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БИОТОРОВЕТЕ - ЕФЕКТИВНОСТ ВЪРХУ ВЕГЕТАТИВНИЯ РАСТЕЖ И ПРОДУКТИВНОСТТА НА ДОМАТИ ПРИ БИОЛОГИЧНО ПОЛСКО ПРОИЗВОДСТВО

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Ключови думи:
биоторове
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Резюме

Целта на това изследване е да се установи влиянието на биоторовете върху вегетативния растеж, добива и продуктивността на доматите отгледани в условията на органично земеделие. Изследването е проведено в полиетиленовата оранжерия и експерименталната площ на Агроекологичния център към Аграрен университет - Пловдив (България), през периода от 2013 до 2014 година с детерминантни домати (*Solanum lycopersicum* L.,) от сорт “Трапезица”. Стандартният добив е с най-високи стойности при приложение на биотор Емосан при основно торене с биотор Бонепрот - 3140 kg/da (2013) и 3116 kg/da (2014), което определя положителното влияние от изпитваната комбинация от биоторове. Комбинираното приложение на биоторове под формата на основно торене и допълнително вегетационно подхранване има положително влияние върху формирането на стандартния добив, броя и масата на плодовете.

BIOFERTILISERS - EFFICIENCY ON THE VEGETATIVE GROWTH AND PRODUCTIVITY OF TOMATOES CULTIVATED UNDER THE CONDITIONS OF ORGANIC FARMING

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Key words:
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yield

Abstract

The objective of this study was to examine the influence of biofertilisers on the vegetative growth, yield and productivity of tomatoes cultivated under the conditions of organic farming. The research was carried out in the polyethylene greenhouse and experimental field of the Agroecological centre at the Agricultural University - Plovdiv (Bulgaria), in the period from 2013 until 2014 with on determinant tomatoes (*Solanum lycopersicum* L.,) of the variety of “Trapezitsa”. The standard yield had its highest value upon the application of biofertiliser Emosan on the basic fertilization Boneprot - 3140 kg/da (2013) and 3116 kg/da (2014), thus determining the positive impact of the tested combination of biofertilisers. The combined application of biofertilisers in the form of basic fertilisation and additional vegetation feeding had a positive impact on the formation of the standard yield, the number and the mass of fruits.

Introduction

Organic agriculture has become a widely accepted sector of agricultural and food research (Niggli and Willer, 2000). The biological system (agroecosystem) can be consider as a living organism in which all components are mutually connected and they have dynamic relations (Popov, 2013). Organic production is a specific production method preserving environment and providing healthy food of high quality (Arabska, 2014). Fertilization is a very important stage of the production technology (Boteva and Cholakov, 2011). Biofertilisers are eco friendly and are now most, necessary to support developing organic agriculture and sustainable agriculture (Moorthy and Malliga, 2012). They are important in crop farming systems because it is an inexpensive source of nitrogen for the higher yields of crops (Roy *et al.*, 2013). Microorganisms, which can be used as biofertiliser, include bacteria, fungi and blue green algae. These organisms are added to the rhizosphere of the plant to enhance their activity in the soil (Boraste *et al.*, 2009). Through the use of biofertilisers, healthy plants can be grown while enhancing the sustainability and the health of soil (Midan and Sorial, 2011). Tomatoes (*Solanum lycopersicum* L.,) are an important world vegetable crop. The most profitable from an economic point of view is the cultivation of tomatoes for early field production (Murtazov *et al.*, 1984). Application via single irrigation with Bioaktiv increases the yield upon first tomato harvesting (Yakimov, 2013; Yakimov *et al.*, 2013).

The objective of this study was to examine the influence of biofertilisers on the vegetative growth, yield and productivity of tomatoes cultivated under the conditions of organic farming.

Material & methods

The research was carried out in the polyethylene greenhouse and experimental field of the Agroecological centre at the Agricultural University-Plovdiv (Bulgaria), in the period from 2013 until 2014 with on determinant tomatoes (*Solanum lycopersicum* L.,) of the variety of "Trapezitsa". The tomatoes were grown, in conformity with the principles of organic farming. The seedlings were planted on a permanent place during the third decade of May, on a scheme 120+60x30 cm, according to the method of long plots, into 4 replication, with a size of the test plot of 9,6 m^2.

This study includes the biofertilisers- Boneprot Lumbrical, Seasol and Emosan, which are included in the list of permitted substances for organic farming according to Regulation (EC) No. 889/2008.

Boneprot (Italy) it is pellet organic fertilisers, and has the composition: organic nitrogen (N) - 4,5%; phosphorus anhydride (P_2O_5) total - 3,5%; potassium (K_2O) - 3,5%; calcium (CaO) - 5-8%; magnesium (MgO) - 0,8-1%; organic carbon (C) of biological origin - 3%; degree of humification (DH)- 40-4%; $pH_{(H2O)}$- 6-8. Boneprot is an entirely organic fertiliser consisting exclusively of Cattle manure.

Lumbrical (Plovdiv region, Bulgaria) is a product obtained from processing of natural manure and other organic waste by Californian red worms (*Lumbricus rubellus* and *Eisenia foetida*) and consists of their excrements. The commercial product contains ammonium nitrogen (NH_4N) - 33,0 ppm; nitrate nitrogen (NO_3N) - 30,5 ppm; P_2O_5 - 1410 ppm; K_2O - 1910 ppm, MgO- 1,8%; humic and fulvic acids, useful microflora $2x10^{12}$ pce/g; humidity of 45-55%; and pH in water - 6,5-7,0.

Seasol (Australia) is a extract of brown algae (*Durvillaea potatorum)* and consists raw protein (2,5 $\pm$ 0,1% w/w); alginates (6 $\pm$ 2% w/w) and has a variety of mineral elements and traces of Ca (0,05 $\pm$ 0,03% w/w); Mg (0,01 $\pm$ 0,005% w/w); N (0,10 $\pm$ 0,05% w/w), P (0,05 $\pm$ 0,02% w/w); K (2,0 $\pm$ 0,5 % w/w); pH (10,5 $\pm$ 0,5% w/w).

Emosan, HemoZym NK, Hemozym Bio N5 (Italy) contains total nitrogen (N)- 5%; organic nitrogen (N)- 5%; organic carbon (C) of biological origin - 14%; protein - 34 p/p; humidity- 65 p/p; K- 0,4 p/p; P - 0,06 p/p.; pH - 7,0-10,0.

Variants: 1. Control (non-fertilised); 2. Basic fertilisation with Lumbrical+Emosan (HemoZym); 3. Basic fertilisation with Lumbrical+Seasol; 4. Basic fertilisation with Boneprot+Emosan (HemoZym); 5. Basic fertilisation with Boneprot+Seasol.

Fertilisation - Two basic fertilisations were used, namely: Boneprot and Lumbrical. They were applied into the soil through incorporation prior planting of the seedlings on the field in concentration - 35 kg/da for the Boneprot and 200 L/da for the Lumbrical. The liquid biofertilisers Emosan and Seasol were introduced as a soil amendment during the vegetation, two times (after the flower - bud stage and 20 days later) in concentrations of 15 L/da for Emosan, and 0,3-0,4 L/da for Seasol.

Study Parameters:

1. Biometric parameters - on the 50^{th} day, following pricking-out there were 10 plants per variant analyzed, namely the following parameters: stem height (cm), number of leaves, number of nodes, length of leaves (cm) and length of nodes (cm).

2. Yield and Economic productivity of plants: Standard Yield (kg/da); number of fruits per plant - (pcs/plant) 10 plants per treatment were analyzed; mass of fruits (g) and pericarp thickness (mm) - 10 fruits per treatment were analyzed.

3. Statistical data processing - One-way analysis of variance (ANOVA) was used to analyse the differences between treatments (SPSS) (Duncan, 1955).

Results & discussion

The height of tomato stem is characterized with the highest value in the variant with application of Seasol and Lumbrical - 85,3 cm (2013) and 83,4 cm (2014) respectively, as the difference between all variants was proven in 2013 at P<0,05 (Table 1).

In 2013 the largest ***number of leaves*** was reported for plants of the variant characterized with the application of Seasol on Lumbrical - 29 pcs/plant, all of which exceeded the control. In 2014 the highest value was reported for the combination of the Seasol and Boneprot - 32 pcs/plant, following by Seasol on Lumbrical - 28 pcs/plant, as the difference between these two variants, was proven at P<0,05.

Regarding ***the number of nodes*** the largest number of nodes was found upon the application of biofertiliser Seasol on the basic fertilization Lumbrical (2013) and Boneprot (2014).

The vegetative growth was highly expressed upon the application of Seasol on both variants with basic fertilisation. It was established that ***the length of leaves*** had its highest value in cases of plants fed with Seasol on Boneprot - 28,1cm (2013) and 27,4cm (2014) respectively.

Regarding ***the length of nodes*** it was established that the highest value was for the plants from the variant characterized with the application of Seasol on Boneprot- 21,5 cm (2013) and 23,2 cm (2014) respectively. The rich content of nutritional substances in the composition of biofertiliser Boneprot was released more slowly during the vegetation and had a decisive impact on the better vegetative growth of the tomatoes.

Table 1. Vegetative displays in tomatoes - on the 50th day, after pricking off – (2013 and 2014)

Parame-ters	Year	Treatments				
		Control	Basic fertilization with Lumbrical		Basic fertilization with Boneprot	
			+ Emosan	+ Seasol	+ Emosan	+ Seasol
Stem height	2013	56.4 ± 0.673 ^{e}	75.2 ± 2.266 ^{c}	85.3 ± 2.471 ^{a}	78.2 ± 1.391 ^{b}	62.3 ± 1.106 ^{d}
	2014	62.8 ± 0.709 ^{d}	77.2 ± 1.134 ^{c}	83.4 ± 2.825 ^{a}	75.3 ± 1.689 ^{c}	80.4 ± 0.989 ^{b}
Number of leaves	2013	19 ± 0.866 ^{c}	27 ± 1.225 ^{a}	29 ± 1.269 ^{a}	22 ± 1.424 ^{b}	18 ± 2.068 ^{c}
	2014	22 ± 1.000 ^{d}	25 ± 1.302 ^{c}	28 ± 1.364 ^{b}	26 ± 0.972 ^{c}	32 ± 1.641 ^{a}
Number of nodes	2013	7.0 ± 1.00 ^{c}	13.3 ± 0.58 ^{b}	18.0 ± 1.00 ^{a}	14.0 ± 1.00 ^{b}	17.0 ± 1.00 ^{a}
	2014	9.0 ± 1.00 ^{d}	15.0 ± 1.00 ^{c}	17.0 ± 1.00 ^{b}	16.0 ± 1.00 ^{bc}	19.0 ± 1.00 ^{a}
Length of leaves	2013	20.4 ± 0.867 ^{c}	24.2 ± 1.625 ^{b}	25.2 ± 0.706 ^{b}	22.1 ± 0.925 ^{c}	28.1 ± 0.620 ^{a}
	2014	21.5 ± 0.443 ^{c}	22.6 ± 1.035 ^{b}	26.7 ± 0.680 ^{a}	26.9 ± 0.392 ^{a}	27.4 ± 0.784 ^{a}
Length of nodes	2013	16.5 ± 0.660 ^{c}	19.3 ± 0.404 ^{b}	19.7 ± 0.853 ^{b}	20.1 ± 1.014 ^{b}	21.5 ± 0.721 ^{a}
	2014	13.5 ± 0.244 ^{d}	18.3 ± 0.604 ^{c}	19.3 ± 0.518 ^{b}	17.7 ± 0.347 ^{c}	23.2 ± 0.602 ^{a}

a,b,c,d – Duncan's Multiply Range Test, P<0,05

The standard yield in 2013 had its highest value upon the application of Emosan on Boneprot - 3140 kg/da (Table 2), followed by the combination of Emosan on Lumbrical - 3014 kg/da. The higher yield values for the variants with Boneprot proved its positive impact. The results obtained in 2014 confirmed the established positive effect from the application of the Emosan biofertiliser in 2013. The highest value was reported for the combined application of Emosan and Boneprot (3116 kg/da), followed by the combination of Emosan and Lumbrical (2922 kg/da), as the difference between them was proven at P<0,05. The application of Emosan on Boneprot proved to be the better combination due to the contents of the biofertilisers.

The number of fruits per plant varied, as the maximum value was reported for Emosan on Boneprot - 17,3 pcs/plant, (2013) and Seasol on Boneprot - 17,6 pcs/plant (2014). A decisive factor was that the highest values were reported for the variants characterized with the basic fertilisation Boneprot, thus proving its practical, fundamental importance with significance of high productivity.

The fruit mass of tomatoes had high values in all variants as compared to the control, which was indicative of the combined application of the biofertilisers. The highest value was reported for the fruits of the variant with the Emosan biofertiliser on the basic fertilisation Boneprot - 177,2 g (2013) and 188,4 g (2014). The application of the Emosan biofertiliser proved to be more beneficial as compared to the one of the Seasol biofertiliser.

Table 2. Yield and Economic productivity of plants (2013 and 2014)

Parame-ters	Year	Treatments				
		Control	Basic fertilization with Lumbrical		Basic fertilization with Boneprot	
			+ Emosan	+ Seasol	+ Emosan	+ Seasol
Standard yield	2013	1517 ± 17.39 ^{d}	3014 ± 104.15 ^{ab}	2705 ± 9.29 ^{c}	3140 ± 19.08 ^{a}	2872 ± 163.58 ^{b}
	2014	1506 ± 26.31 ^{e}	2922 ± 69.51 ^{b}	2151 ± 44.77 ^{d}	3116 ± 11.59 ^{a}	2757 ± 66.36 ^{c}
Number of fruits	2013	8.8 ± 0.833 ^{c}	14.7 ± 0.707 ^{b}	14.9 ± 0.928 ^{b}	17.3 ± 0.707 ^{a}	15.4 ± 0.882 ^{b}
	2014	7.6 ± 0.527 ^{d}	13.6 ± 1.014 ^{c}	17.2 ± 0.833^{ab}	16.2 ± 0.833 ^{b}	17.6 ± 1.130 ^{a}
Mass of fruits	2013	131.7 ± 2.082 ^{c}	174.0 ± 5.292 ^{a}	162.8 ± 2.021 ^{b}	177.2 ± 1.041 ^{a}	167.6 ± 0.321 ^{b}
	2014	133.7 ± 1.528 ^{d}	179.8 ± 1.756 ^{b}	163.2 ± 1.041 ^{c}	188.4 ± 1.401 ^{a}	164.3 ± 3.055 ^{c}
Pericarp thickness	2013	5.11 ± 0.215 ^{c}	7.66 ± 0.411 ^{a}	7.86 ± 0.240 ^{a}	7.09 ± 0.429 ^{b}	7.72 ± 0.273 ^{a}
	2014	5.18 ± 0.109 ^{c}	6.32 ± 0.222 ^{b}	7.72 ± 0.463 ^{a}	6.32 ± 0.327 ^{b}	6.23 ± 0.588 ^{b}

a,b,c,d – Duncan's Multiply Range Test, P<0,05

The pericarp thickness of tomatoes proved to have the highest value in the case of Seasol on Lumbrical - 7,86 mm (2013) and 7,72 mm (2014) respectively. The higher values upon the application of the Seasol and Emosan biofertilisers on the basic fertilisation Lumbrical demonstrated their good impact on the basic fertilisation, thus determining the application of Lumbrical as significant.

The combined application of biofertilisers in the form of basic fertilisation and additional vegetation feeding had a positive impact on the formation of the standard yield, the number and the mass of fruits.

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