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Behavior of the natural arbuscular mycorrhiza of oil-bearing rose under the influence of organic fertilization

Rumyana Georgieva

Agricultural University, Faculty of Agronomy, Department of Crop Science, 4000 Plovdiv, Bulgaria
Corresponding author: r_georgieva@au-plovdiv.bg

Abstract

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The present study aims to identify the composition of the natural arbuscular mycorrhizal society of Damask rose, and to investigate if the different organic fertilization products influence its colonization rate. The present research also investigated the density of the mycorrhizal community during the plant's crucial growth stages. The experiment was carried out using the randomized complete block design, in three replications over three years (2022, 2023, and 2024). The following organic fertilizers were used in the experiment: dried poultry manure, Polynamatura NP, OrgaNexport N:P 10:8, and vermicompost, each applied at the respective dose. For the test period, the two factors – organic fertilization and climate conditions, do not lead to significant changes in the composition of the natural mycorrhizal society. The species affiliation of 9 arbuscular mycorrhizal fungi was identified. Spores of *Claroideoglomus claroideum, Glomus irregulare, Funneliformis caledonius,* and *Funneliformis mosseae* were detected at the highest frequency. The density of the mycorrhizal community varies, throughout the different stages of rose development. The highest density is observed during the flowering phase, when the plants have the greatest nutrient demands. In contrast, the leaf occurrence phase is associated with the lowest density of the arbuscular mycorrhizal community. Fertilization with bone meal stimulates the density of mycorrhiza to the greatest extent for the entire testing period. During the flowering phase, fertilization with meat and bone meal increases the colonization rate between 28.3% for the second year and 32.6% for the third year. As a result of fertilization with vermicompost, the percentage of colonization increases between 8.5% for the second year and 16.9% for the first year. A similar effect is exerted by fertilizing with dried poultry manure. The control variants report the lowest values for the indicator. In years with better precipitation, such as 2023 and 2024, a higher percentage of colonization and an increased density of spores are reported.

Keywords: Damasc rose; fertilization; mycorrhiza colonization; organic production

Introduction

The efforts of today's scientists are directed toward implementing new agrotechnical practices, to enhance the yield and quality of medicinal plant production. Such practices include gentle tillage to preserve beneficial microorganisms, such as arbuscular mycorrhiza (AM) (Cameron, 2010; Raviv, 2010). AM has been documented to affect the accumulation of constituents with therapeutic functions (Copetta et al., 2006; Zubek et al., 2010). Zubek et al. (2013) investigated the presence and biodiversity of AM in the monoculture cultivation of five medicinal plants: *Hypericum perforatum* L., *Levisticum officinale* W. D. J. Koch., *Mentha piperita* L., *Thymus vulgaris* L., and *Chelidonium majus* L., and found that the greater celandine is an unfavorable host and reduces the species diversity of AM in the soil, while the other species kept the colonization rate, within the same limits for the entire study period. It is a known fact that plant species differ in their ability to influence soil, organic matter, and the availability of nutrients in the soil (Bezemer et al.,

2006; Pérez-Bejarano et al., 2010). Soil chemical properties influence soil microbial communities, and Ca and P levels, which are of great importance for AM (Zubek et al., 2013). In previous research, Zubek et al. (2009) did not find a strong correlation between the density of AM societies and soil response. However, they did note the highest diversity in soils with high calcium content. In some cases, a higher phosphorus content may have a negative effect on the degree of colonization with AM (Duan et al., 2010; Entz et al., 2004), while other studies support the opposite thesis (Ryan and Ash 1999; Zubek et al., 2012). The research of Zubek et al. (2013) found that different host plants have varying effects on soil chemical properties. However, these impacts are not permanent or unidirectional, making it difficult to draw definitive conclusions. The same team of authors found that cultivated mycorrhizal plants do not affect the colonization potential of AM. Other authors report that the inclusion of different plant species reflects on the quantity and function of AM societies (Troeh and Loynachan, 2003; Vestberg et al., 2005), which is most likely due to differences in the degree of dependence between mycorrhiza and the host plant. Some authors report little species diversity in agroecosystems (Jansa et al., 2002; Vestberg et al., 2005). Oehl et al. (2004) identified 35 distinct species using different determination methods. Zubek et al. (2012) observed differences in the density and diversity of AM because of different agricultural practices (fertilization, tillage, crop rotation). According to literature sources, *C. claroideum* and *F. mosseae* are the main species identified in medicinal plants (Oehl et al., 2004; Vestberg et al., 2005). Vestberg et al. (2005) found species specificity of AM based on the host plant, while Franke-Snyder et al. (2001) found homogeneity of AM societies in different hosts. Plant species differ in their relationship to AM, and the degree of dependence on symbiosis and agricultural practices can alter the composition of these societies (Zubek et al., 2013). Previous crops can stimulate the formation of AM and favor the growth of the next crop. Panja and Chaudhuri (2004) observed increased growth in maize and citrus when planted after a mycorrhizal precursor, regardless of soil type. Gianinazzi et al. (2010) reported an increased growth rate and accumulation of secondary metabolites in plants associated with AM. With reduced and non-intensive treatments, a smaller part of the external mycorrhizal mycelium is destroyed, and the hyphae manage to maintain their reticulated structure. Several studies indicate that because of more intensive treatments, the mycelium breaks and the colonization % decreases (Gollner, 2003; St John and Koske, 1988). Douds et al. (1995) investigated and compared the influence of different soil treatments on the density of arbuscular mycorrhizal societies, and found that the highest colonization potential occurred by zero tillage. With such a cultivation technology, an even distribution of arbuscular fungus spores in depth is also observed. The same authors' team reported that mechanical tillage affected negatively the intensity and speed of colonization of the host's roots. Gollner (2003) found that the efficiency of extra radial arbuscular mycelium for absorbing more phosphorus decreases with increasing intensity of soil treatments. Arbuscular mycorrhizal fungi are highly effective partners in our ecosystem. As plant symbionts, they colonize more than 80% of our land plants, including most cultivated plants, and stimulate their development by promoting increased nutrient and water uptake, increased drought tolerance, improved soil structure, and having a positive effect on plant health (Smith & Read, 2008). Although there is little information about the arbuscular mycorrhiza of roses, it is known that these plants are permanently mycorrhized (Augé et al., 1986). In previous investigations, Georgieva et al. (2024) found that selected organic pesticides have no significant effect on the AMF colonization rate. According to Abdel-Salam et al. (2018), colonization of rose roots from arbuscular mycorrhizal fungi can reduce the negative effects of drought-induced stress on plant growth in arid and semi-arid regions. Furthermore, Møller et al. (2009) argue that arbuscular mycorrhizal fungi are promising partners in reducing *Botrytis cinerea* infection in roses. Several factors can influence the composition of the mycorrhizal society (Likar et al., 2017; Zaller et al., 2018).

Currently, there is no literature available on the biodiversity of arbuscular mycorrhizal communities in both organic and conventional cultivation of oil-bearing roses. In this context, the present study aims to identify the composition of the natural arbuscular mycorrhizal society of organic Damask rose, and to investigate if the different organic fertilization products influence its colonization rate.

Material and Methods

Field experiment

For the study, five-year Damascena rose (*Rosa damascena* Mill.) plantations were used, located in the region of the village of Rozovo (W: 42.565657, L: 25.416037), part of the Rose Valley of Bulgaria. The experiment was carried out using the randomized complete block design in three replications over three years (2022, 2023, and 2024). The area of each plot is $18m^{2,}$ covering two rows and 21 plants. The row distance is 3 m, and the individual bushes are located 0.40 m apart. The experimental setup included the following fertilizers: dried poultry manure (DPM) Polynamatura NP (organic nitrogen 2%; P_20_5 2.5%, K_2O 2%; MgO 2%, CaO 12%; B 0.004%, Mn 0.04%; Zn 0.02%, organic carbon 20%) in a dose of 60 kg ha^{-1}; bone meal (BM) OrgaNexport N:P

10:8 (meal from bones, horns and hooves, organic nitrogen 10%, organic carbon 40%, P_20_5 8%), in a dose of 50 kg ha^{-1}, vermicompost (VC) Biohumus (organic manure 50-60%, organic carbon 35%, organic nitrogen 3%, P_20_5 2.2%, K_2O 1.2%, CaO 8.31%), applied in a dose of 1l per bush. The data were compared to the unfertilized control. The fertilizers were distributed in autumn before the last tillage.

Randomly selected roots of an oil-bearing rose were used to estimate the percentage of colonization with AMF. To investigate the dynamics of the AMF community, root samples were collected four times per growing season, during the important growth stages of the plant: leaf occurrence, bud formation, flowering, and secondary shoot growth. The species composition of the mycorrhizal society was determined, based on 36 root samples (3 samples per variant). Sampling took place in the flowering phase, because at this moment the plant's need for nutrients is greatest and the density of mycorrhiza is the highest. The plants were randomly selected because according to the literature overview, the population density of mycorrhizal societies varies within narrow limits (Gollner, 2003; St John and Koske, 1988). To determine the impact of fertilization, six 500 g soil samples have been taken from the roots of three plants per plot. These samples are subsequently mixed for statistical data processing. Sampling took place from 0–27 cm depth. Fine roots were cleaned from soil and 2 cm root segments were used for the further staining procedure to determine the density of the arbuscular mycorrhizal community. The cleaned segments were placed in falcon tubes with a capacity of 15 ml, and poured with a 30% alcohol solution. The segments prepared in this way were subjected to a staining procedure. The subsequent treatment began with immersion of the root segments in 10% KOH for one day, for bleaching and boiling in a water bath with a temperature of 90°C for four minutes. This was followed by a triple rinse with tap water and staining in a 5% solution of ink and vinegar, according to the method of Vierheilig et al. (1998). After staining, the roots were again rinsed with tap water and stored in 30% ethanol. The colonization rate of arbuscular mycorrhizal root was determined according to the method of gridline intersection (Newman, 1966; Giovanetti and Mosse, 1980). The degree of colonization of the roots was calculated using the formula:

The diversity of the arbuscular mycorrhizal community has been assessed using a light microscope Kern ODC 825. The method used by Zhang et al. (2004) was used to calculate the frequency of occurrence (FO). This involved dividing the number of soil samples, in which the species was identified by the total number of samples, and expressing the result as a percentage. This approach allows the categorization of AMP species as dominant (FO>66%), common (33%≤FO≤66%), and rare (FO≤33%) (Betancur-Agudelo et al., 2021). Spores were counted using the wet sieving and decanting method of Gerdemann and Nicolson (1963), followed by sucrose density centrifugation (Ianson and Allen, 1986). First 100 g of soil from every variant was dispersed in 1L of water and centrifuged. The suspension was then decanted through sieves (mesh diameter 500-40 μm), and the 40% sucrose solution was added. All residues were filtered, and the intact spores were counted under a stereomicroscope. For the identification of the spores literature sources (Oehl et al., 2003, 2004; Walker and Souders, 1986), as well as online resources (Home | INVAM (ku.edu)) have been used. As for soil management, the inter-rows were plowed to a depth of 18-20 cm in the spring. Before blooming, the soil was cultivated twice at a depth of 5-6 cm. In the second year, before the last cultivation, the soil was limed (ground limestone in a dose of 3t ha^{-1}), to adjust the pH value. The area was not irrigated.

Soil and climatic characteristics of the region

Todorova et al. (2020) established the dominant soil type of the region is represented by deluvial noncalcareous sediments, which according to the World Reference Base for Soil Resources classified the soils as *Fluvosols.* A characteristic feature of these soils is that organic matter is lost very quickly. To be able to track the soil stock with the main chemical elements, soil samples were taken annually from the 0-30 cm layer. The pH values ranged from 4.30 in the first year, to 5.20 in the third year of the investigation. The content of humus by Turin (Trendafilov and Popova, 2007) was between 3.30 to 4.10% for the study period. To determine the mineral nitrogen content, the method of Kjeldahl (Goyal et al., 2022) was applied with values ranging between 14.33 to 16.20 mg kg^{-1} for the first and the third year, respectively. The available potassium and phosphorus content was measured using the Egner-Riem method (GOST 26208-91, 1993). The potassium values ranged from 15.50 mg/100 g to 17.40 mg/100 g. Over the study period, the mobile phosphorus content varied from 11.54 mg/100 g in the first year, to 13.10 mg/100 g in the third year. The content of SOC was measured according to the Nikitin-modified Tyurin method (Slepetiene et al., 2023) with values varying between 13.82 mg g $^{-1}$ and 16.8 mg g $^{-1}$.

The region is characterized by a continental climate. The temperature values and the amount of precipitation have changed dynamically during the study period (Figure 1). Annual rainfall in the first year was 186.7 mm lower than the long-term average of the region, but precipitations were more evenly distributed. In 2023, the amount of precipitation was 1016.6 mm, which exceeded the long-term average

by 84.8 mm. In terms of precipitation, last year was closest to the climatic norm of the region. Comparing the average monthly temperatures in every year of the investigation with the values of the multi-year period, it can be concluded that a tendency towards a permanent increase in the indicator is established.

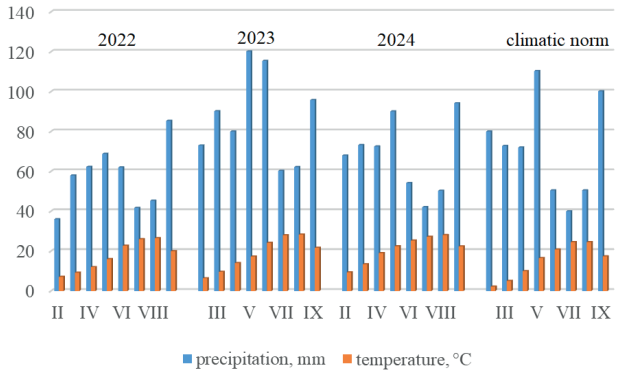

Fig. 1. Climatic conditions during the vegetation period of *Rosa damascena*

Data processing

Statistical data processing is carried out using one-way analysis of variance (ANOVA). The least significant differences were assessed using Tukey's HSD Test.

Results and Discussion

In this study, the composition of the natural mycorrhizal society on the roots of the Damask rose, grown organically, is reported for the first time. The main species that have been identified by the roots of the organically grown rose Damascena are reflected in Table 1. As a result of the analyses of the root samples, the species affiliation of 9 arbuscular mycorrhizal fungi was defined. Spores of *Claroideoglomus claroideum, Glomus irregulare, Funneliformis caledonius,* and *Funneliformis mosseae* were identified in the highest frequency. Spores of *Glomus mosseae* were identified in half of the samples, and spores of *Glomus constrictum, Scutellospora dipurpurescens,* and *Archaeospora trappei* were detected in single samples. In the present study, no significant changes in the species composition of AMF communities were observed. The probable reason is that for the needs of the study a perennial rose plantation was used, in which the mycorrhizal community is already established and adapted to the changing soil environment.

Zubek et al. (2013) investigated species diversity and mycorrhizal society density in lovage, St. John's wort, mint, and thyme and documented that *Claroideoglomus claroideum* spores were present in the highest density on the roots of the medicinal plants studied. The density of *Funneliformis mosseae* and *Diversispora* sp. is moderate, and the spores of *Archaeospora trappei* have been found only on mint roots. Although the influence of arbuscular, mushroom mycelium on the formation and accumulation of ingredients with therapeutic properties in some medicinal plants has been extensively studied (Kapoor et al., 2007; Copetta et al., 2006; Toussaint et al., 2007; Ceccarelli et al., 2010; Zubek et al., 2010), there is still a lack of literature on symbiotic relationships and species composition and diversity of mycorrhizal societies in these cultures.

Table 1. Species composition of the arbuscular mycorrhizal society (*Glomeromycota*) in Damasc rose

Representatives	Frequency of occurrence*
Claroideoglomus claroideum	D
Glomus irregulare	D
Glomus mosseae	C
Glomus constrictum	single spores
Glomus albidum	R
Scutellospora dipurpurescens	single spores
Archaeospora trappei	single spores
Funneliformis caledonius	D
Funneliformis mosseae	D

*D-dominant (FO > 66%), C-common (33% ≤ FO ≤ 66%), R-rare (FO ≤ 33%)

According to literature data, the density of mycorrhizal societies can vary due to several external factors. Reducing the biodiversity of the arbuscular mycorrhizal society negatively affects plant functionality (Hodge et al., 2010). Key ecosystem processes are affected by biodiversity loss (Wagg et al., 2014), and ecosystem services provided by soil rhizobium (Gianinazzi et al., 2010). The composition of AM societies varies according to the phenological phase, especially during flowering and maturation, since these phases are accompanied by changes in the composition of root exudates (Lucas García et al., 2001). Another factor that can negatively affect the composition of the mycorrhizal society is the cultivation technology used (Likar et al., 2017; Zaller et al., 2018).

After the winter period, the vegetation of rose bushes begins with the leaf occurrence. During the study period, this stage is associated with the lowest % of colonization. By the unfertilized control, the values are the lowest and vary between 2.2% for the third year and 3.4% for the second year. The organic fertilizers significantly increase the parameter, and the differences with the control variants are statistically significant and proven. The other distinguishing feature of this growth stage is the presence of mainly AMF hyphae and

to a lesser extent vesicular structures in the analyzed samples. During the bud formation, the colonization rate increases significantly. For the whole period of the investigation, the largest % share was occupied by the hyphae and arbuscules. In 2022, the total % of colonization ranges between 6.4% for the unfertilized control and 25.6% for the variates fertilized with bone meal (Table 2).

Table 2. Mycorrhizal colonization frequency of arbuscules, vesicles, and hyphae (%) in 2022

Growth stage	Treatment	Hyphae	Arbuscules	Vesicular	Total
Leaf occurrence	VC	6.8^{b}	0	1.1^{b}	7.9^{b}
	DPM	5.8^{b}	0	0.4^{a}	6.2^{b}
	MB	8.2^{b}	0	0.9^{b}	9.1^{c}
	Control	2^{a}	0	0.8^{a}	2.8^{a}
LSD 5%		2.3		0.5	3.1
Bud formation	VC	7.6^{a}	7.2^{c}	3.3^{a}	18.1^{b}
	DPM	8.7^{b}	5.1^{b}	2.4^{a}	16.2^{b}
	MB	13.5^{c}	6.3^{b}	5.8^{b}	25.6^{c}
	Control	3.6^{a}	1.6^{a}	1.2^{a}	6.4^{a}
LSD 5%		4.7	2.5	2.7	7.8
Flowering	VC	11.9^{a}	11.3^{b}	7.2^{b}	30.4^{b}
	DPM	20.3^{b}	9.8^{b}	5.1^{b}	35.2^{b}
	MB	19.2^{b}	15.9^{c}	8.2^{c}	43.3^{c}
	Control	8.6^{a}	3.4^{a}	1.5^{a}	13.5^{a}
LSD 5%		7.2	5.6	3.2	14.2
Secondary shoots growth	VC	10.8^{a}	10.3^{b}	6.7^{b}	27.8^{b}
	DPM	14.5^{b}	9.5^{b}	4.6^{b}	28.6^{b}
	MB	19.6^{d}	12.4^{c}	7.7^{c}	39.7^{c}
	Control	7.7^{a}	2.3^{a}	1.6^{a}	11.6^{a}
LSD 5%		3.8	4.9	2.8	13.8

* values with different letters show statistically significant differences ($P < 0.05$)

In the second and third years, an increase of up to 10% was reported in the control variants, which should be explained by the more optimal conditions for developing the AMF community, probably the better pH soil reaction. The highest rate of colonization was observed because of fertilization with bone meal with values of 36.3% for the second year (Table 3), and 34.2% for the third year (Table 4). During all three years, the highest percentage of colonization was observed at the flowering stage, possibly due to the plant‘s increased nutrient requirements.

Table 3. Mycorrhizal colonization frequency of arbuscules, vesicles, and hyphae (%) in 2023

Growth stage	Treatment	Hyphae	Arbuscules	Vesicular	Total
Leaf occurrence	VC	6.2^{b}	0	0.5^{a}	6.7^{b}
	DPM	6.6^{b}	0	0.7^{b}	7.3^{b}
	MB	7.4^{b}	0	1.2^{c}	8.6^{c}
	Control	3^{a}	0	0.4^{a}	3.4^{a}
LSD 5%		2.6		0.3	2.6
Bud formation	VC	11.6^{b}	8.5^{b}	5.3^{b}	25.4^{b}
	DPM	12.8^{b}	10.3^{b}	5.6^{b}	28.7^{b}
	MB	21.9^{d}	12.5^{c}	1.9^{a}	36.3^{c}
	Control	8.3^{a}	4.2^{a}	3.4^{a}	15.9^{a}
LSD 5%		4.8	3.9	2.1	9.3
Flowering	VC	24.8^{b}	12.5^{a}	3.3^{a}	40.6^{a}
	DPM	23.4^{a}	19.7^{c}	3.7^{a}	46.8^{b}
	MB	36.6^{d}	16.2^{b}	7.6^{b}	60.4^{c}
	Control	17.5^{a}	10.9^{a}	3.7^{a}	32.1^{a}
LSD 5%		6.2	3.8	2.4	10.4
Secondary shoots growth	VC	22.6^{a}	10.3^{a}	4.8^{a}	37.7^{a}
	DPM	27.4^{b}	12.7^{b}	2.2^{a}	42.3^{b}
	MB	34.8^{c}	14.3^{c}	5.8^{b}	54.9^{c}
	Control	15.6^{a}	7.1^{a}	6^{b}	28.7^{a}
LSD 5%		7.3	3.4	2.4	11.2

* values with different letters show statistically significant differences ($P < 0.05$)

The lowest values were reported by the control. As a result of fertilization with vermicompost, the percentage of colonization increases between 8.5% for the second year and 16.9% for the first year. A similar effect is exerted by fertilizing with dried poultry manure, as the differences in the action of the two organic fertilizers are statistically unproven, which places them in the same statistical group. As a result of bone meal fertilization, the colonization rate increases on average by up to 30% compared to the control, 16% compared to vermicompost, and up to 12% compared to the variants fertilized with dried poultry manure. In the next phase of the development of the oil-bearing rose, a slight decrease in the degree of colonization is reported. Again, fertilizing with bone meal greatly stimulates the density of AM society. Payal Mago and Mukerji (1994) detected seasonal trends in the AM density by some species of *Lamiaceae*. The highest colonization rate was recorded in the summer period.

In general, organic fertilization increases the density of the AM community in the oil-bearing rose, and fertilization with

Table 4. Mycorrhizal colonization frequency of arbuscules, vesicles, and hyphae (%) in 2024

Growth stage	Treatment	Hyphae	Arbuscules	Vesicular	Total
Leaf occurrence	VC	7.8[b]		0.4a	8.2[b]
	DPM	6.8[b]		0.8[b]	7.6[b]
	MB	7.5[b]		1.4[d]	8.9[c]
	Control	1.6[a]		0.6[a]	2.2[a]
LSD 5%		3.2		0.3	3.1
Bud formation	VC	12.6[b]	8.8[a]	7.4[c]	28.8[b]
	DPM	13.3[b]	10.5[b]	3.7[a]	27.5[b]
	MB	21.2[c]	10.7[b]	2.3[a]	34.2[c]
	Control	7.6[a]	6.4[a]	2.9[a]	16.9[a]
LSD 5%		4.6	3.1	2.5	8.5
Flowering	VC	25.3[b]	13.4[b]	4.8[b]	43.5[b]
	DPM	25.2[b]	18.3[c]	1.2[a]	44.7[b]
	MB	37.6[c]	16.3[b]	5.4[b]	59.3[c]
	Control	16.2[a]	8.3[a]	2.2[a]	26.7[a]
LSD 5%		8.7	4.7	2.4	15.3
Secondary shoots growth	VC	24.1a	9.5[a]	5.8[b]	39.4[b]
	DPM	28.8[b]	10.2[b]	6.2[b]	45.2[b]
	MB	35.5[c]	15.7[c]	6.9[c]	58.1[c]
	Control	16.2[a]	6.4[a]	1.6[a]	24.2[a]
LSD 5%		9.4	3.8	2.4	11.7

* values with different letters show statistically significant differences ($P < 0.05$).

bone meal turns out to be the most effective, due to the higher content of organic carbon and phosphorus, the two elements that are most important for maintaining symbiotic relationships. Gollner (2003) found that the liquid form of organic fertilizer has the lowest % of mycorrhization, which is due to the relatively higher ammonia content. According to the same author, high levels of ammonia reduce the activity of symbiosis, because they create competition for assimilation between the fungus and the host plant. Despite the high organic carbon content, fertilization with vermicompost has the lowest increase in % of colonization. Gollner (2003) found that in biological production systems, the top layer contains more arbuscular fungus spores. In the present study, the density of the mycorrhizal society, expressed as a percentage of colonization, is higher in the lower soil horizon, up to 27 cm. This is because oil-bearing rose is a perennial plant with a well-developed root system. For the test period, the % of colonization also varies under the influence of climatic conditions, because there is a dynamic in the values of the control variants.

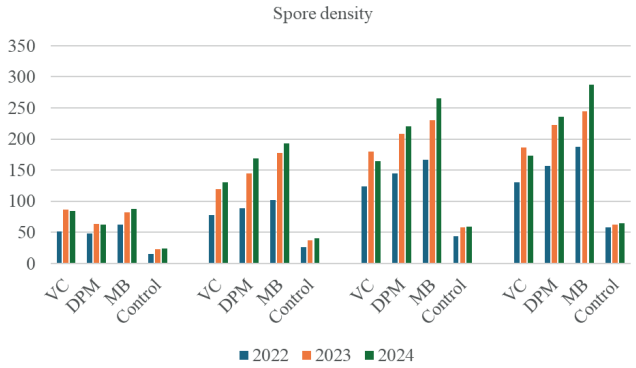

Fig. 2. AMF spore density (in 50 cm³ soil) for the period 2022-2024

The density of spores in the arbuscular mycorrhizal community changes dynamically during the various stages of rose plantation development under the influence of organic fertilization. The most beneficial effect on the indicator is again exerted by fertilization with bone meal, and in the control variants, the values are the lowest (Figure 2). Sporulation is the reaction of the arbuscular mycorrhizal fungi, to spore lost due to leaching, mortality, germination (Sivakumar, 2013). Plant communities, soil characteristics, the sporulating nature of the fungus, and the growing period of the host plant are among the most important factors that can cause variation in the spore density of AMF. Arbuscular mycorrhiza plays a crucial role in ecosystem sustainability. Understanding seasonal variations in mycorrhizal society density is essential for comprehending its relationship with the host plant.

Conclusions

The study was able to identify 9 arbuscular mycorrhizal fungi species. The organic fertilization applied, as well as the environmental conditions, did not significantly change the composition of the mycorrhizal society. The density of the mycorrhizal community changes throughout the various stages of rose development. The highest values are observed during the flowering phase, when the plants have the greatest nutrient demands. In contrast, the lowest density of the arbuscular mycorrhizal community is associated with the leaf occurrence phase. Fertilization with bone meal significantly enhances mycorrhizal density, throughout the entire testing period. During the flowering phase, applying bone meal increased the colonization rate by an average of up to 30%. In contrast, the use of vermicompost increased the colonization percentage by an average of 14% compared to the control. A similar effect was noted with the application of dried poultry

manure. In years with better precipitation, such as 2023 and 2024, a higher percentage of colonization and an increased density of spores are reported. The product OrgaNexport N:P 10:8 can be recommended, and used successfully for sustainable farming purposes.

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