Scientific Papers. Series B, Horticulture. Vol. LXIV, No. 2, 2020
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

THE INFLUENCE OF SOME BIOPRODUCTS ON THE YIELD AND CHEMICAL COMPOSITION OF THE PEACHES UNDER THE CONDITIONS OF INTEGRATED PLANT PRODUCTION

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Abstract

Studies were carried out in the period 2018-2019 in a fruit-bearing peach orchard on the territory of the Fruit-Growing Institute, Bulgaria. The influence of different fertilizer norms of Lumbreco, Agrifull and Humustim bioproducts on the yield and chemical composition of the 'Glohaven' cultivar grafted on vegetative pad GF677 was studied. The highest yield was obtained after applying Agrifull with an average yield of 32.16 t/ha followed by Lumbreko with 29.64 t/ha. With a yield close to the control plants, the variant is fertilized with Humustim 22.42t/ha. The best results are reported by Brix of 12.7% and 12.0% were established in the variants treated with Lumbreco at all the applied rates and those with Agrifull at the rate of 1 L/da - 12.2%. Sugar content ranged from 4.7% in the untreated control to 10.44% in the variant with the application of Lumbrco soil nutrition. Peaches are rich in K, Mg, P and Ca. Imported bioproducts do not significantly affect the content of the main macro elements. The higher fertilizer norms had a positive effect on the content of N, P and Mg, and the differences with the fertilizer control for the element P and Mg were statistically proven.

Key words*: peach, bioproducts fertilization, yield, macro elements.*

INTRODUCTION

The major problem in integrated production systems is that when mineral fertilization is reduced, it is difficult to maintain the nutrient balance in the soil-plant system, required to produce high yields (Reganold et al., 2001). Chang et al. (2010) announced that the quality and quantity of the fertilizers applied are the key factors affecting growth, yield and fruit quality. However, the long-term use of chemical fertilizers leads to a deterioration of soil characteristics and fertility. The excessive use of inorganic fertilizers creates environmental problems and the situation can be improved by the use of organic products (Von-Bennewitz & Hlousek, 2006; Marzouka, & Kassem, 2011; Liu, C. H. & Liu Y., 2012). Biofertilizers contain useful microorganisms instead of synthetic chemicals, which improve plant growth on the one hand and protect the environment and maintain soil fertility, on the other (Grzyb et al., 2014). Organic fertilization is based on the use of natural products: manure extracts, a fertilizer from red California worms, natural resources rich in biologically active substances, compost derived from wood and paper waste (Edwards & Bohlen, 1996; Leroy et al., 2007). Along with those products, new sources are being sought. Biofertilizers, produced entirely from natural products that do not pollute the environment and the production itself, play a decisive and successful role. There are no harmful residual substances and cause no harm to human health. Despite the growing interest in bioproducts as substitutes for synthetic agrochemicals, knowledge about how the different levels of fertilization affect nutritional components is still limited (Carbonaro et al., 2002).

The aim of the present study was to evaluate the effect of the different rates of the bioproducts (Lumbreco, Agriful and Humustim) on the yield and chemical composition of 'Glohaven' peach fruits in integrated production.

MATERIALS AND METHODS

The study was carried out in 2018-2019 in a fruit-bearing peach plantation on the territory of the Fruit-Growing Institute - Plovdiv,

Bulgaria. The subject of the study was 'Glohaven' cultivar grafted on the vegetative rootstock GF677. The soil was alluvial-meadow with a neutral soil reaction of pH 7.10 and well supplied with phosphorus (22 mg/100 g) and potassium (26 mg/100 g). Planting distance was 5 × 3 m (670 trees/ha).

Agriful was applied to soil as water solution. Two rates of 1.0 and 2.0 L/da were studied. Humustim was used as a foliar fertilizer at three rates of 200, 240 and 300 ml/da. Lumbreco was applied in three variants: **I** – foliar nutrition (1 L/da); **II** – soil application (2 L/da) and **III** – combined foliar nutrition (360 ml/da) + soil application (2 L/da). Each of the variants was in three replications. The control was untreated, without foliar or soil nutrition.

The fertilization rates were introduced four times during vegetation, every 15-20 days from April to July inclusive.

The yield was reported at the fruit maturity stage by replications and variants in kg/tree. Statistical evaluation of the differences between the yields obtained by variants was carried out by Duncan's test. The average samples for chemical analyses were taken randomly at the time of fruit maturity by fertilization variants. The chemical analysis of the fruit flesh included determining the N, P, K, Ca, Mg, Fe contents, the dry matter content - refractometrically by Brix%; sugars - by Schoorl - Regenbogen; the acid content - titrimetrically and the active acidity (pH) - by potentiometric titration.

RESULTS AND DISCUSSIONS

All the bioproducts had a better effect on the yield compared to the untreated control variant. In 2019 the results obtained for the yield in all the three variants of fertilization showed the same tendency, with significantly higher yields compared to 2018.

Data on rainfall and the average, maximum and minimum daily temperatures during the growing season in the years of the study are presented in Figure 1.

Experimental year 2018 was characterized by humid weather, rainfall reaching 480 mm and 34% probability. The year was very hot: the average daily temperature was 20ºC and 2% probability. The maximum temperatures exceeded 35ºC during the second and third decades of July, as well as throughout August, which was not favourable for the peach crop, since that is the period of fruit growth and ripening. Precipitation during the vegetation period of 2019 was 431 mm and the year was characterized as moderately humid and 16% probability. However, with the exception of the heavy rainfall in May, the precipitation probability was 63%. The year was hot: the average daily temperature was 19.6º C and 13.5% probability. The maximum temperatures exceeded 35ºC mainly in the second and third decades of August (Figure 1).

In terms of their climatic characteristics, the years of the study covered a wide enough spectrum, which makes the results representative.

The yields obtained in 2018 after soil and foliar application of Lumbreco showed no statistically significant difference between the two variants and they amounted to 29.5 kg/tree and 28.2 kg/tree, respectively. The highest yield (43 kg/tree) was reported in the variant of combined application of the fertilizer, the differences to the other variants and to the untreated control being statistically significant (Figure 2). In 2019 the highest yield was reported in the variant with soil application of Lumbreco - 71 kg/tree, followed by foliar + soil application - 61 kg/tree, the differences to the control being statistically significant.

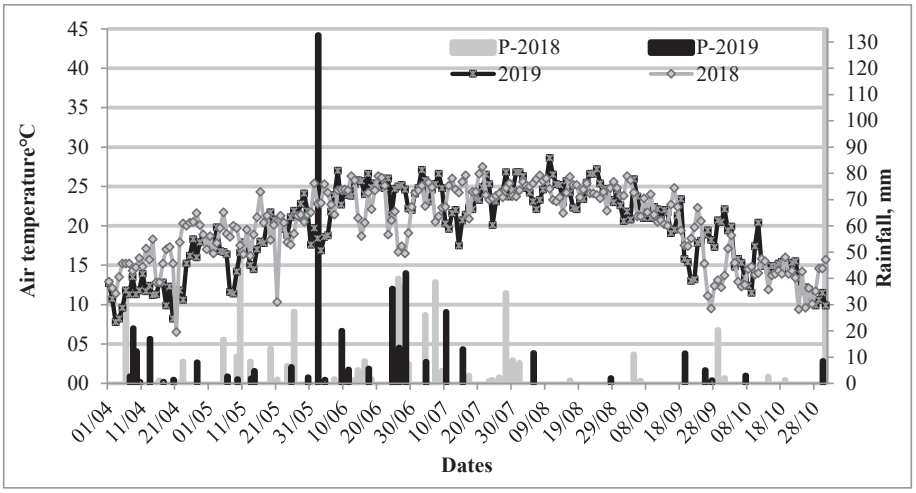

Figure 1. Rainfall and course of the average and the maximum daily temperatures during the vegetation period of 2018 and 2019

The results obtained for the yields are presented in Figures 2, 3 and 4.

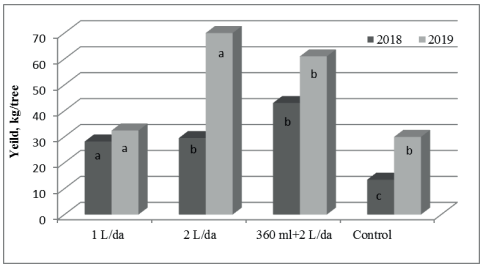

Figure 2. Yield per tree from 'Glohaven' cv. in different variants with application of Lumbreco during the period 2018-2019

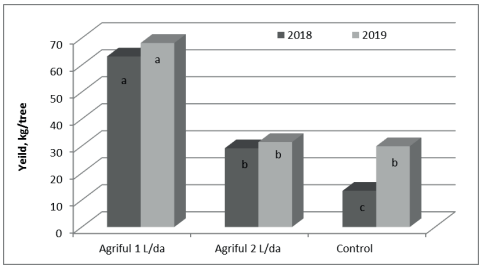

Figure 3. Yield per tree from 'Glohaven' cv. in different variants with application of Agrifull during the period 2018-2019

For Agriful, the rate of 1 L/da showed the best results for both years of the study, the yields being 63 kg/tree (2018) and 68 kg/tree (2019) versus 29 and 31 kg/tree at the rate of 2 L/da. The higher fertilization rate depressed the yields and resulted in a yield comparable with that of the control trees (Figure 3).

The results obtained after the application of Humustim were quite controversial over the two years. In 2018, the lowest fertilization rate of 200 ml/da gave a yield comparable with the control - 14.83 kg/tree. The yields obtained with increasing rates of fertilization also increased, the differences to the control being statistically significant (Figure 4).

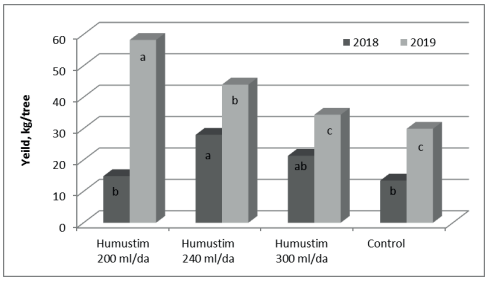

Figure 4. Yield per tree from 'Glohaven' cv. in different variants with application of Humustim during the period 2018-2019

It was not the case in 2019, when by far the highest yield was reported at the rate of 200 ml/da, but with the rate increase the average yield per tree decreased and at the rate of 300

ml/da the yield was 34.4 kg/tree and it was similar to that in the control - 29.93 kg/tree.
The differences between the variants are even more obvious when calculating the average yield per ha. Agriful resulted in the highest average yield of 32.16 t/ha, followed by Lumbreco with 29.64 t/ha. The yield was close to the control plants in the variant treated with Humustim (22.42 t/ha) (Table 1).

Table 1. Average yields of 'Glohaven' cv. after treatment with different bioproducts for the period 2018-2019

Variants	Yeild, t/ha		
	2018	2019	Average yeild, t/ha
Lumbreco	22,48	36,79	29,64 b
Agriful	30,93	33,38	32,16 b
Humustim	14,33	30,51	22,42 a
Control	9,00	20,05	14,53 a

The yields obtained after treatment with Agriful and Lumbreco bioproducts were optimal for the peach crop and can successfully replace the application of chemical fertilizers. The recommended rate of Agriful is 1 L/da and of Lumbreco - soil application of 2 L/da, as well as the combined application (soil + foliar) of the bioproduct.

With regard to the biochemical parameters of the peach fruits, differences were found between the years of the study. In 2018, lower levels of total sugars were observed for all the variants with fertilization. The values were about a unit lower compared to 2019. In 2019 the characteristics Brix, % and total sugars, % were higher in all the treated variants (Table 2). The highest values 12.7% were reported in 2019, when the climatic factors were more favourable for the peach crop. The precipitation sum during the vegetation season was 431 mm, i.e. the year is characterized as average.
More pronounced differences were found between the applied fertilization rates of a given bioproduct than between the bioproducts. Increasing the fertilization rates increased the dry matter content (Brix, %) and the total sugars content. Brix soluble solids content ranged within 8.7% to 12.7%. The best values of 12.7% and 12.0% were reported in the variants treated with Lumbreco at all the rates applied and those with Agriful at a rate of 1 L/da - 12.2%. The sugar content varied from 4.7% in the untreated control to 10.44% in the variant with Lumbreco nutrition. Increasing Lumbreco rates resulted in an increase in total sugars by 2.74%.

Table 2. Biochemical composition of peach fruits of 'Glohaven' cultivar at different treatment variants

Variants/Rate	Lumbreco			Agriful		Humustim			Control
	1 L/da	2 L/da	360 ml+2L/da	1.0 L/da	2.0 L/da	200 ml/da	240 ml/da	300 ml/da	0
2018									
Brix, %	11.40	11.80	11.8	11.4	10.8	8.70	9.60	10.30	8.30
Total sugars, %	6.88	7.08	7.44	6.96	6.60	4.84	5.18	6.60	4.70
Inverted sugar, %	1.68	1.74	2.20	1.80	1.80	1.94	1.54	1.62	0.96
Sucrose, %	4.94	5.07	4.98	4.90	4.56	2.76	3.46	4.73	3.55
Total acids, %	0.42	0.39	0.40	0.49	0.39	0.51	0.42	0.44	0.50
pH	3.82	3.65	3.66	3.48	3.61	3.57	3.54	3.53	3.57
Acidimetritic coefficient	16.36	18.15	18.75	14.08	16.77	9.47	12.42	14.87	9.38
2019									
Brix, %	12.00	12.00	1270	12.2	10.9	11.6	11.2	11.40	10.6
Total sugars, %	8.14	10.44	9.68	8.48	9.04	7.58	8.48	9.74	7.70
Inverted sugar, %	2.20	2.60	2.54	2.54	1.94	1.94	2.00	1.80	2.20
Sucrose, %	5.64	7.45	6.78	5.64	6.75	5.36	6.16	7.30	6.18
Total acids, %	0.42	0.35	0.39	0.43	0.38	0.38	0.42	0.39	0.43
pH	3.70	3.68	3.64	3.79	3.81	3.79	3.62	3.69	3.68
Acidimetritic coefficient	19.21	30.14	24.81	19.54	23.79	19.77	20.33	24.96	17.89

Sucrose is the dominant sugar in peaches. Fruits are characterized by high values of its content. Sucrose values are on average about 2.7 times higher than the values of inverted sugars. The best sucrose values of 7.45% and

6.78% were found in the variants of soil and combined treatment with Lumbreco.

The acid content was not significantly affected by the fertilizers applied. Acids ranged from 0.39% to 0.50% in the different fertilization variants.

The sugar-acid ratio is an indicator that characterizes the taste qualities of fruits. It gives information about the balance between total sugars and acids in them. In the studied variants, the sugar-acid ratio ranged from 9.38 to 30.14. The results showed different tendencies during the years of the study, but the values were optimal in all the variants. In the two experimental years the control plants yielded a sugar-acid ratio that was lower compared to the variants with the application of bioproducts.

Elemental analysis of fruits is not a common practice to estimate the sufficiency of a fertilization programme and the nutritional value of fruit (Basar, 2006). Peach fruits are rich in potassium, magnesium, phosphorus and calcium. The major nutrient found in the mesocarp of peaches is potassium, where it is accumulated with fruit ripening (Tagliavini et al., 2000). Optimal K content leads to a high degree of photosynthesis and translocation of soluble sugars and organic acids, thus improving fruit quality (Crisosto & Costa, 2008).

The results obtained for the chemical composition of the fruits of 'Glohaven' cultivar are presented in Table 3.

Table 3. Concentrations of the elements in the fruit flesh samples of the variants

	Percentage					mg kg^{-1}
Variants	N	P	K	Ca	Mg	Fe
Lumbreco I	0.67 b	0.192 a	1.58 d	0.132 d	0.704 a	69.85 c
Lumbreco II	0.67 b	0.194 a	1.67 c	0.639 a	0.608 b	97.88 a
Lumbreco III	0.99 a	0.112 b	1.84 b	0.256 c	0.578 c	38.96 d
Control	0.66 b	0.062 c	1.96 a	0.400 b	0.305 d	81.25 b
Agriful 1 L/da	0.91 a	0.176 b	1.72 c	0.390 a	0.419 a	73.90 b
Agriful 2 L/da	0.77 b	0.234 a	1.91 b	0.118 c	0.424 a	70.93 c
Control	0.66 c	0.062 c	1.96 a	0.400 a	0.305 b	81.25 a
Humustim 200 ml/da	0.64 c	0.103 b	1.77 b	0.256 d	0.303 c	64.37 c
Humustim 240 ml/da	0.76 b	0.128 a	1.96 a	0.390 c	0.508 a	71.12 b
Humustim 300 ml/da	0.88 a	0.138 a	2.00 a	0.517 a	0.450 b	72.07 b
Control	0.66 c	0.062 c	1.96 a	0.400 b	0.305 c	81.25 a

The results obtained show that the imported bioproducts did not significantly influence the content of the major macro elements. The higher fertilization rates had a positive effect on the nitrogen, phosphorus and magnesium content, the differences to the untreated control being statistically significant for phosphorus and magnesium (Table 3). Potassium and calcium contents in fruits were optimal in all the variants. The opposite tendency was observed for those elements - the application of bioproducts had a negative effect on the content of those elements in the fruit flesh. The control plants had higher values than the treated plants, the differences being statistically significant. Probably that can be explained by the good soil supply with potassium.

CONCLUSIONS

The yields obtained after treatment with Agriful and Lumbreco bioproducts were optimal for the peach crop and the bioproducts can successfully replace the application of chemical fertilizers. The rate of 1 L/da is recommended for Agriful and for Lumbreco - soil treatment at a rate of 2 L/da, as well as a

combined application (soil treatment with 2 L/da + foliar application of 360 ml/da).

The biochemical parameters of peach fruits showed more pronounced differences between the applied fertilization rates of a given bioproduct than between the separate organic products used. The best Brix % values of 12.7% and 12.0% were established in the variants treated with Lumbreco at all the rates applied and those with Agriful - at the rate of 1 L/da - 12.2%.

The bioproducts used (Agriful, Lumbreco and Humustim) did not significantly affect the content of the major macroelements. The higher rates had a positive effect on nitrogen, phosphorus and magnesium contents.

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