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INFLUENCE OF ORGANIC FERTILIZATION ON THE NUTRITIONAL REGIME OF TOMATOES

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Abstract

During the period 2012-2014, in steel-glasshouse on the experimental field of Agricultural University - Plovdiv, was carried out a study about elements of organic tomatoes production technology. The following organic fertilizers have been tested: Evrobio; Osmo Bio garden; Biofa; Orgamax; Agrobiosol; Naturale; Lumbrikompost; Alga 600 PO 2; Hemozim bio 5 N5P3K6; StimAK; Softgard. The organic fertilizers have been introduced in their recommended norms. We have explored the influence of fertilization with organic soil fertilizers and foliar spray on productivity of greenhouse grown tomatoes by late production technology. It was established the nutritional substances were assimilated during the whole vegetation period but with different intensity.More intensive assimilation of N, P, K from the beginning of fruit formation to mass bearing was established in both variants with fertilizers in the soil alone, and with soil fertilizers and foliar sprays.

Key words*:greenhouse tomato, biological production, assimilation of nutritional substances.*

INTRODUCTION

Organic vegetable production, under greenhouse conditions in particular, usually is related to lower yields. Some of the performed studies state this assertion (Pascale, 2004). Most commonly, the studies are done on separate elements of the technology of organic production, or only separate organic fertilizers are tested for root, leaf or combined application (Chapagain & Wiesman, 2004; Gravel et al., 2012; Hidalgo-Gonzales et al., 1998; Kolota & Osinska, 2000; Márquez-Hernández et al., 2013; Tringovska, 2012**;** Yu et al., 2010; Liu et al., 2012; Martins et al., 2010, Nakano, 2003; Surrage et al., 2010; Yildirim, 2007; Pascale et al. 2004). The results in this case are quite multidirectional, too. The number of the studies is low, and in our country we lack surveys on the combined effect of a larger range of organic fertilizers with root, leaf, nutrient reserving and vegetative application under greenhouse conditions.

In order to optimize biological fertilization, it is necessary to establish the absorption of nutrients. In such studies for other conventional vegetable crops - eggplant, tomatoes and peppers (Villora et al., 1988; Boteva & Kostova, 2009; Doikova & Rankov, 2003) state that the absorption of plant nutrients is strongly influenced by the yield and the formed vegetative mass.

To clarify the matters about nutritional regime of the greenhouse tomatoes, an experiment was set when keeping the requirements of organic production.

MATERIALS AND METHODS

For the period 2012-2014 a soil experiment was set to study the elements from the technology for organic tomato production. The effect of fertilization with organic fertilizers and combinations from them on the nutritional regime of the greenhouse tomatoes - grown in accordance with the technology for late production was studied (Kartalov et al., 1979). The experimental work was conducted in the steel-glasshouses in the experimental field of the Agricultural University - Plovdiv with indeterminate tomatoes - sort Fado F_1. The experiment was conducted in geoponic environment under all the requirements for organic production (with application of a complete technology for organic production). A drip irrigation system was used, which is also

used for fertigation with the liquid organic fertilizers. Plant protection was applied with organic agents. Various combinations between 8 organic fertilizers for root fertilization and 3 fertilizers for leaf application were studied. The following 15 variants were studied: 1. N_{44}:P_8:K_{52}; 2. Agrobiosol + Osmo Bio garden + Biofa; 3. Lumbrikompost + Osmo Bio garden + Alga 600 PO 2; 4. Orgamax + Hemozim bio 5 $N_5P_3K_6$ + Biofa; 5. Agrobiosol + Hemozim bio 5 $N_5P_3K_6$ + Biofa; 6. Evrobio + Lumbrikompost + Hydrolysed proteins + Softgard; 7. Orgamax + Lumbrikompost + Stimak+ Softgard; 8. Agrobiosol + Lumbrikompost + Stimak + Softgard; 9. Naturale + Lumbrikompost + Stimak+ Softgard. One variant with mineral fertilization was used as a control: NH_4NO_3, TSP (46% P_2O_5) and K_2SO_4 under optimal levels for greenhouse tomatoes - N_{44}:P_8:K_{52}. Two of the organic fertilizers were applied on vegetative growth through fertigation: StimAK and Hemozim. The organic fertilizers were used in the recommended norms - not vegetative and vegetative (four times - from the beginning of fruit formation every other 15 days). The foliar spray was performed twice with an interval of 10 days, starting three weeks after planting. The plants were grown from seedlings in a heated steel-glasshouse with period for sowing - the first ten days of January and planting in the third ten days of March. The field experiment was setup in 4 repetitions with 14 plants in each repetition (Barov, 1982). The following planting scheme was applied: 40+85+70+85+40 x 42.5 cm with 28000 plants/ha and nutritional area per plant of 3400 cm^2. The plants formed with one stem, the tops were pruned 50 days before the last harvesting. The productivity of the plants was determined as: early yield - up to the fifth pick - kg/m^2; total yield - up to the end of vegetation - kg/m^2. Mineralization of plant material for analysis of P and K was performed using dry ashing and subsequent extraction with 2 M HCl (Chapman & Pratt, 1961). Phosphorus and potassium were then quantified by spectrophotometry and flamephotometry, respectively. Total N was determined by the Kjeldahl method.

Agrobiosolis an organic fertilizer - granular biomass with no additives from conventional materials. Contains dry matter - 95.6%; organic matter - 90.7%; pH ($CaCl_2$) - 3; humidity - 4%; N (total) - 6-8%; phosphates (P_2O_5) - 0.5-1.5%; potassium (K_2O) 0.5-1.5%; C: N 6: 1; CaO 0.21%; MgO 0.05%; Cl, 0.04%; With 1.80%; Zn 6.0 mg/kg; Fe 101 mg/kg; B 7.1 mg/kg; other trace elements and vitamins.

Orgamax is a soil, organic - humic fertilizer made from carefully selected and processed lignites. It is of organic origin and is free from pathogens and heavy metals. With its rich in organic matter and humic substances composition, it improves the chemical properties of the soil (cation exchange capacity), thus making more nutrients in the soil available to the plants, creating better conditions for their assimilation. Suitable for greenhouse, vegetable production. Contains a guaranteed composition of 1% organic nitrogen N; 30% total organic matter (17.4% organic hydrocarbon); 7% humic substances; 8% sulfur (SO_3); 1% iron (Fe); 5-6 pH; 17/1 C/N ratio; 8% max moisture.

Eurobio P 26 N - pro is an organic fertilizer containing P, CaO and the patented N-pro complex. Phosphorus feeding increases with time; calcium neutralizes soil pH and creates a microenvironment that facilitates the absorption of all soil micro and macroelements; By improving soil pH, Eurobio activates the bacterial flora and stimulates the mineralization process primarily of nitrogen. The patented N-pro complex helps to facilitate the mineralization of organic matter in the soil by converting nitrogen into a plant accessible form - nitrate, nitrite and ammonia.

Naturale NPK 8-8-6 contains organic nitrogen 8%; P_2O_5 - 8%; K_2O - 6%; MgO - 2%; Organic Biocarbon - 30%. It is a high quality organic fertilizer, both in terms of raw materials used and in terms of its extremely low humidity level. It is obtained as a result of the exclusive use of organic substances of vegetable origin, bone meal and organic products, which is why it manages to ensure a gradual and continuous supply of nitrogen, thus providing the plants with nutrients throughout the cultivation cycle. Immediate over dosage with nitrogen, leading to strong vegetative growth and weakening of plants, is avoided. It is used in the form of pellets with sizes ranging from 3-4 mm. in diameter and 8-10 mm. length and humidity not exceeding 10%. The pellets produced in this

way are excellent for spreading with all types of fertilizer spreaders and, after being in the soil, quickly disintegrate due to the fact that they absorb up to 4 times more water than their own weight.

LK (Lumbrikompost) N1.71: P3.49: K1.71: Ca 6.25: Mg 2.14 - Organic fertilizer from California worms. Biohumus (lumbricompost) is a product that results from the vital activity of the red California worms (*Lumbricus rubellus* and *Eisenia foetida*), which feed on organic residues. After being processed by the body of the worms, these raw materials change extremely favorably. Worm faeces are high humus fertilizer. Contains a large amount of beneficial bacteria and other microorganisms, many biologically active plant stimulants, vitamins, amino acids and antibiotics added to it during the digestive process of the worm

Osmo Bio garden 6-5-7 (+4) is organic granular fertilizer for general nutrition in greenhouse plants from March to September. Provides fast nourishment and does not burn plants. The special composition of premium materials guarantees a slow release period of 3-6 months and keeps the soil structure in good condition. It is suitable for growing vegetables. The product contains seaweed, which provides the plant with a wide range of essential trace elements. The special formula guarantees remarkable results in the development of each plant in a greenhouse. Fertilizer improves soil structure and fertility. Suitable for organic production.

Alga 600 PO 2 is an organic liquid leaf fertilizer containing N 5%; P_2O_5 4%; K_2O 15%; amino acids > 1%; PGR enzymes (plant hormones); OM organic matter > 15%; pH 8-9. Organic substances contained in Alga 600 PO 2 are a formulation of organic liquid fertilizer, which thanks to its formula acts as a rapidly digestible complex food. Increases the plant's resistance to drought and frost. L-Amino acids together with N and K increase protein synthesis. Stimulates photosynthesis and absorption of nutrients. Promotes the synthesis of sugars (starch). Creates reserves of nutrients (tubers). Increases vitamin content in plants. Acts as an organic catalyst. Has a positive effect on the quantity and quality of production.

Biofa is a natural extract of brown algae used as antistress factor and nutritional supplement in plants. Contains: dry matter -10.89%, pH-7.4, organic carbon - 26.0%, total nitrogen (N) - 0.20%, total phosphorus (P_2O_5) - 0.011%, total potassium (K_2O) - 0.20%, total calcium (CaO) - 0.12%, total magnesium (Mg) - 0.05%, total sulfur (S) - 0.24%. Trace elements in ppm: Cu - 0.81; Zn - 4.10; B - 8.7; Mn - 0.43; Fe - 4.18; Mo- 0.03.

Stimak is a multicomponent, amino acid fertilizer derived from hydrolyzed vegetable and yeast proteins with 30% dry matter.Used as a biostimulator for plants to promote their growth and sustainability. It contains a dry matter of not less than - 44%, of which: organic substance - 82% and amino acids - 35%, total nitrogen (N) - 3.8%, total phosphorus (P_2O_5) - 4%, total potassium- (K_2O) - 4.4%, total calcium (CaO) - 0.035%, total magnesium (MgO) - 0.22%; trace elements (mg/kg): zinc - 75, copper - 4, manganese - 24, boron - 38, iron - 50.

Softgard is a Coftgap limited edition. that contain: N - 5%; P_2O_5 - 4%; K_2O - 3%; Cu (xylene) > 2%; Zn (xelatene) > 1%; Chitosan > 2.6%; OM > 5%; pH 4-6.

RESULTS AND DISCUSSIONS

The amount of nutrients extracted by the yield and vegetative massis different. This is due to the changes in the mineral composition of the plants, the plant mass and the yield (Table 1).

First are the group of variants in which the foliar treatment with Softgard is applied against a background of Lumbrikompost (LK) and Stimak fertigation. The total amount of N, P_2O_5 and K_2O absorbed is highest after the introduction of Orgamax + LK + Stimak + Softgard - 30.72 kg/da, of which 10.43 kg/da N, 6.44 kg/da P_2O_5 and 13.85 kg/da K_2O. They are followed by the plants grown after application of Agrobiosol + LK + Stimak + Softgard - 28.63 kg/da (9.80 kg/da N; 6.44 kg/da P_2O_5; 13.85 kg/da K_2O) and Evrobio + Lumbrikompost + Stimak + Softgard - 25.55 kg/da of which 9.67 kg/da N; 5.73 kg/da P_2O_5; 10.15 kg/da K_2O. Last but not least in this group, the plants fertilized with Naturale + LK + Stimak + Softgard– 25.54 kg/da of which 9.46 kg/da N; 6.38 kg/da P_2O_5; 9.70 kg/da K_2O.

After this group of variants is placed the control variant torus with N_{44}: P_8: K_{52} - 23.97 kg/da, of which 9.08 kg/da N, 5.83 kg/da P_2O_5 and 9.05 kg/da K_2O.

Fewer nutrients from the control have mastered the options fertilized with Osmo organic fertilizer. The highest nutrients in this group were absorbed by plants grown after LK + Osmo + Alga - 21.73 kg/da (8.11 kg/da N; 4.90 kg/da P_2O_5; 8.72 kg/da K_2O). Agrobiosol + Osmo + Biofa fertilizers rank - 23.71 kg/da, of which 7.98 kg/da N, 4.61 kg/da P_2O_5 and 11.12 kg/da K_2O.

At least nutrients are absorbed by the plants after application of Orgamax + Hemozim + Biofa - 20.50 kg/da, of which 6.88 kg/da N; 4.56 kg/l P_2O_5; 9.07 kg/da K_2O.

Changes in the extracted amounts of N, P_2O_5 and K_2O are related to the changes in the accumulated overhead mass per decare. The amount of nitrogen and potassium absorbed from the soil by the stemsand inflorescences is highest when fertilizing with Agrobiosol + Osmo + Biofa - 2.87 kg and 5.64 kg respectively, and phosphorus after fertilizing with Agrobiosol + LK + Stimak + Softgard - 0.95. In organic fertilization, nitrogen is at least after application of Orgamax + Hemozim + Biofa - 2.01 kg, phosphorus after organic fertilization with Evrobio + Lumbrikompost + Stimak + Softgard - 0.64 and potassium after application of Evrobio + Lumbrikompost + Stimak + Softgard- 2.91 kg. In the leaves, the amount of nutrients extracted (13.69 kg) is greatest after the application of Naturale + LK + Stimak+ Softgard, respectively - 5.87 kg of nitrogen, 5.25 kg of phosphorus and 2.57 kg of potassium. The smallest amounts of N and P_2O_5 with the stalks are extracted when fertilizing with Agrobiosol + Osmo + Biofa, 3.70 and 3.27 kg, respectively. The amount of K_2O stems absorbed is at least at control N_{44}: P_8: K_{52}.

Changes in the extracted amounts of nutrients under the influence of applied fertilization and foliar spraw also lead to changes in their ratio (Table 2). In all variants except the control, the proportion of potassium, followed by nitrogen and phosphorus, prevails. Control and Naturale + LK + Stimak+ Softgard show an increase in the proportion of nitrogen at the expense of potassium.

In order to determine the rate of fertilization and the type of fertilizers used in greenhouse tomatoes, it is necessary to know the necessary quantities of nutrients to form a unit of production. The following nutrient quantities were required to form one ton of fruit from the fertilized plants - 0.96 kg to 1.95 kg for nitrogen, 0.58 kg to 1.20 kg for phosphorus and 1.03 kg to 2.59 kg for potassium (Table 3).

After organic fertilization, the highest consumption of nutrients is needed to build one ton of production from the plants grown by the combined application of Orgamax + LK + Stimak+ Softgard - 5.74 kg of which 1.95 kg of nitrogen, 1.20 kg of phosphorus and 2.59 kg of potassium, and the smallest after LK + Osmo + Alga - 2.58 kg of which 0.96 kg of nitrogen, 0.58 kg of phosphorus and 1.03 kg of potassium. In control plants, these amounts are 1.73 kg for nitrogen, 1.11 kg for phosphorus and 1.73 kg for potassium, respectively.

Compared to their total amount, the proportion of potassium is highest and phosphorus is the lowest for all variants.

Table 1. Organic export of nutrients from greenhouse tomatoes, averaged over the period 2012-2014, kg/da

Variants	stems + inflorescences + Roots			leaves			fruits		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1. N_{44}:P_8:K_{52}	2.90	0.86	5.05	4.94	4.45	1.57	1.25	0.52	2.43
2. Agrobiosol+Osmo+Biofa	2.87	0.91	5.64	3.70	3.27	2.05	1.41	0.42	3.43
3. Lumbrikompost+Osmo+Alga	2.06	0.74	3.95	4.30	3.52	1.81	1.75	0.63	2.96
4. Orgamax+Hemozim+Biofa	2.01	0.82	4.39	3.83	3.28	1.82	1.04	0.46	2.86
5. Evrobio+LK+Stimak+Softgard	2.20	0.64	2.91	5.08	4.16	1.94	2.40	0.93	5.29
6. Orgamax+LK+Stimak+Softgard	2.38	0.73	4.50	4.91	4.44	2.32	3.14	1.28	7.03
7. Agrobiosol+LK+Stimak+Softgard	2.85	0.95	5.36	5.15	4.60	2.41	1.81	0.76	4.75
8. Naturale+LK+Stimak+Softgard	2.39	0.73	4.71	5.87	5.25	2.57	1.20	0.40	2.42

Table 2. Proportion of digested nutrients under the influence of applied fertilization and foliar spray on average for the period 2012-2014

Variants	Organic exports of Nutrients throughout the plant, kg/da			Proportion NPK, %		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1. $N_{44}:P_8:K_{52}$	9.08	5.83	9.05	37.90	24.33	37.77
2. Agrobiosol+Osmo+Biofa	7.98	4.61	11.12	33.66	19.43	46.91
3. Lumbrikompost+Osmo+Alga	8.11	4.90	8.72	37.33	22.54	40.13
4. Orgamax+Hemozim+Biofa	6.88	4.56	9.07	33.54	22.22	44.24
5. Evrobio+LK+Stimak+Softgard	9.67	5.73	10.15	37.84	22.44	39.72
6. Orgamax+LK+Stimka+Softgard	10.43	6.44	13.85	33.96	20.96	45.08
7. Agrobiosol+LK+Stimak+Softgard	9.80	6.31	12.52	34.24	22.02	43.74
8. Naturale+LK+Stimak+Softgard	9.46	6.38	9.70	37.04	24.97	37.98

Table 3.Nutrients consumed to form 1000 kg of production on average for the period 2012-2014

Variants	Total yield, t/da	Required quantitiesnutrients per tonne of production, kg / da		
		N	P_2O_5	K_2O
1. $N_{44}:P_8:K_{52}$	5.24	1.73	1.11	1.73
2. Agrobiosol+Osmo+Biofa	6.26	1.27	0.74	1.78
3. Lumbrikompost+Osmo+Alga	8.44	0.96	0.58	1.03
4. Orgamax+Hemozim+Biofa	4.92	1.40	0.93	1.84
5. Evrobio+LK+Stimak+Softgard	5.11	1.89	1.12	1.98
6. Orgamax+LK+Stimak+Softgard	5.35	1.95	1.20	2.59
7. Agrobiosol+LK+Stimak+Softgard	7.22	1.36	0.87	1.74
8. Naturale+LK+Stimak+Softgard	7.48	1.27	0.85	1.30

CONCLUSIONS

Organic fertilizers are able to supply the need for basic nutrients for growing tomatoes in steel-glass greenhouses in late production.

The amount of nutrients extracted in 1 decade is the highest after fertilization with Orgamax + LK + Stimak + Softgard - 30.72 kg, of which nitrogen represents 33.96%, phosphorus - 20.96% and potassium - 45.08%.

The proportion of the three nutrients is not significantly affected by the fertilization variants.

The consumption of nutrients (nitrogen, phosphorus and potassium) for the formation of 1000 kg of production is higher in the background, including biological fertilizers LK and Stimak.

The amounts recovered are from 0.96 to 1.95 kg for nitrogen, from 0.58 to 1.20 kg for phosphorus and from 1.03 to 2.59 kg for potassium. The most nitrogen, phosphorus and potassium are extracted by Orgamax + LK + Stimak + Softgard plants.

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