Prospects for the use of biopreparations based on VAM during growing cucumber in protected ground

A.A. Mikheev, and *A.V.* Konstantinovich*

Russian State Agrarian University-Moscow Timiryazev Agricultural Academy, 127434, 49, Timiryazevskaya Street, Moscow, Russian Federation

Abstract. The research was carried out in 2022-2023 by the USPC of Horticulture and Vegetable Growing named after V.I. Edelstein RSAU-MAA named after K.A. Timiryazev (Moscow). In the conditions of a film ground greenhouse and planting during the spring-summer rotation, experiments were carried out to assess the effect of biological preparations based on vesicular-arbuscular mycorrhiza (VAM) on the growth and productivity of cucumber plants (*Cucumis sativus* L). Studies have shown that the use of biological preparations positively affected the vegetative growth of *Cucumis sativus* L plants of the parthenocarpic early-maturing hybrid F_1 SV4097CV, which affected the photosynthetic surface area, and also significantly affected the development of plants, accelerating the passage of the main phenophases. There was an increase in plant yield and production at an earlier date, which is extremely important when growing plants in protected soil conditions during the transition to organic agriculture.

1 Introduction

The National Organic Union of the Russian Federation and the Research Institute of Organic Agriculture (Switzerland) predict continued growth in the volume of the organic products market, not only livestock, but also crop production, and it is assumed that by 2025 the volume of the organic products market may amount to 3.5...5% of the total volume of the world market of agricultural products.

A significant problem for producers of crop production in the transition period to organic agriculture is the inadmissibility of the use of chemical mineral fertilizers and plant protection products when growing crops. The use of bacterial and microbiological preparations can be a solution to the issue of providing plants with nutrients to produce organic products.

Vesicular-arbuscular mycorrhiza (VAM) is a soil microflora that forms symbiotic associations with the root system of plants, which makes it possible to significantly increase its absorbing surface [1, 10].

The formation of mycorrhiza is noted in most plant species, with arbuscular mycorrhiza being the most widespread type [1, 4, 5]. Fungi forming arbuscular mycorrhiza receive a

* Corresponding author: Konstantinovich@rgau-msha.ru

positive effect from symbiosis and play a key role in the development and functioning of symbiosis. There are about 200 morphoids of arbuscolo-mycorrhizal fungi, nevertheless, each of these morphoids has a variety of both genetic and functional [5,6].

Fungi, secreting enzymes, release nitrogen, phosphorus and other macro- and microelements, which are subsequently absorbed by them and transferred to the plant, or the root system of the plant has the ability to absorb them [4,8]. Plants face a related problem, which is that phosphorus is absorbed by the roots faster than it can be replaced in the process by natural diffusion from the soil layer. This imbalance leads to depletion of phosphorus compounds in the rhizosphere near the roots, which can further limit the phosphorus absorption. For this reason, plants either increase the efficiency with which they can absorb available phosphorus from the soil, or release phosphorus from insoluble sources using various mechanisms mainly extracting phosphorus reserves in the soil [5,6, 9].

The purpose of the experiment is to assess the effect of biologics based on the increase in cucumber yield when grown in film ground greenhouses.

2 Materials and Methods

The experiments were carried out on an area of 280 m^2 in a spring film soil at the USPC of Vegetable Growing and Horticulture named after V.I. Edelstein on the territory of the FSBEI HE RSAU-MAA named after K.A. Timiryazev, Moscow, the objects of research are BioMicoriza and Edgis biopreparations. The main component of the preparations is the spores of the fungus species *Glomus sp*. The preparation was introduced during the planting of seedlings of the cucumber hybrid SV4097TSV F_1. Planting of 25-day seedlings was carried out in the second decade of May according to the scheme 90+50X25 cm. The experiment is based on a 3-fold repetition, as a control, plants were grown without the introduction of biological preparations. The area of the accounting plot is 2.4 m^2 [2,3.7].

To determine the presence of mycorrhiza formation between cucumber plants and fungi of biological products, light microscopy was performed, and, if necessary, a cytological method for studying arbuscular mycorrhiza using the Vinogradsky-Breed method.

Fig. 1. Arbuscules of the fungus species *Glomus sp.* at the root of the cucumber hybrid SV4097TSV F_1.

Phenological observations were carried out according to the method of V.A. Batmanov. The main phenophases of cucumber plants are: the appearance of the 1st real leaf, the

formation of the third leaf, the beginning of the formation of lateral shoots, budding, flowering, the first and last harvest of fruits [3].

3 Results and Discussion

The results of phenological observations of cucumber plants SV4097CV F_1 (Table1) allowed to establish an earlier onset of the main phenophases when using mycorrhiza phenophase biologics, namely, the beginning of the formation of lateral shoots, budding of female flowers, flowering of female flowers, and ovary formation.. The data indicate a greater intake of the main NPK macronutrients in the variants of the experiment with the introduction of VAM biopreparations, in particular, nitrogen, responsible for the growth of the photosynthetic surface (leaf area) and the overall growth of cucumber plants, phosphorus and potassium – stimulating the formation of more ovaries and, accordingly, ensuring plant productivity. Cucumber plants in variants with the use of BioMicoriza biopreparation underwent the above-mentioned phenophases on 34, 41, 43, and 45 days from the moment of sowing seeds. In the variant with the biological preparation Edgis - 34, 41, 44, and 45 days. It was found that the plants of the control variant lag in development in the range from 1 to 2 days.

This confirms the penetration through the root system of easily accessible and easily digestible compounds of nitrogen, phosphorus, potassium, and basic trace elements. On average, cucumber fruits accumulate 4-6% of dry matter. Nevertheless, fruits harvested from plants under the influence of BioMicoriza accumulated on average from 5.38% to 6.67% of dry matter over the entire observation period. Cucumber fruits obtained from plants grown with the use of the Edgis preparation accumulated from 5.53% to 7.05% of dry matter. The control without the use of biopreparations demonstrated the accumulation of dry matter from 4.89% to 5.49%.

Table 1. The timing of the passage of the main phenophases by cucumber plants SV4097CV F_1 in a ground greenhouse (average for 2022-2023).

Experiment options	Seed sowing date	Number of days from the emergence of seedlings to								Fruiting period	
		Beginning of the emergence of [illegible]	Appearance of mass shoots	Appearance of the 1st real leaf	Formation of the 3rd leaf	Beginning of the formation of lateral shoots	Budding	Flowering phase	Ovary formation	First harvest of fruits	Last harvest of fruits
BioMicoriza	20.04	4	6	13	25	34	41	43	45	50	117
Edgis	20.04	4	6	13	25	34	41	44	45	50	117
Control	20.04	4	6	13	27	36	42	45	47	50	117

The timely passage of phenophases by plants, the development of a powerful vegetative part, a large area of the photo-assimilation surface is an integral part of the cucumber harvest formation, contributes to the accumulation of sugars and important organic compounds

useful for the human body. At the same time, cucumber ovaries react very subtly to the lack of mineral nutrition. With a lack of nitrogen and potassium, yellowing of the ovaries occurs, their drying out, and then dumping by the plant. In the variants and using biopreparations based on VAM BiMicoriza and Edgis, the yellowing and discharge of the ovaries during the fruiting period in 2022 and 2023 amounted to no more than 1-3%. At the same time, at the control, the discharge was slightly higher at the level of 4-10%. The supply of more nutrients due to the symbiosis between the roots of cucumber plants and the fungal hyphae *Glomus sp.* had an impact for the better on the quality and output of marketable products.

The yield of marketable products from plants grown using the Biomicoriza preparation was 93.5%, with the Edgis preparation – 94% (2) of the total number of harvested fruits. Indicators of the yield of marketable products from control plants at the level of 87.75% (2) signal a weaker absorption of nutrients or the content of compounds difficult to reach for cucumber in the soil.

Table 2. Dynamics of the receipt of cucumber hybrid products SV4097CV F_1 (average for 2022-2023).

Biopreparation	Yield, kg/m²							Total yield, kg/m²	Output of marketable products, %
	July			August			September		
	I decade	II decade	III decade	I decade	II decade	III decade	I decade		
BioMicoriza	2,02	10,64	11,20	12,06	5,47	3,99	2,20	47,58	93,5
Edgis	2,27	9,72	11,70	12,82	6,18	4,99	2,90	50,57	94
Control	2,12	8,68	9,38	9,64	4,96	2,86	1,64	39,27	87,75
LSD$_{05}$							**1,185**		

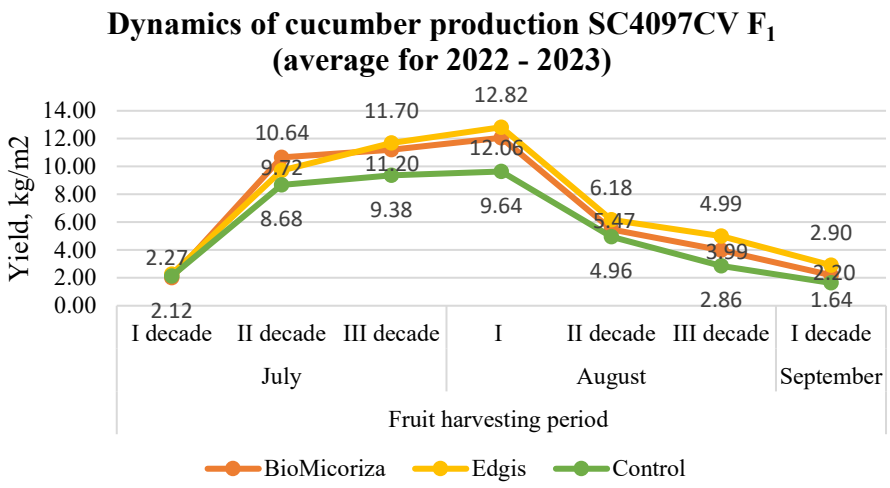

Fig. 2. Dynamics of cucumber production SV4097CV F_1 depending on the use of biopreparations.

When analyzing the total fruit yield of the cucumber hybrid SV4097CV F_1 (Table 2) during the fruiting periods in 2022 and 2023, a steady trend towards an increase in yield can be noted when using biopreparations based on VAM. The highest yield was shown by plants when applying VAM based biopreparation Edgis - 50.57 kg/m^2, which proves the positive effect of this preparation on the intake of necessary minerals actively involved in the nutrition of plants and the development of commercial fruits. Cucumber plants were characterized by a slightly lower yield when applying the BioMicoriza biopreparation - 47.58 kg/m^2, which suggests the presence of an insufficient number of fungi in the preparation or the use of strains that do not enter into a symbiotic relationship with the cucumber root system or insufficiently cleave hard-to-reach forms of nitrogen, phosphorus, and potassium from the greenhouse substrate

4 Conclusion

After analyzing the results of the study, we can conclude that there is a significant increase in the yield of cucumber crop in the conditions of film ground greenhouses when using VAM based biopreparations of BioMicoriza and Edgis brands. In general, we can recommend the use of these drugs to organic producers. It is worth noting that the use of biopreparations BioMicoriza and Edgis allowed to increase the resistance of cucumber plants to powdery mildew in the late stages of development, which may indicate the prospects for the use of fungi of the species *Glomus sp*. for inclusion in the biological plant protection system.

References

1. A.P. Bondarenko, A.A. Vedernikova, O.B. Vaishlya, *Microorganisms of the rhizosphere. Educational and methodical manual* (Pavlodar, 2018) 237.
2. S.S. Litvinov, *Methodology of field experience in vegetable growing* (M.: SSU All-Russian Research Institute of Vegetable Growing, 2011) 650.
3. L.A. Chistyakova, O.V. Baklanova, A.V. Konstantinovich, Potatoes and vegetables, **8** 15-16 (2016).
4. A.I. Rechkin, G.N. Ladygina, *Geochemical role of microorganisms* (electronic textbook) (Nizhny Novgorod, 2010) 73.
5. H. Abbasi, A. Ambreen, S. Rushda, American Journal of Plant Nutrition and Fertilization Technology, **5,** 40-49 (2015).
6. M. Habte, N.W. Osorio, *Arbuscular Mycorrhizas: Producing and Applying Arbuscular Mycorrhizal Inoculum* (USA: College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa) 47 (2001).
7. S. Xiuxiu, L. Yansu, Y. Xianchang, et al., Adv Plants Agric Res., **9(1),** 127-130 (2019).
8. A. Hodge, C.D. Campbell, A.H. Fitter, Nature, **413,** 297-299 (2001).
9. M.C. Brundrett, L. Tedersoo, New Phytologist, **220(4),** 1108-1115 (2018).
10. M.I. Makarov, Soil science **2,** 220-233 (2019).