Influence of the biofertiliser *Seasol* on yield of pepper (*Capsicum annuum* L.) cultivated under organic agriculture conditions

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Abstract

The experiment was carried out in 2009-2011 on the certified organic farm of the Agroecological Centre at the Agricultural University, Plovdiv (Bulgaria). The research aimed to examine the impact of biofertilisers on the productivity of pepper, cv. Kurtovska kapiya 1619, cultivated under organic agriculture conditions. The tested biofertiliser was Seasol (Earthcare) (Seasol International, Australia), which was applied during vegetation (i.e. at the pepper growing stages of flower buds and mass fruit-set) on the top of basic-fertilisations, namely the solid 'Lumbrical' and 'Boneprot'. Seasol was applied in optimum concentrations and in concentrations reduced by 50%. The biofertiliser applications were in compliance with the list of permitted soil additives by the European Regulation (EC) No. 889/2008. The use of biofertilisers led to increase in yield of the pepper by 8% to 39%. The results showed that the percentage of non- standard production decreased upon the application of organic fertilisation. The increase in the standard yield was stronger in comparison with the non- fertilised (control) plants upon the combined application of the biofertiliser Seasol on the basic fertilisation Boneprot and the basic fertilisation Lumbrical, as an average from the three years ($p<0,1$). The biofertiliser Seasol had a positive effect on number of fruits per plant compared to non- fertilised (control) plants. The combination of the biofertiliser Seasol as an amendment to the basic fertilisation with Lumbrical had a favourable effect and resulted in increase in the standard yield. The research results provided grounds for recommending this combination to the existing fertilisation schemes for ensuring optimum productivity and environment protection when growing organic pepper.

Key words: biofertilisers, biofertilizers,biofertilisation, biofertilization, organic farming, productivity, yield, Bulgaria, Europe.

Introduction

Agricultural policy in Bulgaria is directed towards implementing the European Model of Agriculture and building a highly efficient, competitive and stable agriculture that is in conformity with the requirements and principles of the Common Agricultural Policy of the European Union (Vasileva, 2006). Organic agriculture is a new perspective for Bulgaria (Karov, et al. 1997) where distinctive agricultural conditions exist for the development of efficient and ecologically- friendly agriculture (Topalov, et al. 1993) The organic certification of agricultural land in Bulgaria has so far achieved modest results (Paull & Hennig, 2013) with 25,022 hectares certified for organic agriculture along with 543,655 ha certified for organic wild collection (Willer, Lernoud & Kilcher, 2013).

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Dincheva, et al. (2008) state that vegetable production must be directed not only towards obtaining maximum yield, but also towards optimisation of fertilisation systems in order to ensure the stable ecological environment, economic production and ecological products. In recent years there has been an increase in demand for vegetables of high ecological value, which has contributed to the expanding use of organic fertilisers (Boteva & Cholakov, 2010). In our country, sweet pepper is one of the most competitive vegetables intended for fresh consumption (Cholakov, et al. 1996).

Organic products containing beneficial microorganisms are an alternative to the large quantities of mineral fertilisers and therefore some authors call them 'biofertilisers' (e.g. Tringovska & Naydenov, 2003; Davari, Sharma & Mirzakhani, 2012). Biofertilisers are low- cost, effective and renewable source of plant nutrients to supplement chemical fertilisers. Microorganisms, which can be used in biofertilisers, include bacteria, fungi and blue green algae. These organisms are added to the rhizosphere of the plant to enhance activity in the soil (Boraste, et al. 2009). Use of liquid biofertilisers is one of the practices of organic agriculture that aims to achieve balanced plant nutrition. As a result, higher yields are expected with no significant cost increases (Alves, et al. 2009). Organic manure contains higher levels of readily-available nutritional elements which are essentially required for plant growth (El-Sayed & Elzaawely, 2010). The use of biofertilisers is an 'environmentally-friendly' opportunity when searching for alternative solutions to improving the food regime of pepper cultivation.

Objectives

This research aimed at investigating the impact of vegetative feeding with biofertilisers on production capacity of pepper grown under organic agriculture conditions.

Materials and Methods

The experiment was carried out in 2009 - 2011 on the certified organic farm of the Agroecological Centre at the Agricultural University - Plovdiv (Bulgaria).

The agro-climatic resources of Bulgaria are determined by its geographic location, the relief and the influence of nearby sea- basins i.e. the Mediterranean Sea and the Black Sea. Considering climate, Plovdiv is a part of the Transitional continental climatic sub-region of Bulgaria to the European continental climatic region and a climatic region of East - Middle Bulgaria (Ahmed, 2004).

Soil features included an alluvial soil type of clay-sandy composition and having relatively soft structure with approximately 2% of humus (by Turin methodology), mineral nitrogen (NH_4-N + NO_3-N) by distillation, i.e. 1.8 mg/ 100g of soil; mobile P_2O_5, i.e. 18.2 mg/100g and mobile K_2O i.e. 16.4 mg/100g of soil (by Egner - Ream method), and soil $pH_{/H2O/}$ of ~7.5 determined by the potenciometric method.

The treatments with biofertilisers were as follows:

1. Control (non - fertilised)
2. Basic fertilisation with Boneprot (optimum concentration)
3. Basic fertilisation with Boneprot (50%) + Seasol
4. Basic fertilisation with Lumbrical (optimum concentration)

5. Basic fertilisation with Lumbrical (50%) + Seasol

The research included pepper of cv. 'Kurtovska Kapiya 1619'. The pepper was cultivated by using the existing technology for mid-early field production, in conjunction with the principles of organic agriculture. Pepper is a demanding crop culture with regard to the preceding crop. Suitable preceding crops are vegetable varieties from the family *Fabaceae* and the family *Cucurbitaceae* (Panayotov, et al. 2007). The present research used bean as a preceding crop during the three vegetation years of the experiment.

Fertilisation

Two basic fertilisations were used, namely: Lumbrical and Boneprot, applied into the soil through incorporation prior to planting of the seedlings on the field. The biofertilisers were applied in two concentrations, i.e. optimum (400 L/da for the basic fertilisation with Lumbrical and 70 kg/da for the basic fertilisation with Boneprot) and optimum concentrations reduced by 50%. Biofertiliser Seasol was introduced in soil as an amendment in concentration 1:500, i.e. 0.3 - 0.4 L/da during the vegetation and at the pepper growing stage 'flower bud' and 'mass fruit-set' (Vlahova, 2013).

The pepper seedlings were planted on a permanent field during the third decade of May on a high-levelled seed-bed, according to a sowing scheme 120 + 60 x 15 cm. The experiment was done according to the method of long plots, in four replications with a size of a test plot of 9.6 m^2.

Table 1: Specifications of chemical content of biofertilisers (in %) used in the study.

№	Biofertiliser	N				P_2O_5	K_2O	Recommended dose (per ha)
		Organic N	Total N	NH_4N	NO_3N			
1.	Lumbrical	n/a	2.21	0.0033	0.00305	0.141	0.191	4000 L
2.	Boneprot	4.5	n/a	n/a	n/a	3.5	3.5	700 kg
3.	Seasol	n/a	0.10 ± 0.05	n/a	n/a	0.05 ± 0.02	2.0 ± 0.5	3-4 L

Note: n/a = data not available.

Major features of the biofertilisers used in the study

This study included following three proprietary commercially available biofertilisers - Lumbrical, Boneprot and Seasol (Earthcare) (Table 1), the active ingredients of which are in the list of permitted substances for organic farming according to European Regulation (EC) No. 889/2008.

Lumbrical (private producer, village Kostievo, Plovdiv region, Bulgaria) is a product obtained from processing of animal manure and other organic waste by the Californian red worms (*Lumbricus rubellus* and *Eisenia foetida*) and consists of their excrements. The commercial product has humidity of 45 - 55% and organic matter content of 45 - 50%. Ammonium nitrogen (NH_4N) is 33.0 ppm; nitrate nitrogen (NO_3N) is 30.5 ppm; P_2O_5 and K_2O are 1410 ppm and 1910 ppm respectively, MgO is 1.8%. It contains useful microflora 2 x 10^{12} pce/g, humic and fulvic acids, nutritional substances. The product has a pH of 6.5 - 7.0 (pH in H_2O).

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Boneprot (Arkobaleno, Italy) is a pellet organic fertiliser and has following 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 - 30%; humification rate (HR) - 10 - 13%; degree of humification (DH) - 40 - 42%; humification index (HI) - 1.3 - 1.4%; humidity - 13 - 15%; pH in water - 6 - 8. Boneprot is entirely organic fertiliser consisting mainly of cattle manure collected from farms which do not use antibiotics and are subject to controlled fermentation for a period of about one year.

Seasol (Earthcare) from Seasol International Pty Ltd. (Australia) is an extract of brown algae *Durvillaea potatorum*. Seasol is a 100% liquid natural seaweed extract. It contains 60% of alginic acids. The commercial product contains as follows: raw protein (2.5 ± 0.1% w/w); alginates (6 ± 2% w/w); total solidity (10.0 ± 0.5% w/w), and pH (10.5 ± 0.5% w/w) and has a variety of mineral elements and traces of Ca (0.05 ± 0.03% w/w), Mg (0.01 ± 0.005% w/w), N (0.10 ± 0.05% w/w), P (0.05 ± 0.02% w/w), K (2.0 ± 0.5% w/w), Cu (0.3 ± 0.2% w/w) and cytokines.

Parameters studied

The following parameters were investigated:

1. Yield (standard and non-standard) in kg/da (i.e. kg/0.1ha).
2. Economic productivity of plants:

   a) Average number of fruits per plant - (pcs/plant) - 10 plants per treatment were analysed.

   b) Average mass of fruits (g) - 10 fruits per treatment were analysed.

   c) Pericarp thickness (mm) - (pcs/plant) - 10 plants per treatment were analysed.

Statistical data processing was done using Microsoft Office Excel 2007; SPSS; Biostat; and STATISTICA - StatSoft Treatment 9.0. One-way analysis of variance (ANOVA) was used to analyse the differences between treatments (SPSS treatment 7.5). All data were analyzed by using Duncan’s multiple range test (Duncan, 1955) at $P<0.05$ level. In the tables below, different letter(s) within a column indicates a significant difference by Duncan’s multiple range-test. BIOSTAT was used to compare the results (treated compared to the control (untreated)).

Results

1. Yield

Dynamics of the standard yield of the pepper cv. ‘Kurtovska Kapiya 1619’ in the experimental period 2009- 2011 are reported on Table 2. The overall increase of yield compared to non-fertilised (control) was detected after basic fertilisation with Boneprot. It ranged from 16.6% to 35.1% in 2009, from 23.2% to 26.0% in 2010, from 8.3% to 22.3% in 2011. After basic fertilisation with Lumbrical the increase ranged from 21.1% to 28.5% in 2009, from 35.1% to 38.7% in 2010 and from 13.1% to 26.1% in 2011.

The highest yield was reported after additional feeding with the biofertiliser Seasol on the basic fertilisation Lumbrical, i.e. 1520 kg/da (2010) and 1450 kg/da (2011) respectively. The yield increase compared to the control was by 38.7% and 26.1% respectively. The difference between treated and control plants was significant (at $P_{0.1\%}$). The positive impact confirmed suitability of combination of both biofertilisers on the yield. This can be attributed to seaweed extract in biofertiliser Seasol and rich content of organic substance 45 - 50% in Lumbrical.

Table 2. standard and non - standard yield (2009 - 2011), (Duncan's Multiple Range Test, P<0.05)*.

No	Treatments	2009			2010			2011			Average for the period
		Standard Yield (kg/ da)		Non-standard Yield (kg/ da)	Standard Yield (kg/ da)		Non-standard Yield (kg/ da)	Standard Yield (kg/ da)		Non-standard Yield (kg/ da)	
		Mean; St. Dev.	GD		Mean; St. Dev.	GD		Mean; St. Dev.	GD		
1.	Control	987 ± 13.53 ^{d}	Base	41.2	1096 ± 316.16 ^{e}	Base	31.0	1150 ± 137.98 ^{g}	Base	36.3	1177.7
2.	Boneprot (optimum)	1151 ± 84.22 ^{cd}	ns	40.8	1381 ± 349.74 ^{d}	++	25.4	1245 ± 66.46 ^{fg}	ns	22.5	1259.0
3.	Boneprot (50%) + Seasol	1334 ± 380.23 ^{abc}	+	38.9	1350 ± 321.29 ^{d}	++	47.3	1407 ± 21.63 ^{e}	+++	21.5	1363.7
4.	Lumbrical (optimum)	1269 ± 545.35 ^{bcd}	ns	58.4	1481 ± 155.23 ^{cd}	+++	43.6	1301 ± 14.73 ^{f}	++	35.2	1350.3
5.	Lumbrical (50%) + Seasol	1196 ± 248.69 ^{cd}	ns	29.6	1520 ± 99.14 ^{bcd}	+++	41.5	1450 ± 71.46 ^{de}	+++	44.8	1388.7
	$GD_{5\%}$		295.92			169.44			97.74		
	$GD_{1\%}$		403.59			231.09			133.30		
	$GD_{0.1\%}$		546.15			312.72			180.38		

* Values not sharing a common superscript (a, b, c, d, e, f, g) differ significantly (Duncan's Multiple Range Test).

The second best effect on yield was shown by biofertiliser Lumbrical applied in an optimum concentration, respectively 1269 kg/da (2009) and 1481 kg/da (2010), where the increase as compared to the control was by 28.5% and 35.1% respectively. The difference between treated and control plants was significant (at $P_{0.1\%}$). The stimulating effect of Lumbrical on the yield can be attributed to its physical and chemical composition, which makes it more easily assimilated by plants and increased their vegetative growth by improving the level of productivity of pepper.

It was found that combination of biofertilisers Boneprot and Seasol had a positive effect on increase of yield. This effect may be attributed to biofertilisers' composition. Seasol contains auxins and alginates and Boneprot release slowly nutrients in soil during the vegetation and the plants gradually uptake these.

The stimulating effect on the pepper yield was shown by another combination. The additional treatment with the biofertiliser Seasol on basic fertilisation with Boneprot yielded 1334 kg/da (2009) and 1407 kg/da (2011). Compared to non-treated (control) plants, the increase was by 35.1% and 22.3%, respectively. When testing the single application of basic fertilisations, the highest yield was shown by basic fertilisation with Lumbrical compared to basic fertilisation with Boneprot (2009, 2010, 2011).

On average for the experimental period, the highest yield was reported for treatment with Seasol on basic fertilisation with Lumbrical i.e. 1388.7 kg/da, followed by the treatment with Seasol on basic fertilisation with Boneprot i.e. 1363.7 kg/da.

The multi-factorial ANOVA (Statistica, StatSoft) applied for analysing the standard yield is presented in Figure 1.

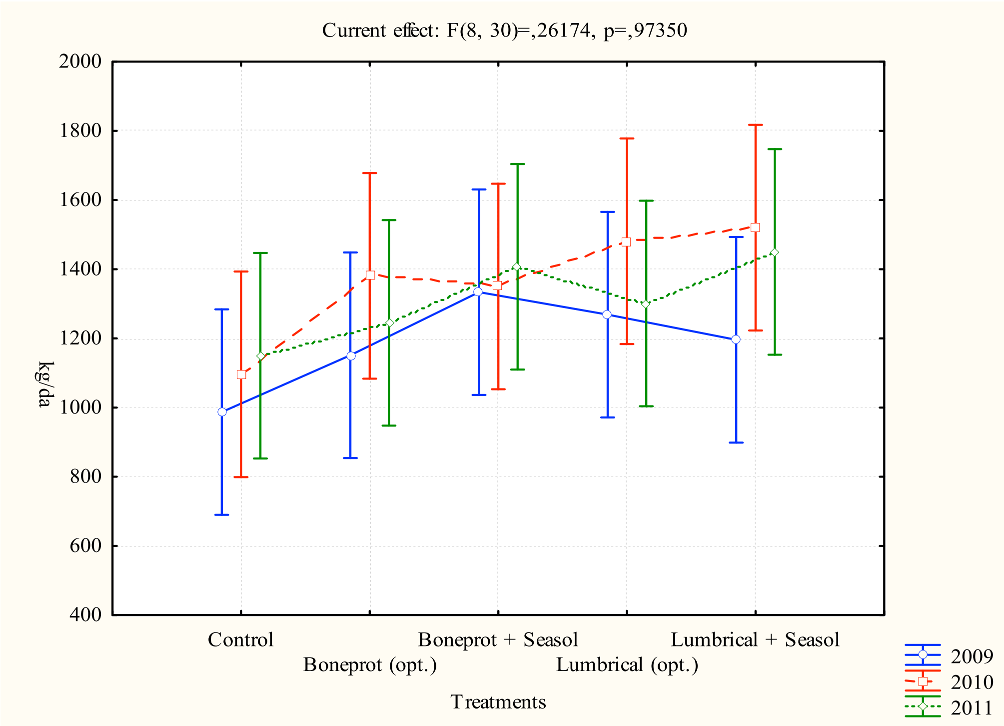

Figure 1. Effect of the interaction of the main fertilisation factors on the yield - 2009 - 2011.

It was found that increase of standard yield of treated plants was significant (P<0,1, Figure 2) compared to non - treated (control) plants under combined application of biofertiliser Seasol on basic fertilisation with Boneprot and basic fertilisation with Lumbrical (as an average from the three experimental years).

The highest average standard yield was shown in 2010 followed by 2011 and 2009. The high 2010 standard yield found was positively impacted by the favourable agro-meteorological conditions during pepper's individual stages growth.

The largest diversions in meteorological conditions were reported in the second half of the pepper vegetation in 2011. In this period of June (a month that is usually the rainiest according to statistics) conditions were extremely dry with temperatures exceeding the average by 2°C. It had a negative effect on the progress of the flower bud stage and on the realized standard yield respectively.

In 2009, the entire period of vegetation from April until end of September was dry. This in combination with average monthly temperatures above average and rainfalls below average had an unfavourable effect on productivity and on obtained standard yield respectively.

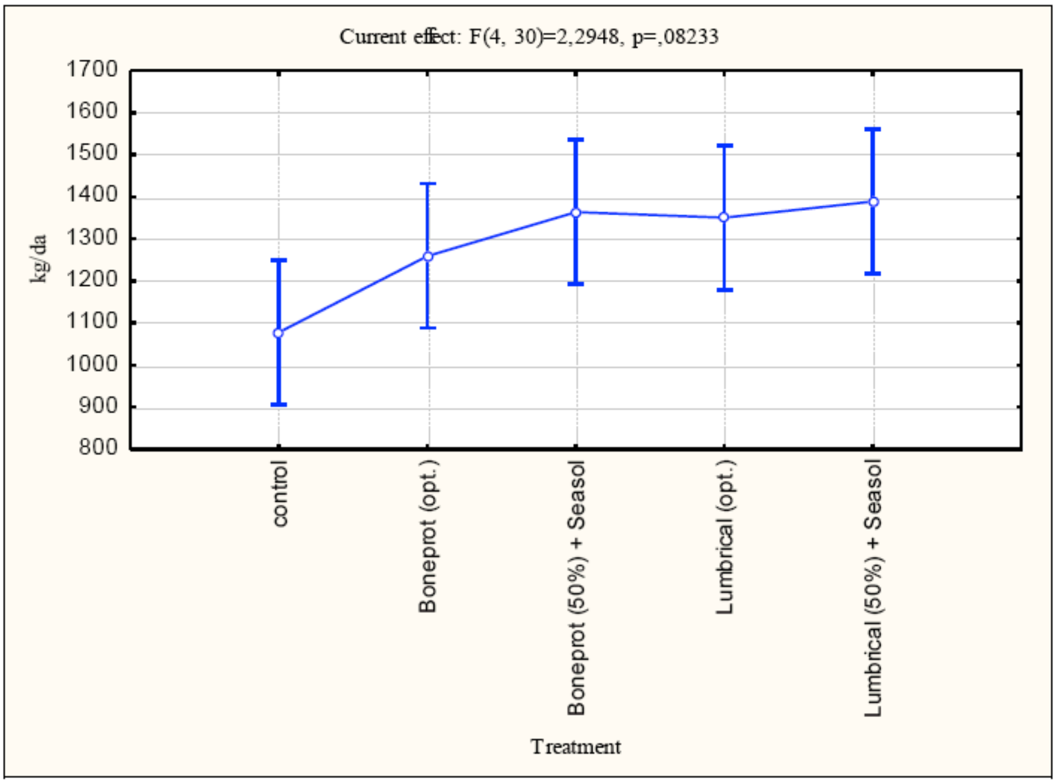

Figure 2. Differences in standard yield between variants after a combined application of biofertilisers (as an average from the three experimental years).

2. Economic productivity of plants

a) Average number of fruits per plant

The yield rate was mostly determined by the number of fruits on plants. The results on the influence of the applied biofertilisers on the number of fruits for the period of experiment 2009 - 2011 are presented in Table 3.

It was found that the number of fruits of treated with biofertilisers plants exceeded those of the non - treated (control) plants. The highest total number of fruits per plant was reported for the combination of Seasol on basic fertilisation with Lumbrical i.e. 7.6 pcs/plant (2010) and 6.0 pcs/plant (2011). The difference between the average values of treated and non- treated was significant at $P_{0.1\%}$. The results confirmed previous findings that additional vegetative feeding with the biofertiliser Seasol can increase pepper productivity. This is apparent for application of Seasol on basic fertilisation with Lumbrical in comparison with the basic fertilisation with Boneprot. This can be attributed to the physical and chemical composition of Lumbrical, which provides nutritional substances in an easily accessible form thus resulting in higher productivity.

Good results were also achieved upon treatment with Seasol on basic fertilisation with Boneprot i.e. 6.2 pcs/plant (2009) and 6.4 pcs/plant (2010). The difference between the average values of treated compared to control plants was significant at $P_{0.1\%}$. For the 3

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years of study, the combined treatments (i.e. Seasol on basic fertilisation Boneprot) had higher values of the number of fruits than the treatments with a single optimum concentration of the basic fertilisations. During the latter, a highest number of fruits were detected after a basic fertilisation with Lumbrical.

Table 3. Number of fruits per plant, cv. Kurtovska kapiya 1619, (Duncan's Multiple Range Test, P<0.05)*.

No	Treatments	2009		2010		2011		Average number for the period
		Mean; St. Dev.;	GD	Mean; St. Dev.;	GD	Mean; St. Dev.;	GD	
1.	Control	4.3 ± 0.707 [f]	Base	4.2 ± 0.833 [g]	Base	4.3 ± 1.225 [f]	Base	4.3
2.	Boneprot (opt.)	5.4 ± 0.882 [de]	++	6.0 ± 0.500 [f]	+++	4.8 ± 0.667 [ef]	ns	5.4
3.	Boneprot (50%) + Seasol	6.2 ± 0.972 [cd]	+++	6.4 ± 0.882 [ef]	+++	5.6 ± 0.527 [cd]	++	6.1
4.	Lumbrical (opt.)	7.9 ± 0.782 [ab]	+++	6.6 ± 0.726 [ef]	+++	5.8 ± 1.093 [cd]	+++	6.8
5.	Lumbrical (50%) + Seasol	5.3 ± 0.500 [e]	+	7.6 ± 0.527 [abcd]	+++	6.0 ± 0.707 [abc]	+++	6.3
	$GD_{5\%}$		0.78		0.67		0.69	
	$GD_{1\%}$		1.06		0.91		0.95	
	$GD_{0,1\%}$		1.43		1.24		1.28	

* Values not sharing a common superscript (a, b, c, d, e, f, g) differ significantly (Duncan's Multiple Range Test).

b) Average mass of fruits

The volume of the yield was affected not only by the number of fruits per plant, but also by their mass. The effect though was not unidirectional during the three years of study. The largest mass of fruits was detected for variants treated with Seasol on the Lumbrical basic fertilisation i.e. 73.7 g (2010) and 72.5 g (2011), thus confirming the conclusion about the larger number of fruits during the same period (Table 4).

The application of the biofertiliser Seasol on both basic fertilisations had a stimulating effect reflecting in the increase in the number of fruits and their mass. Another stimulating effect was shown only once by the variant with an optimum concentration on Boneprot basic fertilisation, in parallel with highest value of mass of fruits. A positive effect on the increase of the mass of fruits was found for the variant with biofertiliser Seasol on Boneprot basic fertilisation with an average of 70.7 g for the 3 - year study period.

The greater thickness of the fruits pericarp was found for the variants treated with Seasol on both basic fertilisations. It confirmed expectations that a combined fertilisation (basic fertilisation plus vegetation feeding) has a better effect than a single application of the biofertiliser in the form of basic fertilisation (Table 5).

The highest value of the pericarp thickness was reported upon application of Seasol on Boneprot basic fertilisation throughout the entire period of the experiment i.e. 5.51 mm (2009), 5.58 mm (2010) and 5,09 mm (2011). The average value for the period was 5.41 mm. The influence on additional application of Seasol was positive when applied on Lumbrical basic fertilisation, i.e. 5.21 mm for the three year study period.

Table 4. Mass of fruits, cv. 'Kurtovska kapiya 1619', g., (Duncan's Multiple Range Test, P<0.05)*.

No	Treatments	2009	2010	2011	Average for the period
		Mean; P<0.05	Mean; P<0.05	Mean; P<0.05	
1.	Control	66.5^{c}	69.2^{d}	69.1^{b}	68.3
2.	Boneprot (opt.)	68.3^{bc}	70.5^{cd}	69.6^{ab}	69.5
3.	Boneprot (50%) + Seasol	67.8^{ab}	72.8^{abc}	71.6^{ab}	70.7
4.	Lumbrical (opt.)	67.1^{abc}	71.3^{bc}	70.2^{ab}	69.5
5.	Lumbrical (50%) + Seasol	67.4^{a}	73.7^{ab}	72.5^{a}	71.2

* Values not sharing a common superscript (a, b, c, d) differ significantly (Duncan's Multiple Range Test).

c) Pericarp thickness

Table 5. Thickness of pericarp of pepper fruits, cv. 'Kurtovska kapiya 1619', mm, (Duncan's Multiple Range Test, P<0.05)*.

No	Treatments	2009	2010	2011	Average for the period
		Mean; St.Dev.	Mean; St.Dev.	Mean; St.Dev.	
1.	Control	4.37 ± 0.699^{c}	4.10 ± 0.307^{d}	4.53 ± 0.28^{d}	4.33
2.	Boneprot (opt.)	4.58 ± 0.706^{bc}	4.81 ± 0.283^{c}	4.61 ± 0.47^{d}	4.67
3.	Boneprot (50 %) + Seasol	5.51 ± 0.651^{ab}	5.58 ± 0.560^{ab}	5.09 ± 0.23^{b}	5.41
4.	Lumbrical (opt.)	5.15 ± 0.562^{abc}	5.03 ± 0.494^{c}	4.73 ± 0.39^{cd}	4.97
5.	Lumbrical (50%) + Seasol	5.46 ± 0.820^{ab}	5.12 ± 0.630^{bc}	5.04 ± 0.46^{bc}	5.21

* Values not sharing a common superscript (a, b, c, d) differ significantly (Duncan's Multiple Range Test).

Discussion

The summarised results for the three - year study period provide grounds to conclude that the combined application of biofertiliser Seasol on Lumbrical basic fertilisation had a stimulating effect resulted in an increase of standard yield, yield features and pericarp thickness, in comparison to the results after a single application of basic fertilisation.

The present research is in conjunction with other research findings (Atiyeh et al., 2001; Vermany, 2007) that shows *combined fertilisation* of biofertilisers provides an opportunity for plants to receive a balanced feeding (distribution of the nutritional substances) during the vegetation, thus supporting better pepper productivity (the number of formed fruits). It was indicated by the high standard yield, the higher number of fruits and a larger fruit mass in comparison with the untreated plants (control). The research also confirms the findings of Cabanillas et al. (2006), who stated that biofertilisers increase the mass and the number of the fruits. Szafirowska & Elkner (2008) point out the reports of Clark et al.

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(1999) with respect to their success in high tomato yielding from organic production owing to compost application.

The results from investigation on pepper standard yield showed an increase in treated compared to non- treated (control) plants. Such result can be attributed to the influence of additional nutrients of applied biofertilisers as well as to combined effect of agro-technical methods and agro-meteorological conditions in the region. During the course of investigation, it was shown that agroecological conditions of the region of the city of Plovdiv are favourable for growing pepper, which combined with the biofertilisation, the agro-technical measures and the preventive and timely biological plant protection provides stimulating environment for developing the biological potential of pepper under organic farming.

Because biofertilisation is a major factor for optimal growth and sustainable yields, the amounts and the forms of macronutrients (i.e. N, P, K) in biofertilisers is of a major importance. The comparison (Table 1) showed that the organic nitrogen and phosphorus (P_2O_5) are of a highest content in the biofertiliser Boneprot. As the addition of nitrogen is directly connected with the increase of the vegetative mass, the supply of high levels of P_2O_5 influences the level of pepper fruitfulness, i.e. a higher number of fruits per plant and overall standard yield. The relatively high amounts of total nitrogen in the biofertiliser Lumbrical also had a positive effect on the pepper vegetative growth.

The superior combinations of biofertilisers, i.e. Boneprot plus Seasol, and Lumbrical plus Seasol, may also be applied on other large-size-fruit peppers, i.e. ssp. macrocarpum, e.g. type Ratund - var. *ratundum*, type Dolma - var. *dolma*, and type Conoid - var. *conoides*, as well as on other crops of the *Solanaceae* Family (e.g. tomatoes and eggplant). Fertiliser doses should be applied in conjunction with the specific requirements of the crops.

Conclusions

In modern agro-ecosystems that use environment-friendly technologies, there is an increasing demand for research based on holistic investigations and examining the effect of systematically-connected agro-ecological factors with the purpose of obtaining optimum production at a lower ecological risk for the environment. This research tried to use such a holistic approach.

The results of the present study regarding the scale of impact of selected biofertilisers on the yield of pepper cv. ‘Kurtovska kapiya 1619’, showed that under organic farming the combination of biofertiliser Seasol as an addition to the biofertiliser Lumbrical as a basic fertiliser had a favourable effect which resulted in an increase of the standard yield and pericarp thickness, in comparison to growth after a single application of basic fertilisation. The present research established that the combined fertilisation provided more balanced distribution of the nutritional substances for the plants during vegetation (i.e. at the pepper growing stages of flower buds and mass fruit-set). It was indicated by the higher standard yield, the higher number of fruits and a larger fruit mass. In parallel, the combined biofertilisation might have introduced sufficient quantity of nutritional substances to the soil without accumulation of toxic compounds to the entire phytocenoses, including soils and underground waters.

The above conclusions provide grounds for recommending this combination for fertilisation schemes of pepper cultivated under organic agriculture conditions.

The research also found that the biofertilisers used in the experiment had a positive effect on the biochemical parameters of pepper fruits produced under the conditions of organic agriculture. The application of the biofertiliser Seasol on both basic fertilisations (Boneprot and Lumbrical) had a positive effect on the vitamin C content in the pepper fruits (Vlahova & Popov, 2013).

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References

Ahmed, T., 2004. Study of Allelopathic Relationship in the Soil - Weed - Tomato System. Ph.D Thesis, Agricultural University - Plovdiv, Bulgaria: 156.

Alves, S., Santos, D., Silva, J., Medeiros, J., Cavalcante, L. & Dantas, T., 2009. Nutritional status of sweet pepper cultivated in soils treated with different types of biofertiliser. Acta Scientiarum. Agronomy, 31(4): 661 - 665.

Atiyeh, R.M., Edwards, C., Subler, S. & Metzger, J., 2001. Pig manure vermicompost as a component of a horticultural bedding plant medium: effects on physicochemical properties and plant growth. BioresourceTechnology, 78: 11 - 20.

Boraste, A., Vamsi, K., Jhadar, A., Khairnar, Y., Gupta, N., Trivedi, S., Patil, P., Gupta, G., Gupta, M., Hujapara, K. & Joshi, B., 2009. Biofertilisers: A novel tool for agriculture. International Journal of Microbiology Research, 1(2): 23 - 31.

Boteva, H. & Cholakov, T., 2010. Study on Influence of biofertilisers for growing of tomato in field conditions. Journal of International Scientific Publication: Ecology and Safety, 4(3): 153 - 161.

Cabanillas, C., Ledesma, A. & Longo, O., 2006. Biofertilizers (vermicomposting) as sustainable alternative to urea application in the production of basil (Ocimum basilicum L.). Mol. Medicinal Chem., IDECEFYN, ISSN 1666-888X, 11: 28 - 30.

Cholakov, D., Alexiev, N. & Kostov, D., 1996. Green Pepper. PH Agropress, Sofia, ISBN 954-467-027-0, pp. 59.

Clark, M,S., Horwth, W.R., Shennan, C., Scow, K.M., Lantni, W.T. & Ferris H., 1999. Nitrogen, weeds and water as yield limiting factors in conventional, low-input and organic tomato systems. Agriculture, Ecosystems and Environment 73: 257 - 270.

Davari, M. R., Sharma, S. N., & Mirzakhani, M. (2012). The effect of combinations of organic materials and biofertilisers on productivity, grain quality, nutrient uptake and economics in organic farming of wheat. *Journal of Organic Systems,* 7(2), 27-36.

Dincheva, Z., Dimov, I. & Boteva, H., 2008. Influence of Bioproducts on Green Pepper Yield, Average Early Production. Collection of Reports from the VIIth National Conference with international participants, Plovdiv: 203 - 208.

Duncan, D., 1955. Multiply range and multiple F-test. Biometrics, 11: 1 - 42.

El-Sayed, M. & Elzaawely, A., 2010. Growth and Yield of Cowpea Plants in Response to Organic Fertilisation. Australian Journal of Basic and Applied Sciences, 4 (8): 3244 - 3249. ISSN 1991 - 8178.

Karov, S., Paraskevov, P. & Popov, V., 1997. Organic Agriculture - basic principles and perspectives for its development in Bulgaria. Standard and Certification Programme for Bio (Organic) Agriculture. Agroecological Centre at the Higher Agricultural Institute, Plovdiv, p. 48.

Panayotov, N., Karov, S. & Andreev, R., 2007. Pepper Bio Production. Association for Organic Agriculture - Ecofarm, Plovdiv (edited by S. Karov), pp. 68.

Paull, J., & Hennig, B. (2013). The World of Organic Agriculture - Density-equalizing map. In H. Willer, J. Lernoud & L. Kilcher (Eds.). The World of Organic Agriculture: Statistics and Emerging Trends 2013 (pp. 129): Frick, Switzerland: Research Institute of Organic Agriculture (FiBL) & Bonn: International Federation of Organic Agriculture Movements (IFOAM).

Regulation (EC) No. 889/2008 of 5 September 2008 Laying down detailed rules for the implementation of Council Regulation (EC) No. 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control. Official Journal of the European Union L 250 /1.18.9. 2008: 84.

Szafirowska, A. & Elkner, K., 2008. Yielding and fruit quality of three sweet pepper cultivars from organic and conventional cultivation. Vegetable Crops Research Bulletin 69: 135 - 143.

Topalov, V., Angelova, R. & Karov, S., 1993. Problems of organic agriculture in Bulgaria. Agricultural University - Plovdiv, "Agroeco" Scientific Practical Conference 1993, vol. XXXVIII, book 1: 5 - 16.

Tringovska, I. & Naydenov, M., 2003. Impact of mycorrhizal inoculants on the quality of pricked - out tomato seedlings. “Ecological Problems of Agriculture” Sixth Scientific Practical Conference, Agroeco 2003, Agricultural University - Plovdiv, XLVIII: 271 - 276.

Vasileva, L., 2006. The role of agricultural policy in the development of organic agriculture. Economic alternatives. University of National and world economy, Issue 2, pp.1-11, www.alternativi.unwe.bg/alternativi/ (Viewed: 28 September, 2013).

Vermany, S., 2007. Knowledge and adoption of bio - fertilizers in horticultural and other crops in rural communities of Haryana. Haryana Journal of horticultural Sciences, 36(1 & 2): 86 - 88.

Vlahova, V., 2013. Agroecological aspects of the mid-early production of pepper (Capsicum annuum L.), Ph.D Thesis, Agricultural University - Plovdiv, Bulgaria: 234.

Vlahova, V. & Popov, V., 2013. Quality of pepper fruits (Capsicum annuum L.) upon the application of the biofertilisers cultivated under the conditions of organic agriculture. Journal of International Scientific Publication, Ecology & Safety, 7(3): 4 - 10.

Willer, H., Lernoud, J., & Kilcher, L. (Eds.). (2013). The World of Organic Agriculture: Statistics and Emerging Trends 2013: Frick, Switzerland: Research Institute of Organic Agriculture (FiBL) & Bonn: International Federation of Organic Agriculture Movements (IFOAM).