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The influence of biofertilization on the growth, yield and fruit quality of cv. Topaz apple trees

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Abstract

Mosa W.F.A.E-G, Paszt L.S., Frąc M., Trzciński P., Przybył M., Treder W., Klamkowski K. (2016): **The influence of biofertilization on the growth, yield and fruit quality of cv. Topaz apple trees**. Hort. Sci. (Prague), 43: 105–111.

Maiden apple trees of cv. Topaz were planted in 2011. In the spring of 2014, chemical fertilization (NPK) and various bioproducts: Fertigo, Micosat, Humus UP, Humus Active + Aktywit PM, Aktywit PM, BioFeed Quality, BioFeed Amin, Vinassa, Florovit Natura and Florovit Eko alone or enriched with *Pantoea* sp., *Pseudomonas fluorescens, Klebsiella oxytoca* and *Rhizobium* sp. bacteria species were applied to the apple trees to evaluate their effect on the growth, yield and fruit quality. Our results demonstrated that Yeast + beneficial bacteria gave the highest yield in terms of weight and number of fruits per tree in comparison to control and other treatments. Florovit Natura combined with beneficial bacteria significantly increased tree trunk thickness in July and in November 2014 over control. Photosynthetic rate was higher in July than in August 2014. It was improved by both Florovit Natura and Vinassa supplemented with beneficial bacteria over NPK in July and in August 2014, respectively.

Keywords: NPK; humus UP; vinassa; apple; yeast

Intensive farming practices, which warrant high yield and quality, require extensive use of chemical fertilizers, which are costly and create environmental problems. Therefore, there has recently been a resurgence of interest in environmentally-friendly, sustainable and organic agricultural practices (Esitken et al. 2005). Development and application of sustainable agricultural techniques and biofertilization are vital to alleviate environmental pollution (Vessey 2003). Von-Bennewitz and Hlusek (2006) reported that biofertilization is beneficial in stimulating the growth and fruiting of pome and stone fruits. Biofertilizers have a great potential as supplementary, renewable and environmentally-friendly sources of plant nutrients. Furthermore, they are an important component of integrated nutrient management and plant nutrition system (Raghuwanshi 2012). Possible mechanism of the effectiveness of biofertilizers include mobilization of sparingly available plant mineral nutrients nitrogen fixation and solubilisation of zinc (Goteti et al. 2013), potassium (Maurya et al. 2014) and phos-

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phorus (Verma et al. 2014). O'Connell (1992) stated that the application of biofertilizers containing beneficial microorganisms instead of synthetic chemicals are known to improve plant growth through the supply of plant nutrients and may help to sustain environmental health and soil productivity. Moreover, the use of microbial fertilizers is one way in which organic farmers are able to increase yield and quality of crops without a large investment of money and labour. It can also clean the environment and expand the productive capacity of land by reducing the amount of chemical fertilizer consumption (Pham 2004). Additionally, the soil microorganisms can contribute to the nutrition of plants through a number of mechanisms, including direct effects on the availability of nutrients or plant growth-promoting substances, which are synthesized by bacteria or by facilitating the absorption of certain nutrients from the environment (Farina et al. 2012). Grzyb et al. (2012) showed the improvement in the quality of maiden apple trees following the treatments of granulated manure, Micosat, Humus UP, Humus Active + Aktywit PM, BF Quality, BF Amin, Yeast and Vinassa on the growth of cvs Topaz and Ariwa maiden apple trees, grafted on M.26 rootstock. The aim of this study was to evaluate the effect of mineral fertilization (NPK) and the application of bioproducts alone and in combination with beneficial bacteria on growth, yield and fruit quality of cv. Topaz apple trees.

MATERIAL AND METHODS

The experiment was conducted in the autumn of 2011. Maiden apple trees of cv. Topaz were planted at a spacing of 2 m in a row and 4 m between rows. The experiment was comprised of twenty-two treatments and each was repeated twice with 4 trees. In the spring of 2013, NPK, Fertigo, Micosat, Loose Yeast, Florovit Natura and Florovit Eko (PK) were added to the soil two times: at the end of April and in the middle of June. The other treatments were applied to the soil at the end of May and repeated in the middle of July. Some beneficial bacterial species: *Pantoea* sp., *Pseudomonas fluorescens, Klebsiella oxytoca* and *Rhizobium* sp. were added to the soil via the irrigation system. The same treatments were repeated and applied to the plants in 2014. These are the fertilization combinations used in the experimental orchard in Dąbrowice, 2013–2014:

1. Chemical NPK fertilization (control): 17.64 g/m^2 NH_4NO_3, 6.52 g/m^2 triple super phosphate, and 16.0 g/m^2 K_2SO_4. It was applied as a 60 kg/ha N, 30 kg/ha P, and 80 kg/ha K.
2. Fertigo (manure) (Ferm-O-Feed, Gerstdijk 6, 5704 RG Helmond, Netherlands): Granulated bovine manure containing 55% C, 1% N, 0.3% P and 1% K; and also microelements and soil micro-organisms. The product was applied as a 150 g/m^2 (1,500 kg/ha), equivalent to 45 kg/ha N, 13 kg/ha P and 17 kg/ha K.
3. Micosat (CCS Aosta Srl, Villaggio Olleyes, 9, 11020 Olleyes AO, Italy): Microbial inoculum containing mycorrhizal fungi (*Glomus mosseae* and *G. intraradices*), and plant growth promoting bacteria (*Pseudomonas fluorescense* and *Bacillus subtilis*). The product contains 40% C, 0.15% N, 431 mg/kg P and 9,558 mg/kg K. Micosat F12 WP was applied to the soil at planting at a dose of 10 g/m (100 kg/ha), and again in mid-June in liquid form (Micosat FMS 200) at a rate of 1 g/m^2 (10 kg/ha).
4. Humus UP (Ekodarpol, Dębno, Poland): An extract from vermicomposts containing 0.65% C, 0.03% N, 30.8 mg/kg P and 4,535 mg/kg K. It was applied to the soil as a 2% solution (2 ml/m^2) (20 l/ha).
5. Humus Active + Aktywit PM (Ekodarpol, Dębno, Poland): An extract from vermicomposts based on a product derived from molasses. Humus Active is a soil improver with active humus and populations of beneficial microorganisms, containing 0.78% C, 0.03% N, 1,050 mg/kg P and 4,119 mg/kg)K. Aktywit PM is a soil improver containing 20.5% C, 0.92 % N, 81.2 mg/kg P and 42,990 mg/kg K. Humus Active was applied to the soil as a 2% solution (2 ml/m^2) (20 l/ha) and Aktywit PM was applied to the soil as a 1% solution – 1 ml/m^2 (10 l/ha).
6. BioFeed Quality (Agrobio Products B.V., Wageningen, the Netherlands): An extract from several seaweed species reinforced with humic and fulvic acids, containing 0.6% C, 0.07% N, 32.6 mg/kg P. It was applied to the soil as a 0.5% solution (0.5 ml/m^2) (5 l/ha).
7. BioFeed Amin (Agrobio Products B.V., Wageningen, the Netherlands): An extract reinforced with amino acids – an extract of vegetal amino acids containing 1.12% C, 0.14% N, 347 mg/kg P. The product was applied to the soil as a 0.5% solution (0.5 ml/m^2) (5 l/ha).
8. Loose Yeast (Biopuls Start-up of Micro Life Company, Poznań, Poland). Biopuls Stardust

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Table 1. Content of experimental orchard soil from macro and micronutrients

No. lab.	pH KCl	P	K	Mg	B	Cu	Fe	Mn	Zn
		(mg/1,000 g soil)							
14/473	6.1	11.6	14.5	5.31	2.75	11.0	894	85.0	11.4

Lab. – Chemical Pollution Research Laboratory of the Research Institute of Horticulture, Skierniewice, Poland

composition: Minerals: 67.37 g/kg N, 18.21 g/kg P, 13.58 g/kg K, 3.98 g/kg Ca, 19.58 g/kg Na, 0.13 g/kg Fe, 0.01 g/kg Cu, 2.05 g/kg Mg, 0.15 g/kg Mn, 0.19 g/kg Zn, 0.28 g/kg I, 1.60 mg/kg Fe, 0.40 mg/kg Mo, 11.26 mg/kg Co. Vitamins: 105.26 mg/kg vitamin B1 (hydrochloride thiamine), 33.58 mg/kg vitamin B2 (riboflavin), 0.38 mg/100 g vitamin B12, 2157.89 mg/kg Biotin, 1831.58 mg/kg of folic acid, 75.79 mg/kg pantothenic acid, 5052.63 mg/kg Choline, 164.21 mg/kg of Niacin, 27.89 mg/kg Vitamin E (alpha tocopherol). Amino acids: 31.68 g/kg aspartic acid, 54.84 g/kg glutamic acid, 26.49 g/kg lysine, 5.60 g/kg methionine, 16.21 g/kg threonine, 12.67 g/kg tryptophan, 4.53 g/kg cystine, 25.47 g/kg leucine, 17.26 g/kg isoleucine, 19.26 g/kg valine, 5.58 g/kg histidine, 17.37 g/kg arginine, 18.42 g/kg serine, 34.95 g/kg alanine, 14.00 g/kg phenylalanine, 15.47 g/kg tyrosine, 16.63 g/kg glycine, 15.47 g/kg proline, 1.47 g/kg ornithine, 14.32 g/kg of γ-aminobutyric acid. It was applied to the soil as a 90 g/tree – 360 per plot for one treatment.

9. Vinassa (Józefów Sp. z o.o., Warszaw, Poland): Molasses residue from yeast production containing 12.0% C, 1.86% N, 949 mg/kg P, 17,615 mg/kg K. The product was applied to the soil as a 0.5% solution (0.5 ml/m^2) (5 l/ha).
10. Florovit Natura (NPK) (Grupa Inco S.A., Warszaw, Poland): N – 5%, P_2O_5 – 3%, K_2O – 2%. Organic matter content is at least 30%. The product was applied as 375 g/tree.
11. Florovit Eko (PK) (Grupa Inco S.A., Warsaw, Poland): P_2O_5 – 3%, K_2O – 5%. It was applied as 375 g/tree.

Each one of the treatments mentioned above was applied alone and in combination with bacterial strains. Experimental soil content from macro and micronutrients was cleared in Table 1. The impact of the treatments was noticed by evaluating their influence on the following parameters:

Gas exchange measurements. Net photosynthesis, transpiration and stomatal conductance were recorded. Six readings from each treatment were measured using Lcpro + (ADC BioScientific Ltd. Hoddesdon, England) portable system. Measurements of gas exchange were conducted two times in July and in August 2014 during the vegetative period.

Trunk cross sectional area (TCSA). The TCSA was measured two times in July and in November 2014 during the vegetative period by using a Vernier calliper (Indiamart, Karnataka, India).

Fruit yield per tree. Yield was estimated by calculating the weight in kg and the number of fruits in each treatment at harvest time 2014.

Fruit quality. After fruit storage, the weight of individual fruits, percentage of blush, flesh firmness (FF), total soluble solids content (TSS) and titratable acidity (TA) were measured in 2014. Weight of fruit in g was measured using WPS 2100/C/2 balance (Radwag, Radom, Poland). Flesh firmness was measured by penetrometer method on two opposite sides of each fruit using an EPT-1R Pressure Tester (Lake City Technical Products Inc., Kelowna, Canada), equipped with Magness-Taylor probe (Instron Industrial Products, Grove, USA) of 11 mm diameter. The results were expressed in kg. The TSS and TA were measured in freshly prepared juice. The TSS was determined using ATAGO PR-101 digital refractometer (ATAGO, Tokyo, Japan) and the results were expressed in %. The TA was determined by standard titration method using automatic titrator DL 50 Graphix (Mettler Toledo, Greifensee, Switzerland) by titration of juice with 0.1N NaOH to the end point at pH = 8.1. The results were expressed as a percentage of malic acid. All the obtained results were subjected to uni- or multivariate analysis of variance using Statistica version 10 (Statsoft Inc., 2012).

RESULTS

The results listed in Table 2 showed that stomatal conductance rate in July was greatly enhanced by the application of Florovit Natura over NPK control. Moreover, the effect of Florovit Natura vastly differed from the effect of Fertigo, Micosat, BioFeed Amin and Yeast and from the combination of ben-

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Table 2. The effect of NPK and bioproducts, used alone or enriched with beneficial bacteria on the rate of transpiration, stomatal conductance and photosynthesis in the leaves, and on the trunk thickness of cv. Topaz apple trees grown at Experimental Orchard in Dąbrowice, 2014

Treatments	Transpiration (mmol H_2O m^{-2} s^{-1})		Stomatal conductance (mol m^{-2} s^{-1})		Photosynthesis (mmol CO_2 m^{-2} s^{-1})		Tree trunk thickness (mm)	
	July	August	July	August	July	August	July	November
NPK (control)	3.95^{abc}	1.97^{ab}	0.22^{bcd}	0.43^{b-e}	14.67^{c}	13.65^{a-d}	26^{cd}	31.39^{b}
Fertigo	2.66^{fgh}	2.02^{a}	0.11^{e}	0.43^{cde}	8.26^{d}	13.70^{a-d}	24.02^{d}	$31.81a^{b}$
Micosat	3.65^{a-d}	1.99^{ab}	0.21^{cde}	0.40^{c-f}	14.13^{c}	14.17^{abc}	23.77^{d}	32.1^{ab}
Humus UP	4.10^{ab}	1.65^{b-e}	0.28^{a-d}	0.33^{efg}	16.73^{abc}	12.19^{a-d}	26.62^{bcd}	34.71^{ab}
Humus Active + Aktywit PM	4.29^{a}	1.52^{d-g}	0.31^{ab}	0.30^{efg}	16.13^{abc}	11.24^{cd}	30.46^{abc}	33.99^{ab}
BioFeed Quality	4.06^{ab}	1.72^{a-e}	0.28^{a-d}	0.51^{a-d}	17.84^{abc}	12.21^{a-d}	32.12^{ab}	35.97^{ab}
BioFeed Amin	3.61^{a-d}	1.78^{a-e}	0.22^{bcd}	0.42^{cde}	15.08^{c}	13.52^{a-d}	29.59^{a-d}	32.44^{ab}
Yeast	3.46^{b-e}	1.85^{a-d}	0.23^{bcd}	0.54^{abc}	14.15^{c}	14.34^{ab}	27.69^{a-d}	30.32^{b}
Vinassa	3.97^{abc}	1.91^{abc}	0.31^{ab}	0.60^{a}	17.06^{abc}	14.43^{ab}	31.27^{abc}	35.71^{ab}
Florovit Natura	3.87^{abc}	1.44^{e-h}	0.34^{a}	0.35^{efg}	17.12^{abc}	13.90^{abc}	28.86^{a-d}	32.19^{ab}
Florovit Eko	3.57^{bcd}	1.47^{efg}	0.31^{ab}	0.35^{defg}	16.48^{abc}	12.76^{a-d}	29^{a-d}	32.68^{ab}
NPK + bacteria	2.44^{h}	1.26^{f-i}	0.26^{a-d}	0.30^{efg}	17.96^{abc}	12.56^{a-d}	27.1^{a-d}	30.04^{b}
Fertigo + bacteria	2.45^{h}	1.17^{ghi}	0.19^{de}	0.30^{efg}	15.97^{abc}	14.22^{ab}	29.33^{a-d}	32.09^{ab}
Micosat + bacteria	2.52^{gh}	1.10^{hi}	0.20^{de}	0.28^{efg}	15.48^{bc}	12.81^{a-d}	31.43^{abc}	34.21^{ab}
Humus UP + bacteria	2.65^{fgh}	1.25^{f-i}	0.22^{bcd}	0.29^{efg}	15.16^{bc}	12.84^{a-d}	30.25^{abc}	33.54^{ab}
Humus Active + Aktywit PM + bacteria	3.12^{d-h}	1.27^{f-i}	0.28^{a-d}	0.27^{fg}	16.74^{abc}	11.72^{bcd}	31.54^{abc}	36.01^{ab}
BioFeed Quality + bacteria	3.16^{d-g}	1.05^{i}	0.31^{ab}	0.20^{g}	19.11^{ab}	10.91^{d}	29.43^{a-d}	32.25^{ab}
BioFeed Amin + bacteria	3.13^{d-h}	1.47^{efg}	0.29^{abcd}	0.33^{efg}	17.22^{abc}	12.57^{a-d}	32.46^{ab}	36.32^{ab}
Yeast + bacteria	2.83^{e-h}	1.56^{c-f}	0.22^{bcd}	0.43^{b-e}	17.11^{abc}	13.56^{a-d}	31.87^{abc}	35.7^{ab}
Vinassa + bacteria	3.17^{d-g}	1.94^{ab}	0.27^{a-d}	0.64^{a}	17.89^{abc}	14.74^{a}	32.24^{ab}	35.76^{ab}
Florovit Natura + bacteria	3.31^{c-f}	1.84^{a-d}	0.30^{abc}	0.58^{ab}	19.63^{a}	14.36^{ab}	33.05^{a}	38.28^{a}
Florovit Eko + bacteria	3.05^{d-h}	1.74^{a-e}	0.27^{a-d}	0.51^{abc}	16.90^{abc}	13.91^{abc}	32.32^{ab}	35.73^{ab}

means not sharing the same letter(s) with in each column, are significantly different at 0.05 level of probability

eficial bacteria with Fertigo, Micosat, Humus UP or Yeast. In August, it was markedly increased by the application of Vinassa alone or mixed with beneficial bacteria as compared to NPK. Photosynthetic rate in July was higher than in August. In July, it was improved by the addition of beneficial bacteria to Florovit Natura and BioFeed Quality comparing with NPK. In August, it was significantly improved by the addition of beneficial bacteria to Vinassa over Humus Active + Aktywit PM or BioFeed Quality enriched with beneficial bacteria and Humus Active + Aktywit PM. The data in Table 2 also cleared that the tree trunk thickness was markedly increased by the application of Florovit Natura enriched with beneficial bacteria in July and in November over NPK treatment. Furthermore, it was remarkably enhanced by the addition of beneficial bacteria to BioFeed Amin, Vinassa and Florovit Eko comparing with NPK treatment. In November, it was significantly enhanced by Florovit Natura vaccinated with beneficial bacteria over NPK, NPK + beneficial bacteria and Yeast. All the treatments increased the tree trunk thickness in November even they were used alone or mixed with beneficial bacteria over the control except NPK+ Bacteria and Yeast.

Results in Table 3 cleared that Yeast supplemented with beneficial bacteria was the best treatment which gave the best yield in terms of fruit weight and number of fruits per tree over NPK control and the other treatments. Although Yeast plus beneficial bacteria markedly improved the fruit weight, the incremental increase in the number of fruit per tree was insignifi-

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Table 3. The effect of NPK and bioproducts, used alone or enriched with beneficial bacteria, on yield and characteristics of the apple cv. Topaz fruit grown at Experimental Orchard in Dąbrowice, 2014

Treatments	Yield as number of fruits per tree	Yield as weight of fruits (kg/tree)	Fruit weight (g)	Blush (%)	Acidity (%)	Firmness (kg)	TSS (%)
NPK (control)	28.75^{a-e}	5.11^{b-f}	193.99^{abc}	88.12^{ab}	0.77^{b}	5.57^{ab}	14.77^{abc}
Fertigo	25.37^{c-f}	4.71^{c-g}	179.27^{bc}	90.83^{ab}	0.73^{c-f}	6.29^{a}	14.62^{a-e}
Micosat	22.75^{def}	3.53^{fg}	183.39^{abc}	93.33^{a}	0.66^{j}	5.77^{ab}	14.11^{c-g}
Humus UP	19.75^{f}	3.83^{efg}	201.28^{abc}	90.00^{ab}	0.69^{ghi}	6.24^{a}	14.34^{b-g}
Humus Active + Aktywit PM	19.875^{f}	3.43^{g}	172.94^{bc}	90.83^{ab}	0.75^{bcd}	6.13^{ab}	14.80^{ab}
BioFeed Quality	27.00^{b-f}	5.29^{a-e}	188.43^{abc}	92.50^{ab}	0.68^{hij}	5.63^{ab}	13.90^{fg}
BioFeed Amin	28.87^{a-e}	5.20^{a-e}	187.92^{abc}	90.00^{ab}	0.72^{c-g}	6.14^{ab}	14.47^{a-f}
Yeast	26.00^{c-f}	5.10^{b-f}	209.34^{ab}	88.75^{ab}	0.69^{g-j}	5.94^{ab}	14.06^{d-g}
Vinassa	30.50^{a-d}	5.72^{abc}	202.05^{abc}	82.50^{ab}	0.69^{f-i}	6.02^{ab}	13.80^{g}
Florovit Natura	30.50^{a-d}	5.59^{a-d}	184.57^{abc}	80.00^{b}	0.68^{ij}	5.74^{ab}	13.95^{efg}
Florovit Eko	23.50^{def}	4.03^{d-g}	182.13^{abc}	90.00^{ab}	0.72^{c-h}	5.72^{ab}	14.35^{b-g}
NPK + bacteria	28.00^{a-e}	5.06^{b-f}	205.97^{abc}	90.62^{ab}	0.82^{a}	5.36^{b}	15.05^{a}
Fertigo + bacteria	33.87^{ab}	5.64^{abcd}	176.52^{bc}	87.92^{ab}	0.74^{b-e}	5.48^{ab}	14.78^{abc}
Micosat + bacteria	32.50^{abc}	5.34^{abcde}	180.14^{bc}	88.44^{ab}	0.75^{bc}	5.64^{ab}	14.96^{ab}
Humus UP + bacteria	29.00^{a-e}	6.23^{abc}	175.59^{bc}	88.54^{ab}	0.71^{d-i}	5.73^{ab}	14.38^{a-g}
Humus Active + Aktywit PM + bacteria	22.12^{ef}	4.68^{c-g}	186.13^{abc}	85.42^{ab}	0.71^{d-i}	5.83^{ab}	14.36^{b-g}
BioFeed Quality + bacteria	32.12^{abc}	5.27^{a-e}	171.21^{c}	93.75^{a}	0.68^{ij}	5.59^{ab}	14.11^{c-g}
BioFeed amin + bacteria	29.75^{a-e}	5.91^{abc}	198.02^{abc}	93.40^{a}	0.70^{e-i}	5.80^{ab}	13.78^{g}
Yeast + bacteria	35.00^{a}	6.78^{a}	190.51^{abc}	94.37^{a}	0.74^{b-e}	5.72^{ab}	14.66^{a-d}
Vinassa + bacteria	30.00^{a-d}	5.98^{abc}	203.29^{abc}	94.37^{a}	0.74^{b-e}	5.64^{ab}	14.64^{a-d}
Florovit Natura + bacteria	28.50^{a-e}	6.08^{abc}	217.42^{a}	92.50^{ab}	0.74^{bcd}	5.87^{ab}	14.38^{a-g}
Florovit Eko + bacteria	34.87^{a}	6.54^{ab}	202.72^{abc}	95.00^{a}	0.69^{f-i}	5.42^{b}	14.12^{c-g}

TSS – total soluble solids

cant compared with control. Additionally, they were vastly increased by Yeast or Florovit Eko combined with beneficial bacteria over Humus Active + Aktywit PM + beneficial bacteria, Fertigo, Micosat, Humus UP, Humus Active + Aktywit PM, Yeast and Florovit Eko. Fruit weight was slightly improved by supplementing Florovit Natura, NPK, BioFeed Amin, Vinassa and Florovit Eko with beneficial bacteria, Humus UP, Yeast and Vinassa as compared to NPK. The acidity of the fruits was markedly increased by the application of NPK + with beneficial bacteria over control or the other treatments. Moreover, it was statistically raised with NPK over Humus UP, Humus Active + Aktywit PM, BioFeed Amin, BioFeed Quality and Florovit Eko after enriching each one of them with beneficial bacteria. Fruit firmness was greatly improved with Fertigo and Humus UP over NPK or Florovit Eko supplemented with beneficial bacteria. Total soluble solids percentage was markedly improved by NPK + beneficial bacteria over the supplementation of Humus Active + Aktywit PM, BioFeed Amin, BioFeed Quality and Florovit Eko with the beneficial bacteria.

DISCUSSION

The results showed that the addition of *Pantoea* sp., *Pseudomonas fluorescens, Klebsiella oxytoca* and *Rhizobium* sp. bacteria species to Florovit Natura, Florovit Eko, and Vinassa improved stomatal conductance and photosynthetic rate and reduced the transpiration rate as compared to NPK. These results were previously explained by Richardson and Hadobas (1997), Vyas and Gulati (2009) and Ahemad and

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Khan (2011). They stated that *Pseudomonas* and *Rhizobium, Klebsiella* and *Pseudomonas* possess the ability to solubilize insoluble inorganic phosphates and make them available to the plants. P deficiency has a significant influence on leaf photosynthesis and carbon metabolisms in plants (Rao 1996) and could result in smaller size of stomatal opening (Sarker et al. 2010). Furthermore, Khan et al. (2010) mentioned that phosphorus plays an important role in photosynthesis, energy transfer, signal transduction, and respiration in the plant. According to our results Biofeed Amin increased the tree trunk thickness over control. These results agreed with the findings of Rozpara et al. (2014) who found that Biofeed Amin preparation had a positive influence on the growth and development of cv. Ariwa apple trees growing. Additionally, it was markedly enhanced by the application of Florovit Eko enriched with beneficial bacteria in July and in November over NPK treatment. These coincided with the findings of Grzyb et al. (2015) who found that Florovit Eko + mycorrhizal fungi improved the tree trunk diameter of maiden trees of apple cv. Topaz and of sour cherry cv. Debreceni Bötermö.

Yeast supplemented with beneficial bacteria was the best treatment which gave the best yield in terms of fruit weight and the number of fruits per tree over NPK control and the other treatments. These were confirmed by Hegab et al. (2010) who stated that using yeast in different fruit crops was accompanied with enhancing yield and fruit quality. Moreover, Mansour et al. (2011) also found that using yeast via soil, via foliage or via both methods at different concentrations on Kelsey plum trees significantly improved yield and fruit quality in terms of increasing fruit weight. Additionally, Humus UP enhanced the fruit weight over control in our results and this was in parallel to the findings of Li et al. (1999) who found that humic materials significantly enhanced apple fruit weight. On the opposite side, our results showed that Humus Active + Aktywit PM and Humus UP did not have any great effect on the fruit number or the fruit weight as compared to control. These were not consistent to the findings of Rozpara et al. (2014) who noticed that the largest and highest amounts of fruit of cv. Ariwa apple trees were harvested from the trees fertilized with Humus UP and Humus Active + Aktywit PM. The addition of *Pantoea* sp., *Pseudomonas fluorescens, Klebsiella oxytoca* and *Rhizobium* sp. bacteria species to Biofeed Quality, Yeast, Vinassa and Florovit Eko improved plant growth, yield and fruit quality of cv. Topaz apple trees. These results were previously emphasized by Bashan and Holguin (1998). They mentioned that some of the associative and free-living rhizosphere bacteria exert beneficial effects and enhance growth of many crop plants. Microbial bioferilizers increased yield and improved physical and chemical quality characteristics of pears (Attala et al. 2000) and apricot (Ibrahim et al. 2005). Moreover, *Pseudomonas*, *Rhizobium* and *Klebsiella* bacteria species, mostly associated with plant rhizosphere and found to be beneficial for plant growth, yield, and crop quality in apple and apricot (Esitken et al. 2003). Aslantas et al. (2007) stated that plant growth promoting rhizobacteria stimulated the growth and increased fruit yield in apple. In addition, *Bacillus subtilis* OSU- 142, *Bacillus megaterium* M-3, *Burkholderia cepacia* OSU-7 and *Pseudomonas putida* BA-8 bacteria strains, alone or some of their combinations improved fruit set, plant vegetative growth, and fruit chemical characteristics of cv. Kutahya sour cherry (Karakurt et al. 2011).

CONCLUSION

The obtained results indicated that:

– The applied bioproducts used alone and the same bioproducts enriched with beneficial microorganisms had a better, or at least the same, effect compared with NPK on improving the growth, yield and fruit quality of the apple cv. Topaz.
– The applied biofertilizers can be a good alternative to standard NPK fertilization in fruit production with cv. Topaz apple trees.
– The experiment will be continued for the two subsequent years to reveal the beneficial effect of the applied bioproducts on the growth and yielding.

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