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The effect of artificial mycorrhization on the growth and development of plants in a vegetation experiment

O.I. Vinnikova

Nowadays, numerous commercially available biological preparations based on arbuscular mycorrhizal (AM) fungi are suggested for practical use in agriculture. The potential benefits of inoculating soils with AM fingi for crop production have been shown in many studies. However, the level of the universality of such preparations, i.e. the effectiveness of artificial mycorrhization using one particular fungi species for different agricultural plants, still remains unclear. The aim of present study was to assess the possibility and effectiveness of artificial mycorrhization of tomatoes and wheat under in a vegetation experiment. The effects of adding preparation Mycoplant, which contains propagules of endomycorrhizal fungi, to the soil on seed germination, plant morphometric parameters, and the concentration of chlorophyll in wheat and tomato leaves were assessed. Seeds of wheat lines isogenic for Vrn genes of the Myronivska 808 variety and two varieties of tomatoes - the early-ripening Kremenchutsky rannij variety and the late-ripening Ace variety were used in the experiment. The use of Mycoplant stimulated the germination of wheat seeds: the wheat plants sprouted earlier and moved through the consequent stages of development earlier than in control. However, an opposite effect took place on the germination of tomato seeds. The treatment with Mycoplant caused an overall tendency to increase of morphometric parameters in wheat isogenic lines Vrn-A1a and Vrn-D1a at different stages of plant growth and development; that correlated with the formation of surface mycorrhiza on the roots. The positive effect of artificial mycorrhization on the photosynthesis was established only for the isogenic line Vrn-D1a, and only at the stage of grain filling. In tomatoes the formation of arbuscular mycorrhiza due to Mycoplant treatment was observed, but no positive effect on the morphometric parameters or chlorophyll concentration in leaves was detected. The maximum frequency of occurrence of mycorrhiza was found in tomatoes of the Kremenchugskii rannijy variety, and the maximum intensity of mycorrhizal formation was found in experimental series of the late-ripening Ace variety.

Key words*: artificial mycorrhization, isogenic wheat lines, tomatoes, morphometric parameters, chlorophyll concentration*

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About the author:
O.I. Vinnikova – V.N. Karazin Kharkiv National University, Kharkiv, Ukraine, 4, Svobody Maidan, Kharkiv, Ukraine 61022 o.i.vinnikova@karazin.ua, https://orcid.org/ 0000-0001-8632-0213

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Introduction

Over the past few decades, the problem of sustainable development of agricultural production systems – grains and vegetables – has been considered a "hot topic" in applied science. Crop production systems need to be continually improved to reduce their environmental impact and protect and improve soil resources. At the same time, the intensity of food production must be maintained constantly growing, which is currently achieved by increasing soil fertility, mainly through the use of high doses of nitrogen, phosphorus and potassium fertilizers. However, preference should be given to technologies aimed at obtaining high yields while reducing the use of pesticides and synthetic fertilizers (Felföldi et al., 2022; Noceto et al., 2021). Also, for active development, plants need a balanced content of available forms of biogenic elements in the soil. The main natural suppliers of these elements in the soil are microorganisms - bacteria and micromycetes. The growth and development of plants directly depends on the activity of microorganisms, and most importantly, on their quantity. Among biogenic elements, phosphorus is a limited resource that can be depleted (Li et al., 2017). One of the ways to provide plants with phosphorus is the formation of mutualistic relations between the plant organism and mycorrhizal fungi. More than 80% of terrestrial plants form arbuscular mycorrhizae (AM) with Glomeromycota fungi. Mycorrhizae occur in almost all associations and have a significant impact not only on phytobionts, but also on the entire biogeocenosis (Abarca, et al., 2024, Jiang et al., 2017).

Various forms of relationships between fungi and plants have become the basis for their variable use in biotechnology. In conditions of intensive agriculture, AM fungi are as important as in natural habitats. The ecological function of mycorrhizae is displayed, first of all, through the viability of the host plant. The mechanisms of this phenomen a are quite diverse and include mycorrhizal regulation of plant photosynthesis, improvement of the water consumption, increased resistance to adverse factors and provision of the host plant with mineral elements, primarily phosphorus and nitrogen, due to the enlargement of the contact zone between the roots and the soil, as well as the transfer of these elements into better accessible forms for plants. In addition, mycorrhizae help protect root systems against pathogenic soil microorganisms (Dowarah et al., 2022, Elliott et al., 2021, Wei et al., 2023). The symbiosis of agricultural crops with mycorrhizal fungi imcreases the nutritional value of grain and fruits due to more intensive plant production of organic substances (sugars, amino acids) and secondary metabolites – flavonoids, carotenoids, phytochemicals and volatile organic complexes (Dhiman et al., 2022, Fusco et al. 2022). Moreover, AM colonization of plant roots is believed to provide many “non-nutritional” benefits and positive agro-ecosystem properties, sych as a preservation of soil inoculum potential and soil structure (De Vita, 2018).

Reducing the number of plant species in a certain area (for example, wheat-corn rotation), the use of mineral fertilizers and the use of fungicides leads to a decrease in the number and activity of AM fungi. On areas that are constantly used for agricultural production, the number of AM fungal propagules in the upper soil layer (0-30 cm) significantly drops down (Bakonyi, 2018, Elliott et al., 2021). Therefore, in agriculture, AM is a natural alternative to the introduction of large amounts of fertilizers, primarily phosphorus, and can be used both for the preservation of natural ecosystems or for their restoration in case of disruption.

Despite a large number of commercially available biological preparations based on AM fungi, a number of questions in regard of their optimum application still remain unanswered. In particular, it is unclear, whether there is a certain universality of such preparations, that is, whether mycorrhiza can be equally effective with different types of agricultural crops and whether it is possible to use a biopreparation in different conditions (Elliott et al., 2021, Thirkell et al., 2022). There are conflicting data on the sensitivity of some species of cultivated plants, in particular wheat, to AM fungi, that casts doubt on the commercial use of these preparations to improve grain productivity (Yang et al., 2022). Some studies revealed remarkable differences in plant susceptibility and/or response to mycorrhization among wheat genotypes differing in ploidy, geographic origin, and nutrient utilization efficiency (De Vita, 2018). Thus, the sensitivity of different plant varieties or isogenic lines to AM remains essentially uncertain.

In this regard, the aim of the present research was to evaluate the possibility and effectiveness of artificial mycorrhization of tomatoes and wheat under the conditions of a vegetation experiment.

Materials and methods

Biological material. The seeds of wheat (*Triticum aestivum* L.) isogenic lines of *Vrn-A1a*, *Vrn-B1a*, and *VrnD1a* genes were used. These lines were created in the gene pool of the Myronivska 808 variety and are maintained at the Department of Physiology and Biochemistry of Plants and Microorganisms of V.N. Karazin Kharkiv National University. *VRN* (vernalization response) genes control the response of wheat to vernalization. In particular, *VRN* genes determine the pace of plant development, and thus are responsible for the transition from the vegetative period of development to the generative one. The recessive state of these genes determines the winter type of plant development, and the dominance of at least one of the genes triggers a vigorous wheat development program (Dennis, Peacock, 2009).

Seeds of tomatoes (*Lycopersicon esculentum* L.) used in this study were of two commercially available varieties: the early-ripening Kremenchutsky rannij (Kr. rannij) and the late-ripening Ace.

Mycorrhization of seeds was carried out using Mycoplant (Mykolife, Germany), which contains propagules of endomycorrhizal fungi. This biological preparation is intended for artificial mycorrhization of cereals, vegetable crops and some berries. According to the manufacturer, the effectiveness of mycorrhization for various agricultural crops reaches 90%. Also, according to the manufacturer, the effectiveness of the drug does not depend on the type of soil – greenhouse or open field, as well as on soil composition or fertility.

Study design. Plant seeds (15 items of each plant and variety) were sown in vessels filled with 1 L (tomatoes) or 2 L (wheat) of sterile soil, taken from the agrocenosis of the experimental site of the Department of Physiology and Biochemistry of Plants and Microorganisms of the Karazin University, located on the territory of the University Botanical Garden, Kharkiv. The Mycoplant drug was added in

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quantity 5 g of granules per 1 L soil according to the manufacturer's recommendations. Vessels with drug-free sterile soil served as controls. Plants were grown in a vegetation chamber at a temperature of +24±2°C, 16 hours of light per day, and regular watering with tap water.

Seed germination was assessed by the number of sprouts that appeared on the fifth day after sowing. Morphometric parameters, such as length and mass of above-ground and underground parts, and chlorophyll content in the leaves were measured in experimental and control series, and the efficiency of mycorrhizal formation – in the experimental series only (the absence of sponateous appearance of micorrhizal fungi in the plants of control series was checked by microscopy, as described below). Wheat plants were examined at different stages of ontogenesis: tillering, output into a tube, earing and grain filling. Tomato plants were examined at the stages of growth cone differentiation (5-6 leaves), flower formation (7-8 leaves for the early-ripening *Kr. rannij* variety and 12-14 leaves for the late-ripening *Ace* variety) and budding. At meantioned stages of plant development, 5 plants were randomly selected within each series for measurements.

Quantification of chlorophyll a and b was carried out in fixed dry material (dried for 30 min at a temperature of +120°C followed by 24 h at +70°C). Pigments were extracted with 80% acetone. Pigment contents in the solution was measured via the optical density on the spectrophotometer Ulab 102UV (China) at wavelengths λ=649 nm and λ=665 nm. The concentration of chlorophylls was calculated according to H. K. Lichtenthaler's formulas (Lichtenthaler, 1987).

Mycorrhizal formation was assessed in plant roots at the last studied phase of the plant growth. Roots were collected in 5 plants randomly chosen from each vessel. Roots were macerated (10% KOH, 30 min at 95°C), washed and stained with aniline blue in 90% lactic acid. Then 1 cm long root fragments were separated with a scalpel; 20 such fragments were randomly chosen in each experimental series, and pressed preparations were made. Microscopy was carried out using a light microscope at ×600 magnification. On each preparation 50 randomly chosen fields of view per preparation were analyzed; the presence and location of fungi hyphae, arbuscules or vesicles were recorded. The frequency of occurrence of mycorrhizal infection (F, %) was calculated according to the formula:

$$F = \frac{n \times 100}{N}$$

where N – is the total number of analyzed fields of view; n is the number of fields of view in which mycorrhiza was detected.

The intensity of mycorrhizal infection (the degree of plant mycotrophy) was expressed as a cumulative frequency of root zones with different, arbitrary estimated grades of infection:

$$c = \frac{\sum_{i=1}^{5} n_i \times i}{N \times K} \times 100$$

where n_1 – the number of zones with a score of 1; n_2 – the number of zones with a score of 2; n_3 – the number of zones with a score of 3, etc.; N is the total number of investigated root zones (with or without a fungi); K is the highest score on the accounting scale; *i* – the serial number of the root zone. For this assay, 5 zones were consequently analysed along a 1 cm long root fragment.

Statistical analysis. The parameters were measured in three parallel replicates of each series; the results were combined averaged. The entire experiment was repeated twice; the means obtained in two experiments were pooled, and their overall mean and its standard error (SE) were calculated using the built-in option of the Microsoft Excel™ software package. Mean values were compared between experimental series using the Tukey test, considering the difference to be significant at p≤0.05.

Results and Discussion

The first stage of the study included assessing the germination rate of tomato and wheat seeds (Table 1). The germination of wheat seeds was non-simultaneous in control and experimental series; a 5 day earlier germination was observed in series with lines *Vrn-A1a* and *Vrn-B1a* treated with Mycoplant compared to the control; less pronounced speeding up was noted for *Vrn-D1a*. Also, a different pattern was observed for tomatoes: seeds of the *Kr. rannij* germinated in the presence of the drug at the same time as in the control, while for tomato seeds of the *Ace* variety the Mycoplant caused a 5 days earlier germination compared to that in the untreated control.

Table 1. The effect of artificial mycorrhization on the germination of wheat and tomato seeds

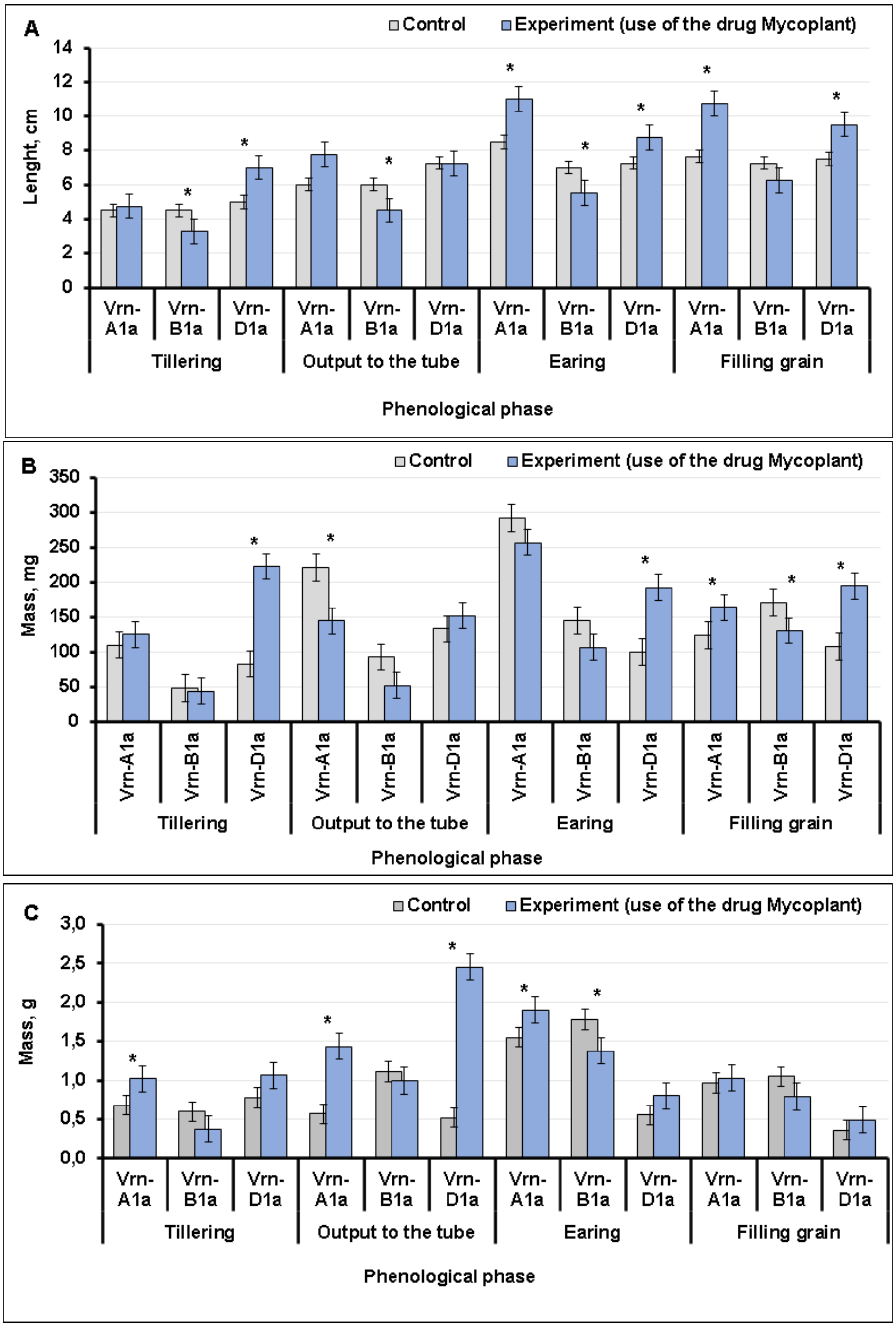
Seeds	Germination, days,	
	Untreated control	Mycoplant
Wheat, *Vrn-A1a*	11	6
Wheat, *Vrn -B1a*	12	7
Wheat, *Vrn-D1a*	8	6
Tomato, *Kr. rannij*	7	7
Tomato, *Ace*	17	9

Further observations of the growth and development of wheat and tomato plants showed that the average intervals of transition between subsequent stages of development were shorter in the series treated with Mycoplant than that in control. For wheat of the isogenic line *Vrn-A1a* this difference was 4.5 days, for the line *Vrn-B1a* – 2.75 days, and for *the Vrn-D1a* line – 3.8 days. For tomatoes, the average interval of transition from one stage of development to another was also shorter in the experiment than in control; mean difference was 8 and 6 days, respectively, for the *Kr. rannij* and *Ace* varieties. Thus, artificial mycorrhization stimulated the seed germination of wheat lines, which have an accelerated growth rates, and in tomatoes such an acceleration was observed only for the late-ripening variety. Also, the positive effect of various biological preparations based on mycorrhizal fungi on the germination and development of agricultural plants was reported by many authors (Berger, 2021, Dhiman, et al., 2022, Fusco et al., 2022, Poleva et al., 2022).

Morphometric parameters – the length of roots and the mass of raw leaves and roots, measured at different stages of plant development in isogenic lines of wheat, are presented in Fig. 1. The mean size of roots in lines *Vrn-A1a* and *Vrn-D1a,* whose seeds germinated in the presence of the Mycoplant, appeared to be significantly longer than that of control plants at almost all stages of development (Fig. 1A), except for the tillering stage in *Vrn-A1a* line and output into a tube in *Vrn-D1a* line. The opposite effect was found for the *Vrn-B1a* line – the average root length of the control plants at almost all stages of development was greater compared to the experimental plants (Fig. 1A). Similar trends occurred in the dynamics of the mass of wheat leaves (Fig. 1C). The mass of roots in the isogenic line *Vrn-D1a* in the Mycoplant-treated series was significantly higher, compared to the control, at almost all stages of growth (Fig. 1B). In contrast to that, in the isogenic line *Vrn-B1a* the mass of the roots was slightly higher in the control compared to the experimental plants during almost the entire study period, and at the grain filling stage this differences reached significance (Fig. 1B) The mass of roots in the isogenic line *Vrn-A1a*, treated with Mycoplant, droped down significantly below the control level at the stage of output into the tube, but at the grain filling stage was higher than that in control (Fig. 1B).

The dynamics of changes in the morphometric parameters in two varieties of tomato plants are presented in Fig. 2. The root length in *Kr.rannij* differed significantly between treated and control series at the stage of 5-6 leaves, meanwhile in the *Ace* variety – In the phase of flower formation and budding (Fig. 2A). The leaf mass of both tomato varieties tended to decrease in the series treated with Mycoplant compared to the control; in *Kr. rannij* this difference was significant in the phase of flower formation (Fig. 2C). The root mass appeared to be significantly lower in treated series than in control of the *Ace* variety at the 5-6 leaf stage (Fig. 2B).

Thus, the positive effect of the Mycoplant on morphometric parameters was observed mainly in isogenic wheat lines, while it was absent in tomato varieties in our study. The data, available in the literature regarding the influence of AM fungi on plant growth, are quite controversial. The experiments on tomatoes of various varieties showed that plants, inoculated with mycorrhiza, had mainly higher root length and mass (Felföldi et al., Z., 2022). Also, mycorrhizae can modify the root morphology: the area of the absorbing surface increases that improves plant nutrition, and thus provides a positive effect on the increase of above-ground biomass (Shahrajabian et al., 2023). The positive effect of mycorrhization on the growth indicators of wheat was also demonstrated by the experiments of T.J. Thirkell (Thirkell et al., 2022); moreover, the intensity of mycorrhizal formation was not always positively correlated with the increase in biomass of plants of different lines. It was also found that the degree of benefit for plants resulting from their colonization by mycorrhizal fungi can vary. In particular, slow-growing plant species with shorter roots and larger diameters benefited more from a symbiotic association with AM fungi than fast-growing plants with thinner and longer



*Note: * – difference is significant as compared with the control, p≤ 0.05*

Fig. 1. Dynamics of changes in morphometric parameters of wheat plants: A – root length; B – mass of roots; C – mass of leaves.

roots (Tran et al., 2019). Plants, used in our experiments, had different types of root systems. Tomatoes, which had thicker roots compared to wheat, did not show a positive reaction after the treatment with AM-carrying substance.

Mycosymbionts to a certain extent influence the process of photosynthesis, which, in turn, determines the amount of products needed by the fungi for nutrition. During mycorrhization of plant roots, Na + transport from roots to shoots is restricted, that increases K^+ / Na^+ , Ca^{2+} / Na^+ and Mg^{2+} / Na^+ ratios in leaves and stems, and this stimulates photosynthetic processes. Also, the presence of AM fungi increases

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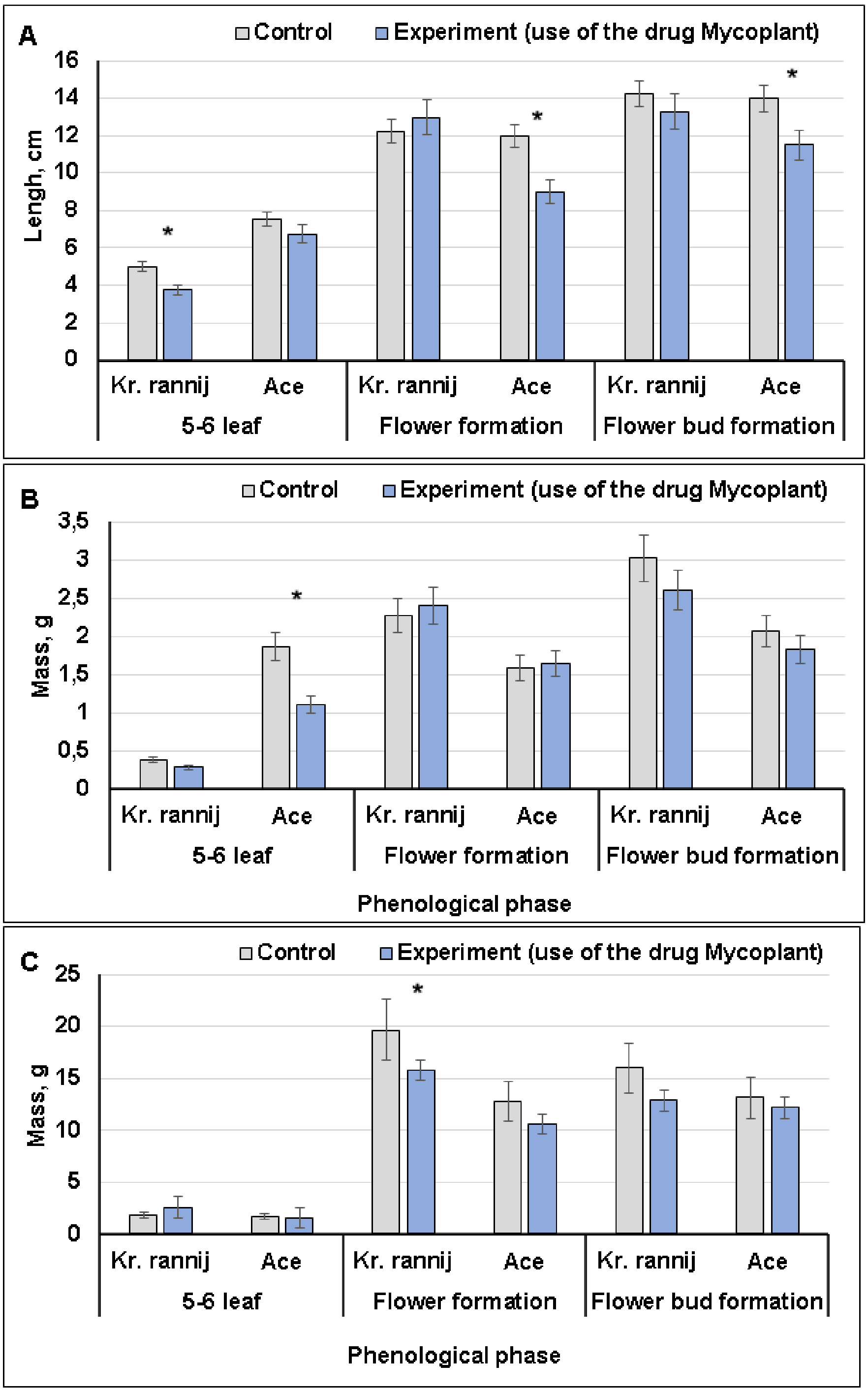


Fig. 2. Dynamics of changes in morphometric parameters of tomato plants: A – root length; B – mass of roots; C – mass of leaves. *Note: * – difference is significant as compared with the control, p≤ 0.05*

the concentration of chlorophyll in leaves of many plants, including crops and tomatoes (Fusco et al., 2022, Khan et al., 2022, Kong et al., 2020). Considering the potential role of the mycorrhizae in the development of the photosynthetic system of plants, we measured the content of chlorophylls in leaves at different stages of plant development. The concentration of chlorophylls *a* and *b* and the sum of chlorophylls were estimated (Fig. 3, Fig. 4).

At almost all studied stages of wheat ontogenesis there was a small difference in the concentrations of chlorophylls *a* and *b* in leaves of plants of Mycoplant-treated series compared to the control. The content of chlorophyll *a* was statistically lower compared to control in the isogenic line *Vrn-B1a* in the phase of output into the tube and in the line Vrn-A1a in the earing phase (Fig. 3A). In the phase of grain filling in wheat leaves of Vrn-B1a and Vrn-D1a lines, the concentration of chlorophyll *a* was significantly higher in the experimental series compared to control plants (Fig. 3A).

The concentration of chlorophyll *b* in the leaves of wheat line *Vrn-B1a* at all stages of plant development, with the exception of the grain filling phase, was significantly lower in series treated with Mycoplant, compared to the control. However, during grain filling the concentration of chlorophyll *b* in leaves of *Vrn-B1a* line plants significantly exceeded that in control (Fig. 3B). A significant decrease in the contents of total chlorophyll compared to the control occurred in wheat leaves of isogenic lines *Vrn-B1a* and *Vrn-A1a*, respectively, in the phase of the output into the tube and earing, and a significant increase of this parameter was detected in lines *Vrn-B1a* and *Vrn-D1a* in grain filling phase (Fig. 3C).

For tomatos of both varieties, there were no significant differences in the concentrations of both chlorophylls either separately or of their sum, except for the content of chlorophyll *b* in leaves of *Ace* variety in the 5-6 leaf phase, when this parameter was significantly higher in the control (Fig. 3A, 3B, 3C). Comparing the effects of mycorrhization on plant growth and chlorophyll contents, it can be noted that in most cases the differences between the series treated with Mycoplant and the control for these two groups of parameters were the opposite. For example, for wheat of the *Vrn-D1a* line, there was a positive effect of mycorrhization on the length and weight of roots during most phases of development, but no increase in the content of photosynthetic pigments was observed (Fig. 1, Fig. 3). On the contrary, the increase in the chlorophyll concentration in the wheat leaves of the *Vrn-B1a* line at the grain filling stage was not accompanied by an increase in the length of the roots and the mass of the plants (Fig. 1, Fig. 3).
Apparently, plant organisms have complex mechanisms of regulation of their growth and development; and, within the scope of this study, we cannot clearly explain the inverse correlation between observed effects. This phenomenon requires additional research and a wider set of measured parameters.

The rate of mycorrhization of wheat and tomato plants was estimated by miscroscopy analysis of roots. To prove that the mycorrhization was produced specifically by Mycoplant, the preparations from roots of plants of control series were examined along with that of the experimental series. No fungal hyphae were found either on the surface or inside the tissues of the analyzed roots of wheat and tomato plants in the control, which indicates the absence of spontaneous appearance of mycorrhizal fungi, e.g., through airborne contamination, under given experimental conditions. The frequency of mycorrhization and its intensity in the experimental series of wheat and tomato plants at the latest studied phases of plant development are given in Table 2.

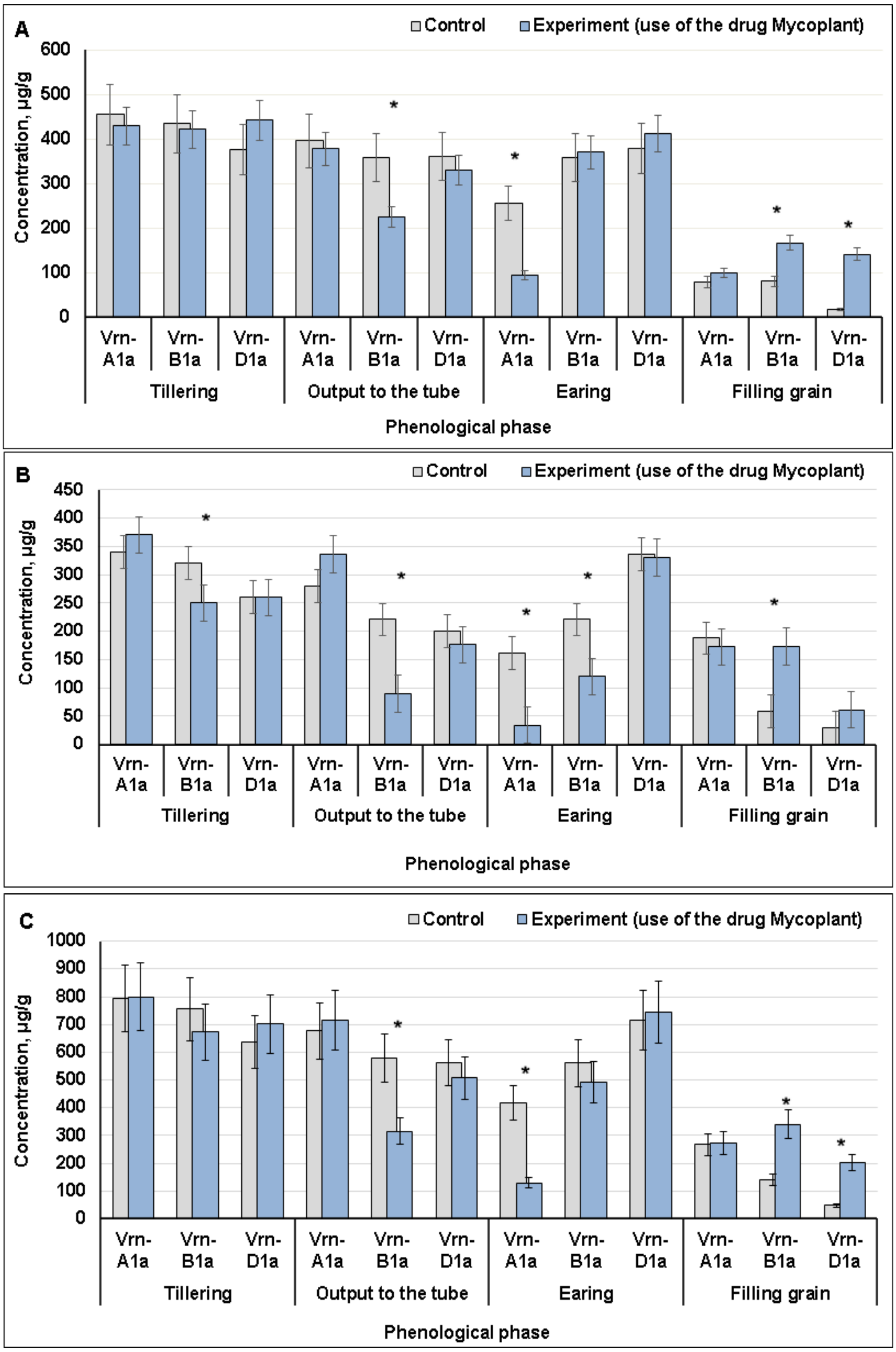
Table 2. Frequency of occurrence and intensity of mycorrhization of the roots of wheat plants (in the grain filling phase) and tomatos (in the flower bud formation phase) plants

Seeds	Frequency of occurrence of mycorrhizal infection (F, %)	Intensity of mycorrhizal infection (C, %)
Wheat, *Vrn-A1a*	73,0	31–42
Wheat, *Vrn -B1a*	62,5	63–67
Wheat, *Vrn-D1a*	81,0	54-57
Tomato, *Kr. rannij*	75,5	34–46
Tomato, *Ace*	52,0	67–71

Noteworthy, the presence of fungal hyphae in wheat was detected exclusively on the surface of the roots. In many cases the yield of fungal hyphae on the root surface was quite high. Despite this fact, which was noted at various studied stages of development of wheat plants, no occurrence of arbuscular mycorrhiza inside the roots was detected in our study. In general, about 72% of wheat plants showed signs of ectomycorrhiza formation, and the rest did not enter into symbiosis with fungi after treatment with Mycoplant.

Mycorrhiza of the arbuscular type was detected only in the roots of experimental tomato plants. Arbuscules were found in roots of both varieties of tomatoes at the stage of flower formation. The frequency of occurrence of mycorrhizal infection reached the maximum value of 75.5% in the series of *Kr. rannij*. In different zones of the roots (the tip was a start point), this parameted varied from 20 to 80%. The frequency of mycorrhizal formation in tomatos of the *Ace* variety was significantly lower – 52%. However, the intensity of mycorrhizal infection in this late-ripening variety was almost twice higher than that in *Kr. rannij* tomatoes.

Thus, the frequency of occurrence of mycorrhiza on root surface in wheat and tomatoes had variations



*Note: * – difference is significant as compared with the control, p≤ 0.05*

Fig. 3. Dynamics of changes in chlorophyll concentration in leaves of isogenic lines of wheat: A – chlorophyll *a*; B – chlorophyll *b*; C – sum of chlorophylls.

depending on the host plant line or variety. There was a tendency to a negative mutual correleation between the intensity of mycorrhization and the frequency of its occurrence in both plants.

According to the literature, the rate of root colonization by AM fungi is not always related to plant growth response and varies widely depending on the host plant genotype. Moreover, under certain environmental conditions and during the development of mycorrhiza, the same fungus can be an endophyte, a mutualistic symbiont, a saprotroph, or a necrotrophic parasite. Suppression of plant growth

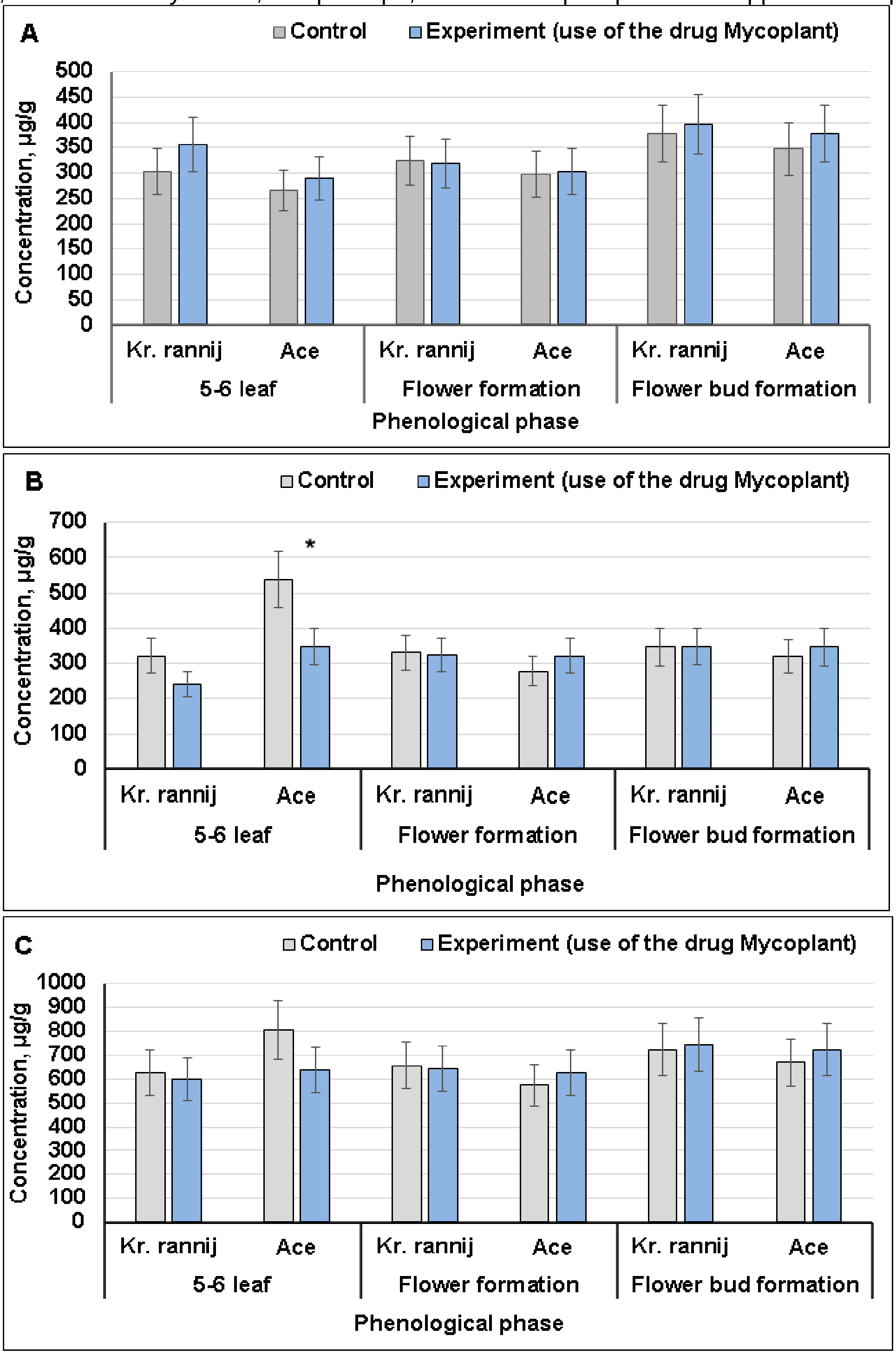


Fig. 4. Dynamics of changes in chlorophyll concentration in leaves of isogenic lines of tomato: A – chlorophyll concentration *a*; B – chlorophyll concentration *b*; C – sum of chlorophylls.

due to the development of arbuscular mycorrhiza, as happened to tomatoes in our study, may be associated with the outflow of sugars from the above-ground parts of the plant to the roots to feed the fungus itself (Brundrett, 2004, Felföldi et al., 2022).

Thus, when the Mycoplant was added to the soil, the germination of wheat seeds was stimulated and the germination of tomato seeds was inhibited: the experimental wheat plants sprouted earlier than the control ones and also earlier moved to the next stage of development. In general, the use of the Mycoplant preparation can have a certain positive effect on morphometric parameters and the intensity of photosynthetic processes occurring in the leaves of wheat lines isogenic for Vrn genes. However, the development of arbuscular mycorrhiza in the roots of experimental plants was not detected; fungal hyphae grew actively only in the rhizoplane. Regarding tomatoes, the opposite effect was observed: on the background of the development of arbuscular mycorrhiza in the roots, there was practically no increase in the chlorophyll contents or in morphometric parameters in experimental plants grown after artificial mycorrhization. The benefits of using AM fungi are obvious for crop producers, so the possibility of soil inoculation with these fungi is the subject of various studies. Further comprehensive study of the mycorrhization of various species and varieties of plants will make it possible to use the acquired knowledge in the practice of sustainable agriculture.

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Вплив штучної мікоризації на ріст і розвиток рослин в умовах вегетаційного досліду

О.І. Віннікова

Нині для практичного використання в сільському господарстві запропоновано численні комерційно доступні біопрепарати на основі арбускулярних мікоризних (АМ) грибів. Потенційні переваги інокуляції ґрунтів АМ грибами для виробництва рослинної продукції були показані в багатьох дослідженнях. Проте рівень універсальності таких препаратів, тобто ефективність штучної мікоризації одним видом грибів для різних сільськогосподарських рослин, досі залишається нез’ясованим. Метою роботи було оцінити можливість та ефективність штучної мікоризації томатів і пшениці у вегетаційному досліді. Оцінено вплив внесення в ґрунт препарату Мікоплант, що містить пропагули ендомікоризних міксоміцетів, на схожість насіння, морфометричні показники рослин, концентрацію хлорофілу в листках пшениці та томатів. У досліді використовували насіння ізогенних за генами *Vrn* ліній пшениці сорту *Миронівська 808* та двох сортів томатів – ранньостиглого сорту *Кременчуцький ранній* та пізньостиглого сорту *Ace*. Застосування препарату Мікоплант стимулювало проростання насіння пшениці: рослини пшениці проростали раніше і переходили до наступної стадії розвитку раніше, ніж у контролі. Проте спостерігався протилежний ефект на схожість насіння томатів. За обробки Мікоплантом виникала тенденція до підвищення морфометричних показників у рослин ізогенних ліній пшениці *Vrn-A1a* та *Vrn-D1a* на різних фазах росту і розвитку – на тлі утворення поверхневої мікоризи на коренях. Позитивний вплив штучної мікоризації на фотосинтез було встановлено лише для ізогенної лінії *Vrn-D1a* і тільки на стадії наливу зерна. У томатів спостерігали утворення арбускулярної мікоризи внаслідок обробки Мікоплантом, але істотного позитивного впливу на морфометричні показники і концентрацію хлорофілу в листках не було виявлено. Максимальна частота появи мікоризи визначалася у томатів сорту *Кременчуцький ранній*, а максимальна інтенсивність мікоризоутворення – у дослідних серіях пізньостиглого сорту *Ace*.

Ключові слова: *штучна мікоризація, ізогенні лінії пшениці, томати, морфометричні показники, концентрація хлорофілів*

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Про автора:
О.І. Віннікова – Харківський національний університет імені В. Н. Каразіна, майдан Свободи, 4, Харків, 61022, Україна, o.i.vinnikova@karazin.ua, https://orcid.org/0000-0001-8632-0213

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