



The influence of microbiological inoculates on plant development in covering mixture

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Abstract. The study investigated seed germination, and plant development of a covering mixture consisting of 40% of spring vetch seeds and other crops under the influence of microbiological inoculants, namely Mycofriend-T and Bioinoculant-BTU-T. It was found that Mycofriend-T on bioinoculant-treated seeds of phacelia, long-stem flax, Sudan grass, and Alexandrian clover stimulated the germination of all crops in the mixture. The germination of the treated seeds increased by 2.5-5% compared to the control. The most significant increase in germination was found in spring vetch when treated with a complex of biological preparations – 7%. When treated with the microbial Mycofriend-T, the germination of seeds of this crop increased by 5%. The linear dimensions of the aboveground part of most plants of the mixture also increased by 10-40% compared to the control, depending on the crop. In the underground part of the plants, the linear dimensions also increased by 6-53% compared to the control, depending on the plant species. The total fresh weight of the aboveground part of plants when using Mycofriend-T

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and the bioinoculant complex increased by 60 and 59%, respectively, demonstrating the stimulating effect of the inoculant agents on the development of plants' leaf surface and stem. However, the most significant increase in fresh weight was found when analysing the data of the underground part of plants: when using Mycofriend-T + Bioinoculant-BTU-T, this indicator increased by 104%, while when using only the microbial Mycofriend-T, the increase was 43% compared to the control. The positive influence of bioinoculants on the functioning of the photosynthetic apparatus of Sudan grass plants was established. These research findings are important for farmers because they demonstrate how to improve the growth and physiological properties of cover crops, which perform many important functions for the soil and main crops

Keywords: *Trichoderma harzianum*; arbuscular fungi; *Rhizophagus irregularis* (*Glomus*); nodule bacteria; cover crops

INTRODUCTION

Harmonisation of the links between agricultural production, ecosystems, and climate is a task that can be solved by regenerative agriculture. In this approach, the use of cover crops is relevant for improving the physicochemical properties of the soil and its biological properties, and reducing production costs. It is essential to form a layer of cover crops with good development of both the vegetative part of the plants and their well-developed root system. Growing cover crops is of interest to both large and small agricultural enterprises, which increases the demand for their seeds and simultaneously poses the problem of ensuring stable germination of crops in different environmental conditions. Cover crops, which can include several plant species from other families, require attention to the compatibility of each crop. Therefore, it is important to use environmentally acceptable methods to mitigate stress and eliminate restrictions on plant development during the growing season.

Studies show that plant growth under various stress conditions is enhanced by the influence of arbuscular mycorrhizal fungi, which stimulate plant nutrient uptake and increase plant resistance to stress factors. A. Wahab *et al.* (2023) analysed the current state of research on the effect of AMF on plants and showed that the symbiotic relationship between mycorrhizal fungi and plants facilitates the acquisition of nutrients and water by plants. The use of AMF is effective for plants to overcome drought stress, as shown in the study by S. Azizi *et al.* (2021). The researchers showed that myrtle plants tolerated drought better due to improved water supply and stimulation of antioxidant defence. N.O. Igiehon *et al.* (2020)

showed that inoculation and mycorrhization of AMF alleviate drought stress and increase soybean yield, plant size, and seed oil content. An increase in the relative humidity of the above-ground shoots also accompanies the positive effect. Increased phosphorus uptake with AMF mycorrhization was shown in experiments with tomatoes by C.T.K. Tran *et al.* (2020), who, however, noted that mycorrhization increases the mobility of some forms of phosphorus, thereby increasing the potential for their leaching from the soil.

In addition to arbuscular fungi, *Trichoderma harzianum*, a well-known antagonist of soil-borne pathogenic fungi, also positively protects plants from phytopathogens. B. Glogoza *et al.* (2023) found that appropriate nodular bacterial inoculants can significantly accelerate plant development, especially in the *Fabaceae* family, which plays a crucial role in cover crop mixtures. According to their studies, rhizobacteria, which promote plant growth, and rhizobia, which can fix nitrogen, contribute to plant health and productivity in several ways. These microorganisms function as biofertilisers, improving plant nutrition, acting as biostimulants, regulating growth, and serving as biopesticides, increasing resistance to abiotic and biotic stress.

J. Poveda & D. Eugui (2022) demonstrated that the synergism between *Trichoderma* and bacteria brings more benefits than their separate use. However, the researchers noted that further investigation is needed to determine the specific mechanisms of this synergistic effect in increasing plant resistance to abiotic stresses. Microbial inoculants involve using live beneficial microorganisms together with seeds at sowing or by adding them to



the growing medium. M. O'Callaghan *et al.* (2022) reviewed modern combinations such as co-inoculation and diverse microbial consortia that can fill different functional niches and increase the resilience of these microbial communities in the environment. The researchers also suggest that such combinations of microorganisms can act additively or synergistically. However, a review of research by A.S.M. Elnahal *et al.* (2022) raised the issue that the effectiveness of microbial inoculants is often controversial, especially in the field. Therefore, there is a critical need for their evaluation, particularly under field conditions. This problem highlights the importance of using research on various cultures in diverse environments.

Thus, several groups of microorganisms have been identified that positively impact the condition of plants and ecosystems. Therefore, obtaining new data on specific applications in combining such microorganisms, mainly when growing cover crops, is relevant. The purpose of the study was to investigate the effect of inoculants from different groups of microorganisms, namely, a combination of microbial preparations containing *Trichoderma harzianum*, arbuscular fungi *Rhizophagus irregularis* (*Glomus*), bacterial complex and a culture of symbiotic nodule bacteria on the development of plants in a cover mixture.

MATERIALS AND METHODS

The studies were conducted in the educational and scientific laboratory of the Department of Ecobiotechnology and Biodiversity, Faculty of Plant Protection, Biotechnology, and Ecology at the National University of Life and Environmental Sciences of Ukraine in 2024. The research used plants from a cover crop mixture provided by Smart Crops LLC (Ukraine). The mixture consisted of seeds of spring vetch (*Vicia sativa* L.), phacelia (*Phacelia tanacetifolia* Benth.), common flax (*Linum usitatissimum*, L.), Sudan grass (*Sorghum bicolor* subsp. *drummondii* (Nees ex Steud.) Millsp. & Chase) and Alexandrian clover (*Trifolium alexandrinum*, L.). In the cover crop mixture, spring vetch seeds accounted for 40%, corresponding to the technological parameters for using cover crops containing representatives of the *Fabaceae* family. Thus, several groups of microorganisms have been identified that positively impact the condition of plants and ecosystems. Therefore,

obtaining new data on specific applications in combining such microorganisms, mainly when growing cover crops, is relevant.

Conditions of the experiment. The study was conducted with preparations of microbiological origin Mycofriend-T and Bioinoculant-BTU-T produced by the biotechnology company BTU (Ukraine). The composition of the biologics Mycofriend-T included arbuscular fungi *Rhizophagus irregularis* (*Glomus*) and the *Trichoderma harzianum*. The microbial contained bacteria *Bacillus velezensis* (*Bacillus subtilis*), *Priestia megaterium* (*Bacillus megaterium* var. *phosphaticum*), *Paenibacillus mucilaginosus* (*Bacillus mucilaginosus*), *Agrobacterium salinitolerans* (*Enterobacter*), *Pseudomonas plecoglossicida* (*Pseudomonas fluorescens*). The total number of viable cells $(1.0-1.5) \times 10^8$ CFU/ml. The biological preparation also included biologically active substances – products of the vital activity of microorganisms: phytohormones, vitamins, and amino acids.

The composition of the microbial Bioinoculant-BTU-T included symbiotic nodular bacteria *Rhizobium leguminosarum* bv. *viciae*, and biologically active products of bacterial life and nutrient medium components (macro-, microelements, etc.). The titre of the biologics ranged from 2.5×10^9 CFU/ml. Both biologics were based on a filler – peat. The research scheme included the following options: Control – no treatment; Option 1 – seed treatment with the biologics Mycofriend-T at the rate of 100 g of the biologics per 1 ha of crops; Option 2 – seed treatment with a complex of biologics Mycofriend-T + Bioinoculant-BTU-T at the rate of 100 g of each biologics per 1 ha of crops.

The seeds of the plants in the covering mixture were moistened for better adhesion and treated with biopreparations according to the research scheme. The seeds were sown in pots with a diameter of 16 cm² for cultivation. The plants were grown in a phytoclimatic chamber, “Silverbox evolution” (France), at a temperature of $20 \pm 2^\circ\text{C}$ and a lighting regime of light/darkness 14/10 hours. The air humidity regime in the chamber was maintained at 70-80%, and the soil humidity in the pots was 50-80% of the lowest moisture capacity. Peat substrate “Universal with biohumus” (Ukraine) was used for cultivation. For research, a sample of 4 plants of each species was used (20 plants in pot) in 3-fold replication for each variant.

The germination of crop seeds was assessed according to DSTU 4138-2002 (2004). In addition, to simulate the germination process in natural conditions, authors modified the germination device developed by them (Fig. 1). The containers were filled with a moistened peat mixture, into which seeds treated according to the scheme were placed. Germination was carried out in a thermostat at 25°C for 4 days.



Figure 1. Study the effect of biological preparations on the germination of spring vetch seeds (*Vicia sativa* L.)

Note: 1 – control; 2 – treatment with a complex of microbial preparations; 3 – treatment with the microbial preparation Mycofriend-T

Source: developed by the authors

The containers were covered with transparent lids, which allowed them to be placed ver-

tically for the natural process of seedling root development and to observe the process. The method of Z. Hrytsayenko *et al.* (2003) was used to determine biometric indicators (lengths of underground and aboveground part) and plant mass. The functional state of Sudan grass leaves was assessed using the method of chlorophyll fluorescence induction (Brion *et al.*, 2000). Statistical processing of the research results was carried out using the Microsoft Excel 2010 software suite ANOVA by methods of variational statistics using the t-test and one-way analysis of variance. Differences in the values of indicators with $p \leq 0.05$ were considered significant (Prylutsky *et al.*, 2017). Microsoft Excel 2010 was used to construct graphs. The table values were $M \pm Sd$, where M – arithmetic mean, and Sd – standard deviation. The experimental studies of plants (both cultivated and wild), including the collection of plant material, were in accordance with institutional, national or international guidelines. The authors adhered to the standards of the Convention on Biological Diversity (1992).

RESULTS AND DISCUSSION

Seed germination is a critical moment in crop development that requires attention from producers. Pre-sowing treatment with biostimulants allows plants to be supported at the initial stage, which is important for plant growth in general. In cover mixtures where several different crops are grown, attention must be paid to their germination. Studies have shown that treatment with bioinoculants stimulated the germination of all crops in the mixture, and the increase in the number of germinated seeds was 2.5-5% compared to the control when using the biologics Mycofriend-T for seeds of phacelia, flax, Sudan grass, and Alexandrian clover (Table 1). The highest increase according to the indicator “seed germination” was found for spring vetch when treated with a complex of biological preparations – 7%. When treated with the biologics Mycofriend-T, the germination of seeds of this crop increased by 5%. The results of a preliminary assessment of the effects of microbial using a modified device (Fig. 1) also demonstrated a positive effect on the germination of spring vetch precisely with the combined action of two bioinoculants.

Table 1. Germination rates of crop seeds in the covering mixture when treated with bioinoculants, %

Crop	Experiment option		
	Control	Mycofriend-T	Mycofriend-T + Bioinoculant-BTU-T
Spring vetch	92.5 ± 0.2	97.5 ± 0.2	99.7 ± 0.2
Phacelia	72.5 ± 0.3	75.0 ± 0.1	-
Flax	90.0 ± 0.2	95.0 ± 0.2	-
Sudan grass	52.5 ± 0.2	57.5 ± 0.3	-
Alexandrian clover	87.5 ± 0.2	90.0 ± 0.3	-

Note: “-” no data available

Source: developed by the authors

In general, it is known that plant colonisation by arbuscular fungi can occur more or less efficiently, depending on the genomes of the fungi and plants entering into symbiosis, and this variability can be observed even at the level of plant varieties of the same species (Cervantes-Gómez *et al.*, 2015; Guigard *et al.*, 2023).

However, even the presence of fungi in the cortical root cells of a plant can stimulate an increase in shoot and root mass, believed to be due to the formation and development of lateral roots (Fiorilli *et al.*, 2018). During the exchanges, the fungus receives the products of plant photosynthesis; in return, the branched hyphal network contributes to the mineralisation and restoration of essential soil nutrients, thus increasing their bioavailability to the plant (Montero *et al.*, 2018; Jiang *et al.*, 2021). Arbuscular fungi play a particular role in increasing the bioavailability of phosphorus, as reported, through the mechanism of expression of genes whose products respond to inorganic phosphate and suppress the phosphorus starvation response of plants, which is typical for soils with low phosphorus content (Campo & San Segundo, 2020).

Thus, with a positive bioinoculation result, it is possible to observe an increase in plant growth and development. The studies have demonstrated a stimulating effect on plant development of the coating mixture of a separate preparation with arbuscular fungi and the complex use of two microbial preparations, which, in particular, shows the importance of choosing the target crop when using such microbial preparations (Fig. 2).

The use of biological products revealed an increase in morphological indicators of both the underground and aboveground parts of the plants of the covering mixture (Table 2). This

was observed for all crops of the mixture, except phacelia, for which no positive effect of treatment with microbial products was found since the length of the aboveground part and the root system were slightly lower than in control. This may be due to the lower physiological performance of the seeds of this crop, as its germination was generally low.

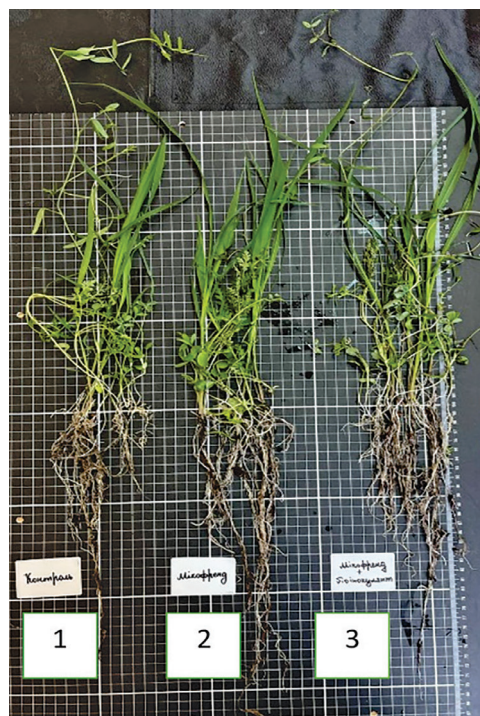


Figure 2. Development of plants in the cover mixture after seed treatment with bioinoculants 21 days after germination

Note: 1 – control; 2 – Mycofriend-T; 3 – Mycofriend-T + Bioinoculant-BTU-T

Source: developed by the authors

Table 2. Effect of bioinoculant preparations on biometric parameters of seedlings of cover crops

Crop	Experiment option	Indicators	
		Underground part, mm	Aboveground part, mm
Phacelia	Control	22.2 ± 1.5	31.4 ± 0.8
	Mycofriend-T	20.3 ± 1.2	30.2 ± 1.3
Flax	Control	47.4 ± 0.8	23.7 ± 1.1
	Mycofriend-T	50.3 ± 1.1	32.3 ± 1.5
Sudan grass	Control	11.1 ± 0.9	6.3 ± 1.4
	Mycofriend-T	24.3 ± 1.2	20.7 ± 1.2
Alexandrian clover	Control	19.4 ± 1.1	32.7 ± 1.3
	Mycofriend-T	21.2 ± 1.5	36.1 ± 1.4

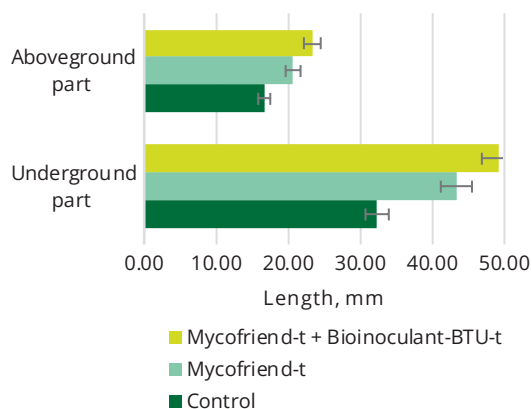
Source: developed by the authors

When seeds were treated with the bioinoculant Mycofriend-T, the length of the root system of flax and clover seedlings increased by 6.0% and 9.0%, respectively, compared to the control. In contrast, the root system of Sudan grass seedlings exceeded the control value by 2 times. The length of the aboveground part of flax and clover seedlings increased by 35% and 10%, respectively, compared to the control, and the aboveground part of Sudan grass plants exceeded the control value by 3 times.

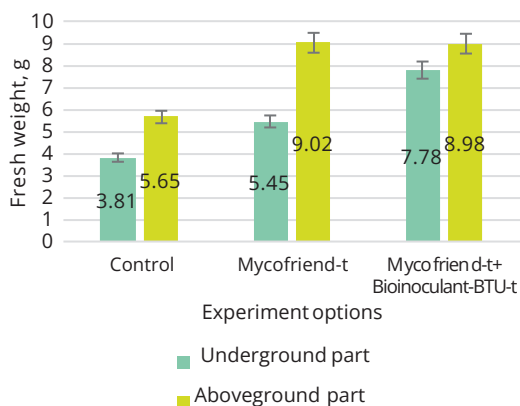
The stimulating effect of the treatment on the development of the aboveground and underground parts of the plants was also established in spring vetch, which was the main crop of the cover mixture under study. Combined treatment with microbial preparations increased the length

of the root system by 53% compared to the control and when treated with Mycofriend-T – by 34%. The aboveground part of the plants also developed better under combined treatment, and its length increased by 40% compared to the control, while Mycofriend-T treatment increased this indicator by 24% (Fig. 3).

In addition, the authors used the preparation Bioinoculant-BTU-T, which contains nodule bacteria with a high tendency to colonise vetch plants, which also contributes to the enhancement of the development of the root system. With the combined treatment of Mycofriend-T and Bioinoculant-BTU-T, an increase in additional roots and root hairs in the root system of plants was also found, which affected the increase in their fresh weight (Fig. 4).

**Figure 3.** Assessment of the effect of bioinoculants on the growth of common spring vetch

Source: developed by the author

**Figure 4.** Accumulation of fresh weight by plants of the cover mixture when treated with bioinoculants

Source: developed by the authors

The total fresh weight of the aboveground part of plants when using Mycofriend-T and the complex of microbial preparations increased by 60% and 59%, respectively, demonstrating the stimulating effect of the inoculant agents on the development of plants' leaf surface and stem. However, the most significant increase in fresh weight was found when analysing the data of the underground part of plants: when using Mycofriend-T+ Bioinoculant-BTU-T, this indicator increased by 104%, while when using only the microbial preparation Mycofriend-T, the increase was 43% compared to the control. Thus, the effect of bioinoculants had a positive effect on the development of the root system in the initial period of plant vegetation.

The induction of chlorophyll fluorescence in Sudan grass leaves was determined to assess the condition of plants treated with microbiological inoculants since its leaf blade most closely matched the conditions for conducting diagnostics using the IF method. This method allows assessing the photosystem II of plants during life, which is important for determining long-term effects on plants and analysing the plant's general condition (Grusha *et al.*, 2014; Kovalyshyn *et al.*, 2016). An increase in the maximum fluorescence value (F_{max}) was noted in plants in variants treated with inoculants compared to the control, which indicates that the photosynthetic process in plants is quite effective (Fig. 5).

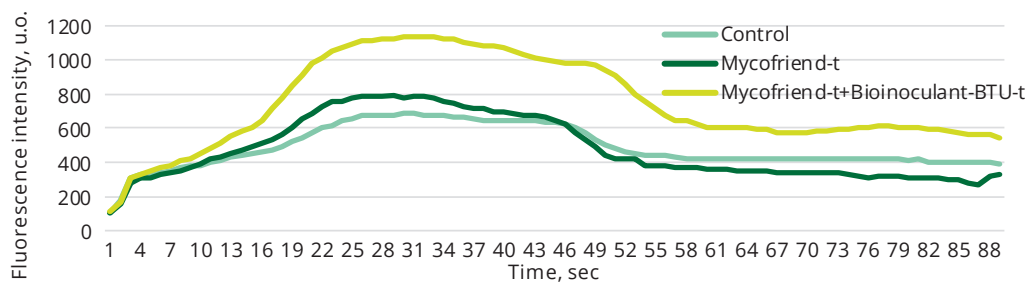


Figure 5. Induction curves of chlorophyll fluorescence in Sudan grass leaves upon treatment with microbial inoculants

Source: developed by the authors

To assess the induction of fluorescence in chlorophyll-bearing tissues, the calculated parameter F_v is used – the chlorophyll fluorescence variable, which is expressed as the difference between the highest fluorescence level and background fluorescence ($F_{max} - F_0$) and provides information about the magnitude of the amplitude of changes in the Kautsky curve. It was found that this indicator

increased when Sudan grass seeds were treated with bioinoculants: under the action of Mycofriend-T, it increased by 18%, and under the action of the complex of biological preparations Mycofriend-T and Bioinoculant-BTU-T – by 77% compared to the control. This also indicates a positive effect of bioinoculants on the functioning of the photosynthetic apparatus of Sudan grass plants (Table 3).

Table 3. Assessment of the influence of bioinoculants on the indices of chlorophyll fluorescence induction in Sudan grass leaves

Experiment option	IF indicators, conventional units					
	F_0	F_{max}	F_{st}	F_v	$(F_{max}-F_{st})/F_{st}$	F_v/F_{max}
Control	103	680	392	577	0.73	0.85
Mycofriend-T	104	784	328	680	1.39	0.87
Mycofriend-T+ Bioinoculant-BTU-T	112	1136	544	1024	1.09	0.9

Note: F_0 – background fluorescence level, F_{max} – fluorescence maximum, F_{st} – stationary fluorescence level, F_v – variable fluorescent, $(F_{max}-F_{st})/F_{st}$ – efficiency of photochemical conversion of energy in FS II, F_v/F_{max} – the maximum quantum yield of the photochemistry of PSII

Source: developed by the author based on research



The maximum quantum yield of photochemistry of PSII is the expression F_v/F_{max} . In healthy plants not exposed to stressors, the ratio F_v/F_m usually varies within 0.70-0.90. For the plants under study, this indicator was within the specified limits. The efficiency of photochemical energy conversion in PSII characterises the rate of linear electron transport and is an integrated indicator of the photosynthesis process. This indicator in the plants under study varied from 0.73 to 1.39 conventional units. It was higher in plants treated with inoculants, which indicates a positive effect of the treatment on the state and functioning of the photosynthetic system in Sudan grass plants.

The results presented demonstrate the improvement of vetch plant growth with AMF inoculation. The effectiveness of arbuscular fungal inoculants was shown in field studies conducted by K. Burak *et al.* (2024) on different vetch cultivars grown on depleted soils with high calcium content in southeastern Turkey. These studies showed that inoculation with arbuscular mycorrhizal fungi reduces the amount of lime in the soil and identified the most effective combinations of fungal isolates that positively affect the biochemical cycles of carbon, nitrogen, and phosphorus. T. Ding *et al.* (2020) also demonstrated the positive effect of the arbuscular mycorrhizal fungus *Sieversingia tortuosa* on atrachnosis resistance and enhanced root growth of spring vetch.

Cover crops are an essential part of sustainable agriculture. Their role was recognised in soil recovery and reduction of weed infestation, including broader environmental impacts (Marcillo & Miguez, 2017; Daryanto *et al.*, 2018), which could lead to an increase in crop productivity and quality over time. However, for cover crops to develop better in the face of climate change, it is important to support their growth and development. The use of bioinoculants improves plant growth and nutrient uptake under resource-limited conditions. In particular, V. Dragičević *et al.* (2020) highlighted the importance of using such inoculants in mixed cropping systems of legumes and cereals to enhance the productivity and resilience of agroecosystems. In this paper, the studies conducted by the authors confirmed the feasibility of pre-sowing treatment of cover crop mixtures with microbial biopreparations since they stimulate biometric and physiological indicators of plants. Treatment of cover

crop mixtures seed contributed to improving seed germination, increased root system and shoots, increased green mass of plants, and optimised photosynthetic processes. Improving the above parameters will make the plant more resistant to abiotic stress factors. Other researchers who investigated the effect of biopreparations on seed treatment of various plants came to such conclusions.

In the study by M. Ebrahimi (2023), inoculation of clover seeds with microbes is recommended to improve their growth and development characteristics under drought conditions because of the positive effects of plant growth-promoting rhizobacteria. The studies by S. Yang *et al.* (2023) confirmed these findings, which indicate that mycorrhizal-based biopreparations improve plant growth parameters and physiological indicators. Namely, in this study, the role of mycorrhizal inoculation in nutrient absorption and its important contribution to plant greater biomass were discussed.

The paper by M. Baidalin *et al.* (2024) showed that double grass mixtures treated with nodule bacteria are more productive than untreated with biological products under the conditions of northern Kazakhstan. The use of inoculants increased the yield of green mass; this study demonstrated that inoculation with nitrogen-fixing bacteria significantly enhances the yield and nutritional quality of legume-cereal grass mixtures in northern Kazakhstan. In the study by K. Abdelaal *et al.* (2024), it was demonstrated that inoculation with mycorrhizal-based biopreparations positively affects the most studied traits, such as chlorophyll concentration and maximum quantum efficiency of PSII; the same trend was observed in the studies of the authors of the present paper under the conditions of using the microbiological Mycofiend-T + Bioinoculant-BTU-T (Table 3).

The stimulating effect of bacterial inoculants was confirmed by B. Glogoza *et al.* (2024). The researchers showed that treating corn seeds with bioinoculants stimulated the growth and development of the root system compared to the control; the mass of roots increased by 12-30%, and the height of plants treated with biological preparations exceeded the control plants by 15-23 cm. In this paper, the authors also demonstrated the stimulating effect of the application on the development of the root system and the mass of cover crops (Table 2, Fig. 3-4).



The combined application of bioinoculants and cover crops represents an effective and environmentally sound strategy for contemporary agriculture. This approach enhances plant resistance to various stress factors, while simultaneously enriching the soil microbiome with beneficial microorganisms. Additionally, it contributes to improving soil structure and fertility, leading to increased productivity and stability of major crop yields. By integrating these practices into existing farming systems, it is possible to promote sustainable agricultural development without compromising environmental integrity or long-term soil health.

CONCLUSIONS

The effect of microbiological inoculants on the development of plants in a cover mixture consisting of 40% spring vetch seeds, and the rest of phacelia, flax, Sudan grass, and Alexandrian clover was studied in laboratory conditions. The germination of the treated seeds increased by 2.5-5% compared to the control. The greatest increase in germination was found in spring vetch when treated with a complex of biological preparations – 7%.

In the aboveground part of the plants, the linear dimensions also increased by 10-40% compared to the control, depending on the plant species. For Sudan grass, the growth of the aboveground part was three times as high as compared to the control. In the underground part of the plants, the linear dimensions also increased by 6-53% compared to the control, depending on the plant species. For Sudan grass, the growth of the aboveground part

was twice as high as compared to the control. The total fresh weight of the aboveground part of plants when using Mycofriend-T and the complex of microbials increased by 60% and 59%, respectively, demonstrating the stimulating effect of the inoculant agents on the development of plants' leaf surface and stem. However, the most significant increase in fresh weight was found when analysing the data of the underground part of plants: when using Mycofriend-T + Bioinoculant-BTU-T, this indicator increased by 104%, while when using only the Mycofriend-T, the increase was 43% compared to the control. The positive influence of bioinoculants on the functioning of the photosynthetic apparatus of Sudan grass plants has been established. In the future, further research is planned to assess the impact of bioinoculants on cover crops, study the mechanisms underlying them, and evaluate their performance under field conditions.

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CONFLICT OF INTEREST

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Анотація. У дослідженні було вивчено проростання насіння та розвиток рослин покривної суміші, що складалася з 40 % насіння вики ярої та інших культур, під впливом мікробіологічних інокулянтів, а саме Мікофренд-Т та Біоінокулянт-БТУ-Т. Встановлено, що Мікофренд-Т на обробленому біоінокулянтами насінні фацелії, льону-довгунця, суданської трави та конюшини олександрійської стимулював проростання всіх культур у суміші. Схожість обробленого насіння зросла на 2,5-5 % порівняно з контролем. Найсуттєвіший приріст схожості виявлено у вики ярої при обробці комплексом біопрепаратів – 7 %. При обробці мікробним препаратом Мікофренд-Т схожість насіння цієї культури зросла на 5 %. Лінійні розміри надземної частини більшості рослин суміші також збільшилися на 10-40 % порівняно з контролем, залежно від культури. У підземній частині рослин лінійні розміри також збільшилися на 6-53 % порівняно з контролем, залежно від виду рослин. Загальна сира маса надземної частини рослин при застосуванні Мікофренд-Т та біоінокулянтного комплексу зростала на 60 та 59 % відповідно, що свідчить про стимулюючий вплив інокулянтів на розвиток листової поверхні та стебла рослин. Однак найбільш суттєвий приріст сирової маси виявлено при аналізі даних підземної частини рослин: при застосуванні Мікофренд-Т + Біоінокулянт-БТУ-Т цей показник збільшився на 104 %, тоді як при використанні лише мікробного препарату Мікофренд-Т приріст становив 43 % порівняно з контролем. Встановлено позитивний вплив біоінокулянтів на функціонування фотосинтетичного апарату рослин суданської трави. Результати досліджень є важливими для аграріїв, оскільки демонструють шляхи покращення росту та фізіологічних властивостей покривних культур, які виконують багато важливих функцій для ґрунту та основних сільськогосподарських культур

Ключові слова: *Trichoderma harzianum*; арбускулярні гриби; *Rhizophagus irregularis* (Glomus); бульбочкові бактерії; покривні культури

