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EFFECT OF APPLIED FERTILIZERS ON VEGETATIVE GROWTH AND "SOIL RESPIRATION" IN ORGANICALLY GROWN *TR. MONOCOCCUM* L.

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Abstract

Biofertilizers application in agro-ecosystem improves the soil properties, protects the environment and has a positive effect on plants. As a result of the application of the studied biofertilizers, the plants heights in spindle phase are higher in all variants, compared to the control one. This difference is greatest at the treated with Baikal EM - 48.57 cm, which is 14% above control, followed by the one, treated with Amalgerol - 47.85 cm and Tryven - 47.73 cm. The positive effect on the studied biofertilizers on Triticum monococcum L., for good nutrition and intensive plant cultivation, is maintained until full density, where the highest values are reported at the variants treated with Lithovit - 99.6 cm (11% above control), Triven - 97.45 cm (8.8%) and Baikal EM - 97 cm (8.3%). The increase of the microbial activity in the soil at the variant, treated with Baikal EM (heading phase) shows a trend that persists on the 7th, 14th and 21st day and has a positive effect on the plant height.

Key words**:** *biofertilizers, organic agriculture, Tr. monococcum L., soil respiration, vegetative growth*

INTRODUCTION

Chemical fertilizers have been used intensively around the world to increase crop yield. However, they have started depositing their harmful effects to the soil and environment, thus causing reduction in soil quality [31, 4] and disturbing the harmony existing among the soil, plant and microbial population [6]. One of the proposed solutions to environmental and human health protection issues is the implementation of natural technologies of plant cultivation and fertilization through the applications of biofertilizers [1]. A biofertilizer includes mainly nitrogen fixing, phosphate solubilizing and plant growth promoting microorganisms [17, 38, 22, 29], which are the basis of the greatest natural gifts of our agricultural science [24]. Biofertilizers have a very significant role in improving soil fertility by fixing atmospheric N, both in association with plant roots and without it, solubilize insoluble soil phosphates and produce plant growth substances in the soil [22]. Biofertilizers are environment friendly agro-input of organic origin and work on the conversion of unavailable essential elements to available form through their routine metabolic activities [24, 36]. Application of biofertilizers improve physico-chemical properties of soil like soil texture, pH [29], encourage plant growth and productivity [2, 37], enhance soil fertility and health [18], and have important and long-term environmental implications [27]. Precisely because the use of biofertilizers makes the agro-ecosystem healthy [3], they are suitable for practising organic farming [28]. Nutrients are the most important limitation to growth and development of plants [32], but optimal crop productivity and optimal nutrient use efficiency must be in balance [5]. Organic fertilizers contain organic compounds which increase soil fertility either directly or by their decay [27], and also improve soil fertility status by activating the soil microbial biomass [26].

Soil is a dynamic, living natural system that is vital to the function of the agroecosystem [12, 8]. The rhizosphere is an area of soil around the roots that is affected by it [9, 25], as a result of the vital activity of soil

microorganisms (respiration, fermentation and decay of organic residues) emit significant amounts of CO_2, which is immediately used by plants [21]. To determine the soil microbial activity, the most characteristic indicator is soil microbial respiration [35, 33].
The einkorn (*Triticum monococcum* L.) was originally cultivated around Karacadag in Turkey [14] and in the Middle-East, Central Asia, Europe and North-Africa [40]. It is grown mainly in France, Turkey, Morocco [10, 7]. Einkorn belongs to the group of "ancient" wheat (*Tr. monococcum* L., *Tr. dicoccum* Sch. and *Tr. spelta* L.) and in recent years the interest in it is significant because it is an alternative to healthy foods [16, 15, 11, 19] and is suitable for the organic system of agriculture [39, 23]. Its cultivation is encouraged because there is conservation of genetic resources in Turkey [20] and Bulgaria [40], biodiversity of wheat is preserved in organic farming. The aim of the study is to trace whether the types of biofertilizers used affect the vegetative growth and soil respiration of einkorn *Tr. monococcum* grown according to the principles of organic crop production.

MATERIALS AND METHODS

The study was conducted in 2014 - 2017 at the Agroecological Center at the Agricultural University on the alluvial - meadow soil. A three - factor experiment was performed by the block method, in three repetitions with the size of the reported plot 10.5 m^2. The factors are- vegetation year (2014/2015; 2015/2016; 2016/2017); type of wheat - einkorn (*Tr. monococcum* L.*)*; Vegetation fertilization - basic fertilization with Agriorgan pallet and foliar fertilization with Amalgerol, Lithovit, Baikal EM and Tryven. Biofertilizer Agiorgan pellets was applied in a dose of 100 kg/da. All foliar fertilizers were applied twice in the tillering and the stem elongation phases in the following concentrations, respectively: Amalgerol - 200 ml/da in tillering phase and 500 ml/da in the stem elongation phase; Lithovit- in a dose of 150 g/da; Baikal EM - with 0.1% solution; Tryven - 400 ml/da. The selected biofertilizers, belong to the list of permitted biofertilizers in the European Union 'Organic' Regulation No. 889 [30].
Characteristics of used biofertilizers:
Amalgerol - is a liquid emulsion concentrate rich in hydrocarbons and natural plant growth hormones. Contains seaweed extracts, distilled paraffin oil, vegetable oils, distilled herbal extracts.
Lithovit - is a high quality nanotechnology product created by tribodynamic activation and micronization. Contains ($CaCO_3$) - 79.19%; ($MgCO_3$) - 4.62%; (Fe) - 1.31% and others.
Baikal EM - 1Y - is a probiotic product containing beneficial microorganisms (lactic acid bacteria, yeast, bifidobacteria, enzymes and spore bacteria) which are antagonists of pathogenic and opportunistic microflora.
Tryven - is a complex mixture of NPK, contains (N) - 24.4%; Organic nitrogen - 17.3%; (P_2O_5) - 17.2%; (K_2O) - 7.42%. It has a good systemic effect, especially nitrogen.
Agriorgan pellet- is an organic fertilizer from sheep manure, enriched with microorganisms and a supplement of trace elements. Contains: Organic nitrogen (N) - 2.5%; (P_2O_5) - 3.0%; (K_2O) - 1.0%; Organic carbon (C) - 28.5%; Humic acids - 6.0%; pH - 6, fulvic acids.
Einkorn (*Triticum monococcum* L.) is the oldest species in the group of covered or non-essential wheat. When threshing, the class spindle breaks and the grain remains tightly wrapped in chaff. In order to be used for food, additional peeling is required. Pepper was used as a precursor for the experiment. For successful control of early spring weeds in the crop is used harrow in March when the crop is in the phenophase twinning, and weeds are in the early stages of development and this method is extremely effective for weed control in crops with a fused surface in the system of organic production. Due to the pronounced resistance to diseases and pests, plant protection was carried out only in the first experimental year (2014 - 2015), against an attack by the common wheat leech (*Lema melanopus*) with Nimazal - a dose of 300 ml/da. Occurrence of a partial attack of rust (*Puccinia graminis f. sp. tritici*) in the same year at the end of the growing season (in the phase of full ripeness) did not require a fight.

Study Parameters: Plant height - measure the height of 10 plants of each variant and each repetition in the phases of twinning, spindling and full maturity; *'Soil respiration'*- total microbiological activity is determined by the amount of CO_2 released (determination of the intensity of CO_2 release). The method used is a modification of the method of Stotzky [34, 33]. The statistical processing of the experimental data was performed using SPSS V. 9.4 for Microsoft Windows by the method of Duncan [13].

RESULTS AND DISCUSSIONS

Plant height- *Tr. monococcum* L. by phenophases

The results for the plants height influenced by the applied biofertilizers show that in 2015 by *Triticum monococcum* L. in tillering phase highest height was reported in the combined application of Baikal EM biofertilizers - 10.30 cm and Lithovit - 10.03 cm on basic fertilization with Agriorgan pallet (Table 1).

At tillering phase highest value of the indicator is at treatment with Amalgerol - 55.40 cm, followed by the this with Tryven - 54.43 cm and Baikal - 53.33 cm, and in full ripeness phase the highest values are at Lithovit treated variants - 95.77 cm, followed by Tryven - 95.20 cm. Higher values are reported in all fertilized variants, but with no trend.

In 2016 highest plant in tillering phase are reported at the variants treated with Lithovit - 22.50 and Amalgerol - 21.17 cm, wher the increase is respectively 7.6% and 1.3%, compared to the control. In stem elongation phase, the plants are reported at Lithovit - 51.20 and Amalgerol - 47.63 cm, from 5.1% and 7.1% above the control.

Table 1. *Tr. monococcum* L plants height, by phenological phases and fertilization variants (2015 - 2017), cm

Phenological phases	**Tillering**					**Stem elongation**					**Full ripeness**				
Year Variants	2015	2016	2017	Ave rage	%	2015	2016	2017	Ave rage	%	2015	2016	2017	Ave rage	%
Control	-	20.90	11.55	16.22	100	-	44.47	40.90	42.68	100	-	93.72	85.4	89.56	100
Agriorgan pellets	8.63	19.57	12.30	13.50	83.2	49.90	47.37	44.03	47.10	110.3	90.73	97.38	90.7	92.94	103.8
Amalgerol	8.67	21.17	11.13	13.66	101.2	55.40	47.63	40.53	47.85	112.1	92.47	104.77	89.7	95.65	107.9
Lithovit	10.03	22.50	10.90	14.48	89.3	52.27	51.20	39.00	47.49	111.3	95.77	106.60	94.8	99.06	110.6
Baikal EM	10.30	20.22	11.30	13.94	85.9	53.33	47.20	45.17	48.57	113.8	92.43	102.97	95.6	97.00	108.3
Tryven	8.17	20.97	12.23	13.79	85.0	54.43	47.50	41.27	47.73	111.8	95.20	101.65	95.5	97.45	108.8

Source: Own survey.

All tested fertilizers have a positive effect on plant growth and their height values exceed control onse. As a result of the treatment with Lithovit, in full ripeness phase the plants reach height of 106.60 cm, followed by these with Amalgerol - 104.77 cm, which is by 14% and 12%. Feeding with the microbial biofertilizer Baikal EM also has a positive effect on plants growth and reaches an average value of 102.97 cm, which is 9.8% above the control. This percentage difference in the agro-ecosystem is essential to take into account the role of the applied vegetative feeding with biofertilizers.

In 2017 in tillering phase, the highest plants are reported at fertilization with Agriorgan pellet only - 12.30 cm, followed by the variant treated with Triven - 12.23 cm. For all other variants of fertilization, the data are inconsistent. During the stem elongation phase, highest plants are reported when treated with Baikal EM - 45.17 cm, which is 10.4% above the control, followed by the Agriorgan pellets, which is 7.6% above the control, but in full ripeness phase, higher values are reported when Baikal EM is applied (95.6 cm) and Tryven (95.5 cm) - 11.9% and 11.8% more than control variant. Average for the period of study in stem elongation phase, all variants of fertilization increase the values of this indicator, as the highest plant height is reported when treated with Baikal EM - 48.57 cm - 14% above the control, , followed by the variants treated with Amalgerol - 47.85 cm and Tryven - 47.73 cm. In full ripeness the data show that all studied

biofertilizers lead to better nutrition and intensive growth of plants in height at *Tr. monococcum* L., most pronounced in the variant treated with Lithovit - 99.6 cm (11% above control), Tryven - 97.45 cm (8.8%) and full ripeness phases at the average values is a tendency for higher plants in the variants treated with foliar fertilizers, on basic fertilization with Agriorgan pellet, compared to the unfertilized control. This shows the complementary effect of foliar fertilizers on plant nutrition.

Baikal EM - 97 cm (8.3%). *Tr. monococcum* L., reacts clearly to the applied biological fertilizers, expressed in an increase in the values of plant height indicator. This finding is confirmed by the synergistic effect of the applied fertilizer combinations with clear efficiency of foliar vegetation nutrition. It can be pointed out that in the stem elongation and distribution, despite the temperature values above the norm, shows a strong influence on the absorption of nutrients by plants in the different phases of their development (Tables 2 and 3).

Lack of moisture in the soil hinders microbiological processes, the absorption of nutrients by plants and vice versa.

Table 2. Air temperature by months, average for the study period (2014-2017)

Months	IX	X	XI	XII	I	II	III	IV	V	VI
2014 – 2015										
Average Monthly t ° C	18.1	12.8	7.9	5.1	3.1	3.7	6.7	12.4	19.3	21.1
On average for the period 1965 - 1995	18.3	12.6	7.4	2.2	-0.4	2.2	6	12.2	17.2	20.9
2015 – 2016										
Average Monthly t ° C	21	12.8	11.3	5.1	-0.1	8.0	9.3	15.5	17.0	23.3
On average for the period 1965 - 1995	18.3	12.6	7.4	2.2	-0.4	2.2	6	12.2	17.2	20.9
2016 – 2017										
Average Monthly t ° C	19.6	12.7	6.6	2.2	-3.9	3.2	9.7	12.7	17.6	22.8
On average for the period 1965 - 1995	18.3	12.6	7.4	2.2	-0.4	2.2	6	12.2	17.2	20.9

Source: Own Survey.

Table 3. Sum of rainfall (mm/m^2) by months for the period of study 2014 – 2017

Months	IX	X	XI	XII	I	II	III	IV	V	VI
2014 – 2015										
Monthly amounts	195.7	121.1	49.5	93.0	17.4	76.6	138.0	14.0	69.5	76.7
On average for the period 1965 - 1995	65	47	35	36	40	48	44	39	32	36
2015-2016										
Monthly amounts	100.6	70.3	39.6	3.6	69.6	24.4	33.9	30.7	64.7	59.7
On average for the period 1965 - 1995	65	47	35	36	40	48	44	39	32	36
2016-2017										
Monthly amounts	2.3	19.7	32.9	2.4	70.1	11.1	47.9	26.1	52.7	15.4
On average for the period 1965 - 1995	65	47	35	36	40	48	44	39	32	36

Source: Own Survey.

Soil respiration' at *Tr.monococcum* L.

The results for 'soil respiration' at *Triticum monococcum* L. after the first biofertilizer feedings during vegetation in 2016 are presented in Table 4 and show that on the 7th day the microbial activity is highest in the control plants and when Tryven is applied, which is due to the rich mineral NPK composition of the fertilizer and the rapid absorption of its organic nitrogen by the rhizosphere microflora together with appropriate temperature of the soil - 18.5 °C and favorable air humidity - 45%. Under the influence of ongoing processes in the soil and the increased microbial activity in the rhizosphere zone of the cereal crop on the 14th day higher values of 'soil respiration' are found in the variants with applied Lithovit and Amalgerol, which has a simulating effect and the crops shows larger values in plant height during tillering phase - 22.50 cm for Lithovit and 21.17 cm for Amalgerol. At plants treated with Tryven, is reported higher soil activity on the 21st day after treatment, which leads to

a higher plants height in the stem elongation phase - 47.50 cm. There was a general decrease in soil activity on the 21st day after treatment in all fertilized variants.

Table 4. 'Soil respiration' (μg CO_2/h/g) data at *Tr.monococcum* L, on the 7th, 14th and 21st day of fertilizer application (2016)

Variants	7th day	14th day	21st day
	Average ± St.dev	Average ± St.dev	Average ± St.dev
First reporting - (phase stem elongation)			
Control	12.50 ± 0.361 [a]	9.33 ± 0.578 [c]	9.53 ± 0.115 [a]
Agriorgan pellets	11.40 ± 0.693 [b]	11.33 ± 1.155 [ab]	9.50 ± 0.173 [a]
Amalgerol	11.20 ± 0.200 [b]	12.33 ± 0.577 [a]	9.63 ± 0.153 [a]
Lithovit	11.43 ± 0.379 [b]	12.33 ± 0.576 [a]	9.67 ± 0.577 [a]
Baikal EM	12.27 ± 0.252 [a]	10.67 ± 0.576 [b]	7.17 ± 0.723 [b]
Tryven	12.33 ± 0.115 [a]	10.67 ± 0.576 [b]	9.70 ± 0.263 [a]
Second reporting - (phase heading)			
Control	6.8 ± 0.153 [b]	7.1 ± 1.044 [c]	6.9 ± 0.115 [c]
Agriorgan pellets	9.2 ± 0.058 [a]	8.63 ± 0.551 [ab]	7.9 ± 0.231 [bc]
Amalgerol	9.2 ± 0.301 [a]	8.20 ± 0.700 [bc]	9.0 ± 0.702 [a]
Lithovit	7.4 ± 1.300 [b]	9.30 ± 0.608 [ab]	10.4 ± 1.039 [a]
Baikal EM	7.2 ± 1.358 [b]	9.57 ± 0.404 [a]	8.6 ± 0.404 [ab]
Tryven	9.2 ± 0.529 [a]	9.20 ± 0.173 [ab]	9.0 ± 0.551 [ab]

Source: Own Survey; Duncan's multiple range test (P<0.05)

The results for the second reporting (heading phase) show that the 'soil respiration'on the 7th day is proven to be more intensive in the variants with biofertilizer Amalgerol, Tryven and with Agriorgan pallet only. There is a definitely proven increase in soil activity on the 14th day in the variant treated with biofertilizer Baikal EM, which is due to the increased microbial activity of the species that find more favorable conditions for development in this environment. The strongest activity of the indicator on the 21st day was found in the variant treated with Lithovit, followed by Amalgerol, which has a positive effect on vegetative growth in the phase of full ripeness where the einkorn height is 95.77. The results of 'soil respiration' at *Triticum monococcum* L. in 2017 (Table 5) after the first feeding with biofertilizers (tillering phase) show that proven microbial soil activity is enhanced at the variant, treated with biofertilizer Baikal EM on the 7th day - 11.85 μg CO_2/h/g to 10.42 μg CO_2/h/g for the control variant, and this trend is maintained on the 14th day (12.91 μg CO_2/h/g, 10.31 μg CO_2/h/g for the control variant) and on 21st day also (12.06 μg CO_2/h/g at 9.32 μg CO_2/h/g for the control variant).

The long-term action of the organic product and the rapid crop assimilation affect the vegetative growth and the plants reach a greater height in the phase of full ripeness - 95.6 cm, compared to the control variant (85.4 cm) (Table 1).

Table 5. 'Soil respiration' (μg CO_2/h/g) data at *Tr.monococcum* L, on the 7th, 14th and 21st day of fertilizer application (2017)

Variants	7th day	14th day	21st day
	Average ± St.dev	Average ± St.dev	Average ± St.dev
First reporting - (phase stem elongation)			
Control	10.42 ± 0.104 [e]	10.31 ± 0.092 [e]	9.32 ± 0.121 [e]
Agriorgan pellets	11.13 ± 0.026 [c]	11.83 ± 0.066 [d]	9.64 ± 0.074 [d]
Amalgerol	11.84 ± 0.050 [a]	12.42 ± 0.171 [b]	11.82 ± 0.132 [b]
Lithovit	10.93 ± 0.078 [d]	12.03 ± 0.062 [c]	11.43 ± 0.162 [c]
Baikal EM	11.85 ± 0.049 [a]	12.91 ± 0.081 [a]	12.06 ± 0.059 [a]
Tryven	11.27 ± 0.015 [b]	11.83 ± 0.047 [cd]	11.82 ± 0.100 [b]
Second reporting - (phase heading)			
Control	9.35 ± 0.050 [d]	8.14 ± 0.026 [f]	7.91 ± 0.032 [f]
Agriorgan pellets	11.32 ± 0.188 [b]	10.28 ± 0.031 [e]	8.14 ± 0.012 [e]
Amalgerol	10.47 ± 0.095 [c]	10.83 ± 0.084 [c]	10.63 ± 0.055 [b]
Lithovit	10.61 ± 0.151 [c]	11.24 ± 0.052 [b]	9.72 ± 0.114 [d]
Baikal EM	11.82 ± 0.038 [a]	12.47 ± 0.090 [a]	12.33 ± 0.020 [a]
Tryven	10.63 ± 0.046 [c]	10.65 ± 0.032 [d]	10.42 ± 0.031 [c]

Source: Own Survey; Duncan's multiple range test (P<0.05).

Higher values of the indicator 'soil respiration' are proven reported seven days after treatment at the Amalgerol-applied variant - 11.84 μg CO_2/h/g at 10.42 for the control. The proven positive effect of fertilization is maintained on the 14th (12.42 at 10.31 μg CO_2/h/g for the control) and 21st days (11.82 at 9.32 μg CO_2/h/g for the control) after the Amalgerol application.

The increased soil microbial activity at the variants, treated with Amalgerol and Baikal EM is also contributed by the favorable environmental factors during the reporting period, the higher soil moisture (19.6 mm/m^2 precipitation) in the previous 7 days before reporting, as well as the average soil temperature - 16.5˚C in the layer of 0 - 10 cm (Table 2).

The agrometeorological conditions of the environment, preceding the second reporting have a strong influence on the soil respiration and vegetative growth of plants. The increase of the microbial activity in the soil at the variant, treated with Baikal EM (heading phase) shows a trend that persists on the 7th, 14th and 21st day and has a positive effect on the plant height. There is an increase in soil microbial activity on the 7th day, in the variant with Agriorgan pellets only, which can be explained by the rich organic composition of the fertilizer.

CONCLUSIONS

Einkorn reacts positively to the applied biofertilizers. All studied biofertilizers increase the height of the plants compared to the control. In the spindle phase, the highest height was reported after treatment with Baikal EM - 48.57cm (14% above control), Amalgerol - 47.85cm and Tryven - 47.73cm, and in full ripeness after treatment with Lithovit - 99.6 cm (11% above control), Tryven - 97.45 cm (8.8%) and Baikal EM - 97 cm (8.3%). 7 days after treatment, the soil microbial activity is highest at the variants, treated with Amalgerol and Baikal EM, on the 14th day at the variants with Baikal EM, Lithovit and Amalgerol applied, and this trend is maintained on the 21st day. At the Tryven-treated variant, is reported higher soil microbial activity on the 21st day after treatment. There is a tendency to increase the values of soil respiration from the 7th to the 14th day and a general decrease to the 21st day.

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