IMPACT OF ORGANIC AND MINERAL FERTILISERS ON POTATO AND TOMATO YIELD IN BULGARIA

Ivanka MITOVA[1], Lilyana KOLEVA[2], Nikolai DINEV[1]

(1) Institute of Soil Science, Agrotechnologies and Plant Protection 'Nikola Pushkarov', National Center for Agrarian Science, Sofia, Bulgaria
e-mail: smolyanovci@abv.bg
e-mail: ndinev@iss-poushkarov.org
(2) University of Forestry, 10 Kliment Ohridski Blvd, 1756, Sofia, Bulgaria
e-mail: lmarkova@ltu.bg

Corresponding author email: *lmarkova@ltu.bg*

Abstract

In recent years, organic farming, or the production of organic food of plant or animal origin, has been increasingly discussed in our country. A few growers decided to reorient production on their farms.

The aim of the study was to evaluate the yields of potatoes and tomatoes under organic, mineral and organic-mineral fertilisation within the framework of a multi-year vegetable crop rotation.The experiments were carried out on alluvial-meadow soil (Mollic fluvisol) in the village Tsalapitsa (42.191734 N, 24.580252 E), Plovdiv region, like every subsequent year, regardless of the crop experienced, the variants were placed on the same area. The results for the yields and the quality of production showed that there was a lack of a clear, unequivocal answer for the choice and recommendation of organic or mineral fertilisation. The highest yield of potatoes was obtained (3242 kg/da) in the variant with mixed fertilisation. The highest tomato yield was recorded in the variant with mixed fertilisation (4307.4 kg/da), and the lowest in the control (without fertilisation) – 1670.1 kg/da.The fertilisation system as a complex, dynamic mechanism is influenced by several factors. The integrated fertilisation system, i.e., the combination of mineral and organic fertilisation increases the overall efficiency, reflected in the productivity and some of the quality indicators of experimental crops, regardless of the increase in the degree of damage by insect herbivores and fungal pathogens.

Key words**: **Solanum lycopersicum L., Solanum tuberosum L, fertilisation

INTRODUCTION

In recent years, more and more people are talking about organic farming in our country and in Europe. Several growers have decided to radically reorient production on their farms. They go from conventional to organic farming or to growing without artificial fertilizers and preparations. Unfortunately, these decisions are informed almost unilaterally, highlighting the potential benefits of organic farming, not commenting and considering the weaknesses such as lower productivity of the systems, the deteriorated visual appearance of products and others (Mitova & Dinev, 2017).

Absolute organic farming of plants cannot always and everywhere be applied. Sometimes it is necessary to use mineral fertilizers at the start of growing a certain crop. However, organic farming has a future as it is environmentally friendly. But a serious obstacle to its implementation is the lack of a sufficient amount of organic fertilizers. In several farms, farmers have organized crop rotations with grass crops, applying organic and green manuring. Thus, soil erosion is reduced compared to the traditional farming system. In crop rotation, by applying organic fertilizers and other plant residues into the soil, the appropriate nutritional regime is supported,

which ensures high yields (Manolov & Manolova, 2009, Yancheva et al., 2003).
In Bulgaria, several experiments have been conducted to evaluate the various technologies for organic farming. Complex studies of technological elements necessary for the development of a technology for the biological cultivation of pepper and tomatoes under field conditions have been carried out (Boteva & Cholakov, 2011a, Boteva & Cholakov, 2011b, Boteva, 2016, Panayotova, 2018). Technological elements for growing early potatoes by biological method have been studied. (Cholakov & Boteva, 2011). The present study was undertaken to make a comparative analysis regarding the influence of mineral and organic fertilisation on yield quality as an element of sustainable agriculture.
The aim of the study was to evaluate the yields of potatoes and tomatoes under organic, mineral and organic-mineral fertilisation within the framework of a multi-year vegetable crop rotation.

MATERIALS AND METHODS

The experiments were carried out on alluvial-meadow soil (Mollic fluvisol) in the village Tsalapitsa (42.191734 N, 24.580252 E), Plovdiv region, like every subsequent year, regardless of the crop experienced, the variants were placed on the same area.
The trial with early potato cultivar and tomato cultivar for processing included the following variants: V1 (unfertilised), V2 (fertilised with manure), V3 (fertilised with mineral fertiliser), V4 (fertilised with manure + mineral fertiliser) and are part of many years of outdoor experiment in vegetable crop rotation conditions with early potato (*Solanum tuberosum* L.) spinach (*Spinacia oleracea* L.), sweet corn Zea mays convar. saccharata var. rugosa, pumpkins *Cucurbita pepo* L, tomato for processing *Solanum lycopersicum L*, onions *Allium cepa L*.
Over the years, the soils in the experimental field have been the subject of several studies. In the experimental area, Teoharov et al. (2009) found mobile nitrogen content of 4.1%, mobile phosphorus – 9.5% and a mobile potassium content of 1.52%, the soil reaction was in H2O – 7.1, and in KCl – 6.5. These characteristics can be taken as basic for research.

RESULTS AND DISCUSSIONS

For the purpose of the research, here only results related to the potato and tomato yields and their quality are described.

Table 1. Influence of organic and mineral fertilisation on the yield and tuber quality of potato early production of cultivar 'Agata'

Variant	Yield ($t.ha^{-1}$)	Above-ground plant mass (g)	Tuber mass (g/tuber)	Number of potato tubers	Dry matter (%)	Total sugars content (%)	Nitrate content ($mg.kg^{-1}$)
unfertilised (V1)	14.25	957.05	33.29	28.75	18.1	4.5	22.35
fertilised with manure (V2)	23.08	2593.07	71.04	36.50	19.1	4.4	56.22
fertilised with mineral fertilizer (V3)	25.67	2745.00	71.30	38.50	19.3	4.4	97.92
fertilised with manure + mineral fertiliser (V4)	32.42	3067.93	101.42	30.25	16.1	5.1	49.79
LSD ≤ 95%	4.049	219.690		7.053			
LSD ≤99%	5.678	307.991		9.888			

The yield harvested at the end of May, 70 days after seeding, define potato production as early (Mitova et al., 2014).
The effect of applied fertilisation was proven, with the yield of different types of fertilisation being from 1.62 to 2.28 times higher than the yield of tubers without fertilisation. The highest potato yield was obtained (32.42 $t.ha^{-1}$) in the variant with mixed fertilisation. The differences in yields

between plants with organic-mineral fertilisation and those with pure organic or mineral fertilisation were statistically higher. Irrespective of the fact that the plants tended to show higher realised yield in the variant with mineral fertilisation than with organic fertilisation, there were not statistically differences between the two types of fertilisation. Johnson and Sideman (2006) also reported higher potato yield obtained from mineral-fertilised plants compared to variants fertilised with organic fertilizers.

The differences in the size of the tubers in plants with organic and mineral fertilisers were small and not statistically proven. The variant with mixed fertilisation was with the largest tubers – 101.42 g/tuber. Plants without fertilisation gave not only the lowest yields, but also the smallest tubers - an average of 33.29 g/tuber.

Like the mass of tubers, there were no detected differences between the plants with organic and mineral fertilisation, but with the mixed organo-mineral fertilisation the dry mass was significantly lower. Considering that about 50% of potatoes in our country are produced in semi-mountainous and mountainous regions, the dry matter content (in terms of cold resistance) can be an important factor when choosing a suitable variety. The total sugars content in the tubers of the unfertilised plants and in the variants with independent organic and mineral fertilisation was almost the same. In tubers with mixed fertilisation, however, the sugar content was significantly higher – 5.1%. The measured nitrate content (Table 1) was highest in the variant with mineral fertilisation at 97.92 mg.kg^{-1} and, even though it was the highest for the experiment, was below the critical values for according to the permissible standards the nitrate content in vegetable products.

Tomato yield from one-time manual harvesting were presented in Table 2, the yields ranged from 1670.1 to 4307.4kg.da^{-1} (Mitova et al., 2016)

Table 2. Influence of organic and mineral fertilisation on the yield and quality of tomato fruit of cultivar ‘Rio Grande’

Variant	Green tomatoes (kg.da^{-1})	Red tomatoes (kg.da^{-1})	Ripening tomato fruits (%)	Total sugars content (%)	Total acids (%)	Absolutely dry biomass (ACB) (%)
unfertilised (V1)	641.1	1029.0	61.6	3.2	0.42	4.45
fertilised with manure(V2)	1061.9	1280.6	54.7	4.8	0.44	5.26
fertilised with mineral fertilizer (V3)	1181.8	2366.8	66.7	3.6	0.49	5.05
fertilised with manure + mineral fertiliser (V4)	1309.4	2997.9	69.6	4.5	0.45	4.76
LSD ≤ 95%	195.12	836.76				
LSD ≤99%	283.91	1217.54				

It is known that the average yields for this tomato production reach 5000-6000 kg.da-1. (Shaban et al., 2014).

The highest yield was recorded in the variant with mixed fertilisation (4307.4 kg.da^{-1}), and the lowest in the control (without fertilisation) – 1670.1 kg.da^{-1}. The yield in the variant with mixed fertilisation was 1.45 times greater than the average yield for the experimental variants, 2.58 times greater than the yield in unfertilised plants, 1.84 times greater than the organic fertiliser variant and 1.21 times greater than that in the mineral fertilisation variant. The values for the content of total sugars (Vasileva et al., 2016,) vary between 3.2 and 4.8% and were comparable to those in the literature: 1.65 – 6.0 % (Ho, 1996).

The fruits from the variants with organic and mixed fertilisation had the highest sugar content – 4.8 and 4.5%. Varieties with a lower acid content are preferred for the canning industry, as organic acids determine the flavor characteristics of tomatoes. The total acid content was similar for all variants (0.42 – 0.49%), with the highest acid content being found in minerally fertilized tomatoes. Dry matter content is also essential for canning tomatoes. In the literature, the limit values for this indicator are between 4.3 and 8.0% (Atanasova et al., 2009; Shaban et al., 2014; Dintcheva et al., 2016).

Fruits from the variant with organic fertilisation had the highest content (5.26%) of absolute dry matter, which was significantly lower than the than the measured contents (6.9 – 7.8%) in a trial with increasing fertilisation rates on the same soil type, with tomato 'Rio Fuego' (Atanasova et al., 2009). The analysis of nitrate content in tomato fruits at full maturity showed their absence. The organic fertilised variants had a higher attack rate by *Phytophthora infestans*, and those without fertilisation and single mineral fertilisation by *Alternaria solani* (Bistrichanov et al., 2016).

The results for the yield and quality of potato and tomato production showed a lack of a definite, unequivocal answer for the choice and recommendation of organic or mineral fertilisation. The fertilisation system as a complex, dynamic mechanism is influenced by several factors: soil and climate conditions, type of cultivated crop, production direction, external factors - market, farm labour force, etc.

CONCLUSIONS

The highest potato yield (32.42 $t.ha^{-1}$) was achieved in the variant with mixed fertilisation. Irrespective of the fact that the plants tended to show higher yield in the variant with mineral fertilisation than with organic fertilisation, there were not statistically differences between the two types of fertilisation.

Potatoes in the variant with mixed organic-mineral fertilisation had the largest tubers (101.42 g/tuber), with a high total sugar content – 5.1% and a low nitrate content – 49.79 $mg.kg^{-1}$.

The highest tomato yield was noted in the variant with mixed fertilisation (4307.4 $kg.da^{-1}$), and the lowest in the control (without fertilisation) – 1670.1 $kg.da^{-1}$. The yield in the variant with mixed fertilisation was 1.45 times greater than the average yield for the experimental variants, 2.58 times greater than the yield in unfertilized plants, 1.84 times greater than the organic fertilized variant and 1.21 times greater than that in the mineral fertilisation variant.

Tomatoes from the variant with organic fertilisation had a low yield, but the largest fruits, with a higher content of total sugars and absolutely dry biomass compared to the fruit production from the plants with mineral and organo-mineral fertilisation. Acid content was highest in tomatoes with mineral fertilisation.

At the expense of the low yield, the fruits of tomatoes with organic fertilisation had the largest fruits, with a higher content of total sugars and dry matter compared to the production of plants with mineral and organo-mineral fertilisation. Acid content was highest in tomatoes with mineral fertilisation.

The results give reason to assume that the joint use of mineral and organic fertiliser increases the overall efficiency, reflected in the productivity of the crop, regardless of the increase in the degree of leaf damage by pathogen attack.

REFERENCES

Atanasova E., Mitova, I., Stoicheva, D., (2009). Assessment of biochemical and morphological parameters of procesaing tomatoes in dependence on nitrogen fertilisation. Seminar of ecology. Proceedings, 23-24.04.2009, Sofia, 198-202. (Bg)

Bistrichanov S., Mitova, I., Avramov, Z., Lozanova, V., (2016). The effect of organic and chemical fertilizers on the yield and disease resistance of tomatoes-field production. “Seminar of ecology–2016 ”With international participation”. pp. 21-22.

Boteva, H., Cholakov, T., (2011a). Technological elements in biological production of pepper. International Scientific Conference "100 years of soil science in Bulgaria", May 16-20, Sofia, Part I, pp. 466-470. (Bg)

Boteva, H., Cholakov, T., (2011b). Effectiveness of biofertilizers on the vegetative and productive manifestations of mid-early tomatoes. Scientific reports from the International Scientific Conference "100 years of soil science in Bulgaria", May 16-20, Sofia, Part I, pp. 461-465. (Bg)

Boteva, H., (2016). Productivity and quality of open field tomato after application of bio-fertilizers. Agricultural science and technology, 8, (2), 140-143.

Cholakov, T., Boteva, H., (2011). Influence of fertilisation by vermikompost on the yield from early potatoes. Journalof International Scientific Publications Ecology&Safety, 5, (3), 198-205.

Dintcheva T., Boteva, H., Arnaoudov, B., (2016). Effect of vermicompost and system of cultivation on tomatoes seedlings. Journal of the Scientists Union «ESU»:«Actual problems of modern science and their solutions», 3 (24), 100–104.

Ho, L., (1996). The mechanism of assimilate partitioning and carbohydrate compartmentation in fruit in relation to the quality and yield of tomato. J. Expt. Bot., 47, 1239–1243.

Johnson, S. B., Sideman, E., (2006). Potato facts producing potatoes organically in Maine. Bulletin, 2419, 1-6.

Manolov, I., Manolova, V., (2009). Organic farming a good prospect for the small farmer, Midion Publishing House OOD, 66 pp. (Bg)

Mitova, I., Dinev, N., (2017). Cultivation Development-Conventional and/or Biological?Sustainable. East-West Publishing House-Sofia, ISBN978-619-01-0075-1, 167 pp. (Bg)

Mitova, I., Dinev, N., Vasileva, V., (2014). Effects of Mineral and Organic Fertilisation on Early Potato Production. Bul. Journal of Agricultural Science, 20 (5), 1182- 1188.

Mitova, I., Vasileva, V., Lozanova, V., Dinev, N., (2016). Growth events and yields in Polish tomato production - canned type depending on fertilisation. Soil Science Agrochemistry and Ecology, 50, 3-, 8-15. (Bg)

Panayotova P., 2018. Technological elements in biological production of mid-

early tomatoes. Dissertation work, IZK "Maritsa", Plovdiv, p. 140. (Bg)

Shaban, N., Bistrichanov, S., Moskova, T., Kadum, E., Mitova, I., Tityanov, M., Bumov, P., (2014). Vegetable production, Sofia, LTU, 490 pp. (Bg)

Teoharov, M., Popandova S., Tsolova, V., Banov, M., Ivanov, P., Filcheva, E., Ilieva, R. (2009). Reference database for soils in Bulgaria. SSA, IP "N. Pushkarov". ISBN 978-954-9467-26-0. Advertising and publishing house "Poni", Sofia, 416 pp. (Bg)

Vasileva, V., Mitova, I., Dinev, N., Lozanova, V., (2016). Quality, content and export of nutrients with tomato production. Soil Science Agrochemistry and Ecology, 50, 3-4,63-70. (Bg)

Yancheva, H., Manolov, I., (2003). Essentials of Organic Farming. Plovdiv: IK Vasil Petrov, ISBN 954-9806-46-4, 480 pp. (Bg)