпел, Гумісол, Івін, Емістим С мало позитивний вплив на показники посівних якостей насіння: енергія проростання підвищилась у середньому на 1–34%, лабораторна схожість – на 2–28%. Незалежно від гібриду, намочування насіння в розчинах біологічних препаратів Фітоцид, ФІТОХЕЛП і MycoHelp забезпечило істотне підвищення порівняно з контролем енергії проростання на 34,2%, 32,5% і 32,5% та лабораторної схожості насіння на 27,6%, 27,4% і 27,4% відповідно. За застосування РРР Азотофіт, Івін, Емістим С енергія проростання та лабораторна схожість у середньому зросли порівняно з контролем на 18–28% та 15–24% відповідно. За дії препаратів Мікосан «В», Вимпел і Гумісол показниками схожості та енергії проростання насіння були на рівні контролю. Виявлено позитивний ефект намочування насіння баклажана в розчинах досліджуваних препаратів на показник довжини проростків у середньому в 1,24–1,94 раза. Визначено, що насіння досліджених гібридів баклажана контаміновано фітопатогенними мікроміцетами і залежно від рівня ураження гібриди ранжовано в ряд: Сапфір > Шарапова, Самурай > Лейре > Найт Леді, Фабіна > Дестан. Препарати Мікосан «В», Вимпел і Гумісол порівняно з іншими препаратами мали низьку ефективність проти фітопатогенів на насіння – на рівні 2,5–6,3%. Високу фунгіцидну дію виявили біологічні препарати Фітоцид, ФІТОХЕЛП і MycoHelp, яка залежно від гібриду становила 42,5–68,8%, 30,0–65,6%, 32,5–65,6% відповідно. Ефективність фунгіцидної дії препаратів Івін і Емістим С була на рівні 20,3% і 18,8% відповідно. Висновки. Встановлено позитивну дію на посівні якості насіння та пригнічення фітопатогенів грибної етіології за намочування насіння баклажана у розчинах біопрепаратів (Фітоцид, ФІТОХЕЛП і MycoHelp) та регуляторів росту рослин хімічного (Івін) і природного (Емістим С) походження. Наїбільший стимулювальний ефект препаратів Фітоцид, ФІТОХЕЛП, MycoHelp, Івін і Емістим С на показники посівних якостей насіння виявлено на гібридах Дестан, Лейре і Фабіна. Встановлено пригнічення фітопатогенів на насінні на рівні 51–58% за намочування насіння баклажана у розчинах біологічних препаратів Фітоцид, ФІТОХЕЛП і MycoHelp, на рівні 19–20% за намочування насіння у розчинах РРР Івін та Емістим С. Наїбільший ефект пригнічення фітопатогенів на насінні баклажана за застосування досліджуваних препаратів виявлено на гібридах Дестан, Лейре, Найт Леді, Фабіна.

Ключові слова: Solanum melongena L., гібриди, лабораторна схожість, енергія проростання, фітопатогені.