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INFLUENCE OF VARIOUS BIO-FERTILIZERS ON THE GROWTH AND FRUITING OF 'ARIWA' APPLE TREES GROWING IN AN ORGANIC ORCHARD

Summary

Insufficient number of bio-fertilizers is one of the major problems in organic fruit production in Poland. The lack of nitrogen fertilizers that can be used in organic orchards is particularly noticeable. The aim of the study was to determine the influence of several organic fertilizers on tree growth and yielding, and fruit quality in the apple cultivar 'Ariwa' grown organically. The study was conducted in 2009-2013 in the Experimental Orchard of the Institute of Horticulture in Dąbrowice (central Poland). An experiment was set up to assess the suitability for organic cultivation of the following bio-fertilizers: Micosat, BF Amin, BF Quality, Humus UP, Humus Active + Aktywit PM, Tytanit, and Vinassa. The fertilizers were compared with the control combination without any fertilization (combination 1). The fertilizers were applied annually, beginning in 2009, twice a year. Most of the tested bio-fertilizers produced a positive effect on the growth and productivity of 'Ariwa' apple trees. Some of them also improved the quality of the fruit. The most promising fertilizers proved to be: Humus UP and Humus Active + Aktywit PM, and also BF Amin, Tytanit, and Vinassa.
Keywords: *organic production, apple trees, bio-fertilizers*

WPŁYW RÓŻNYCH BIO-NAWOZÓW NA WZROST I OWOCOWANIE DRZEW JABŁONI ODMIANY 'ARIWA' ROSNĄCYCH W EKOLOGICZNYM SADZIE

Streszczenie

Niewystarczająca liczba bio-nawozów jest jednym z ważniejszych problemów występujących w ekologicznej produkcji owoców w Polsce. Szczególnie odczuwalny jest brak nawozów azotowych możliwych do zastosowania w ekologicznych sadach. Celem badań było określenie wpływu kilku nawozów organicznych na wzrost, plonowanie drzew i jakość owoców jabłoni odmiany 'Ariwa' uprawianych metodą ekologiczną. Badania przeprowadzono w latach 2009-2013 w Sadzie Doświadczalnym Instytutu Ogrodnictwa w Dąbrowicach (centralna Polska). W doświadczeniu badano przydatność do uprawy ekologicznej następujące bio-nawozy: Micosat, BF Amin, BF Qality, Humus UP, Humus Active + Aktivit PM, Tytanit i Vinassa. Badane nawozy porównano z kombinacją kontrolną bez żadnego nawożenia (kombinacja 1). Nawozy stosowano corocznie, począwszy od 2009 roku, dwa razy w ciągu roku. Większość badanych bio-nawozów miała korzystny wpływ na wzrost i produktywność drzew jabłoni odmiany 'Ariwa'. Niektóre z nich poprawiały również jakość owoców. Najbardziej obiecującymi nawozami okazały się: Humus UP, Humus Active + Aktivit PM oraz BF Amin, Tytanit i Vinassa.
Słowa kluczowe: *ekologiczna produkcja, jabłonie, bio-nawozy*

1. Introduction

The increase in consumer interest in organic food is causing a growing demand for organic agricultural products on the market. Meanwhile, the supply of organic products is still small. In Poland, especially low is the production of organic fruit. This production represents less than 1% of all the fruit produced in this country. In the eco-friendly farming system it is not allowed to use chemical fertilizers, pesticides, growth regulators, and food additives. That is why this method of plant cultivation is very difficult. The main problem in organic fruit growing is the low availability of plant protection products that have been registered and approved for use on organic farms. The result is that the crops produced consist of a high proportion of fruits that are diseased and damaged by pests. Many difficulties also arise in the fertilization of organic plantations, especially the supply of plants in the primary component, which is nitrogen [2]. In particular, there is no possibility of a rapid response to the deficiencies of this component in plant tissues. Undernourished trees grow and bear fruit poorly; they produce small fruits of poor quality. There is an urgent need to develop effective methods of reducing the occurrence of diseases and pests in organic orchards as well as to develop programmes of effective fertilization of organically-grown fruit plants. Therefore, the search is continuing for natural fertilizers and preparations, of inorganic and organic origins, that are safe for people and the environment. The preparations are based on natural extracts from land and sea plants, as well as composts. Extracts from plants often contain beneficial soil microorganisms which can control certain pests and diseases [11]. Bio-preparations are fertilizers which have in their composition one or more biologically active organic compounds such as enzymes, amino acids, plant hormones, or vitamins. Bio-preparations can also contain macro and micronutrients [12]. So far, studies have concentrated on the influence of various bio-fertilizers on fruit trees [1, 8], and in recent years several publications have appeared that describe their effects in nursery production [3, 4, 5].

2. Aim of the study

The aim of the study was to assess the effects of several bio-preparations, used in an organic apple orchard, on the growth and fruiting of young trees of the cultivar 'Ariwa'.

3. Materials and methods

The study was conducted in 2009-2013 in the Experimental Orchard in Dąbrowice near Skierniewice (central Poland) on a podzolic sandy-loam soil with a clay subsoil. Kłosowski [7] has described the soil as loamy sands formed from light and medium boulder-clay. The experiment was conducted on a plot of Class IVa soil of rye and potato complex. The average organic matter content in the soil was 1.3%. The chemical composition of the soil according to Olszewski and Krawiec [10] was as follows:

- 0-20 cm layer: pH 6.62, K – 12.37, P – 7.52, Mg – 5.86,
- 20-40 cm layer: pH 6.18, K – 8.42, P – 4.60, Mg – 5.33.

In the autumn of 2008, the soil was fertilized with manure at a rate of 40 t/ha. The experiment was conducted to assess 10 fertilizer preparations intended for use in organic farming in terms of their effect on the growth and fruiting of apple trees. The preparations used in the experiment were: Fertigo ecological manure, Micosat F12 WP, Micosat F MS 200, Humus UP, Humus Active, Aktywit PM, BF Quality, BF Amin, Tytanit, and Vinassa (Table 1).

The study was conducted on young trees of the cultivar 'Ariwa' grafted on M.26 semi-dwarfing rootstock, planted in the spring of 2009 at a spacing of 4.0 m x 2.5 m. The trees were trained in spindle form. Agrotechnical and plant protection treatments were carried out according to the recommendations for organic farming.

A total of 9 fertilization combinations were assessed. A fertilization combination was represented by 4 replications of two trees each. The control combination for the test fertilizers was represented by plots without any fertilization. Application of the bio-preparations was carried out annually, twice during the growing season – the first time in early May, and the second time in the first ten days of June. The preparations: Fertigo manure, Micosat F12 WP, Humus UP, Humus Active + Aktywit PM, BF Quality, BF Amin, and Vinassa were applied by hand to the soil around the tree trunk within a radius equal to the radius of the tree crown, whereas Tytanit was applied to the leaves. In the combinations with Micosat, BF Quality, BF Amin, Tytanit and Vinassa, the trees were additionally fertilized with granular manure at a dose of 75 g/m^2. The assessment was based on fruit yield per tree, fruit size, and fruit colour.

The results were analyzed statistically using univariate analysis of variance without random blocks. Multiple comparisons of the means for the combinations were performed with the Duncan test at a significance level of $p < 0.05$. Bliss's transformation was applied for fruit size and the surface area of the blush. The tabulated data that do not differ significantly from one another are marked with the same letters.

Table 1. Description of the fertilization combinations used in the experiment
Tab. 1. Opis kombinacji nawozowych zastosowanych w doświadczeniu

No.	Fertilizer	Description	Dosage	Manufacturer
1	None (control)	–	–	–
2	Fertigo manure	natural fertilizer from chicken droppings	150 g/m^2 (1500 kg/ha)	Dutch company Ferm-O-Feed
3	Micosat Micosat F12 WP, Micosat F MS 200	microbial inoculum consisting of mycorrhizal fungi and beneficial bacterial strains	1 g/m^2 (10 kg/ha), 20 g/m^2 (200 kg/ha)	Italian company CCS Aosta Sr
4	Humus UP	organo-mineral product, called soil improver, containing beneficial microorganisms and nutritive humus	soil-applied 2% solution (20 l/ha)	Przedsiębiorstwo Produkcyjno Handlowe Ekodarpol, Dębno, Poland
5	Humus Active + Aktywit PM	Humus Active – organo-mineral product with stable active humus; liquid fertilizer containing a rich population of beneficial microorganisms Aktywit PM – product derived from molasses and compounds accelerating absorption by plants and facilitating water access to the smallest colloidal spaces; the product is used only with preparations containing beneficial microorganisms	soil-applied 2% solution (20 l/ha) soil-applied 1% solution (10 l/ha)	Przedsiębiorstwo Produkcyjno Handlowe Ekodarpol, Dębno, Poland
6	BioFeed Amin	extract of plant amino acids	soil-applied 0.5% solution (5 l/ha)	Dutch company Agro Bio Products B.V. Wageningen
7	BioFeed Quality	seaweed extract containing humic and fulvic acids	soil-applied 0.5% solution (5 l/ha)	Dutch company Agro Bio Products B.V. Wageningen
8	Tytanit	liquid mineral plant-growth stimulator containing titanium available to plants	foliarly-applied 0.5% solution (0,5 l/ha)	Intermag, Poland
9	Vinassa	Organo-mineral fertilizing substance containing NPK derived from molasses, free of sugars	soil-applied 0.5% solution (5 l/ha)	Mazowiecka Fabryka Drożdży, Józefów, Poland

Source: Own work / Źródło: opracowanie własne

Weather characteristics during the study period

The characteristics of the climatic conditions were prepared on the basis of the data collected from an on-site meteorological station in the Experimental Orchard in Dąbrowice, situated near the experimental plots. Table 2 lists the mean annual temperatures and precipitation in Dąbrowice. The weather conditions during the study period were variable. Adverse effects on the growth and fruiting of apple trees were produced by low sub-zero temperatures (in 2010), and spring frosts (2011 and 2012). In 2011, the cold weather and rain occurring at the time of flowering resulted in a lower activity of bees, and consequently in less effective pollination.

4. Results

The most strongly growing trees were those on the plots fertilized with the preparations BF Amin and Tytanit. Relatively strong growth was also exhibited by the trees fertilized with Micosat. The weakest-growing trees were on the non-fertilized plots (control combination). In the first four years of fruiting, the highest amounts of fruit were harvested from the trees fertilized with the humic preparations: Humus UP (7.87 kg/tree) and Humus Active + Aktywit PM (6.26 kg/tree). The lowest-yielding trees were the control trees (with no fertilization), which produced only 3.18 kg of fruit per tree. The trees growing on the plots fertilized with the humic preparations achieved the highest productivity (fruiting efficiency) index, expressed as the size of the fruit yield (kg) per 1 cm^2 of the cross-sectional area of the tree trunk. The values of this index for the remaining trees were similar and did not differ from the productivity index of the control trees. The largest fruits, with an average weight of about 164 g, were collected from the trees fertilized with Humus UP. The weight of fruits from the trees within the other combinations was in the range 143-154 g and did not differ significantly from the weight of the control fruits (141 g). Among the fruits harvested from the trees fertilized with Vinassa, Humus UP and manure, the highest proportion consisted of the fruits with a diameter greater than 7 cm. The preparations tested were not found to have an effect on fruit colour (Table 3).

5. Discussion

There are numerous reports in the literature demonstrating that some preparations of a biological origin have a positive influence on the growth and fruiting of cultivated plants. These preparations are, therefore, increasingly being used in organic farming, in which the use of chemical fertilizers is not permitted. Khan et al. [6] report that extracts from seaweed protect plants against biotic stresses (pathogens, weeds, pests) and abiotic stresses (drought, salinity, temperature), and can also improve the physical, chemical and biological properties of the soil by, for example, maintaining the right moisture levels, or supporting the development of beneficial soil microorganisms. Seaweed extracts can also improve nutrient uptake by the roots [2]. According to Wójcik [13], Tytanit, whose main component is titanium, also has a beneficial effect on plant growth and an increase in mineral uptake. Our findings are partly consistent with the results of the authors cited. The preparation BF Amin, which is an extract of plant amino acids, and Tytanit had a positive influence on the growth and development of 'Ariwa' apple trees growing under organic orchard conditions.

Table 2. Characteristics of the climatic conditions in the Experimental Orchard. Mean annual temperatures and precipitation in Dąbrowice, 2009-2013
Tab. 2. Średnie roczne temperatury i opady w Dąbrowicach, w latach 2009-2013

Year	Temperature [°C]			Precipitation [mm]		
	Minimum	Maximum	Mean	Total	Daily maximum	Maximum
2009	-23.03	31.44	8.12	594.2	25.4	9.8
2010	-28.07	34.32	7.10	556.4	34.4	14.8
2011	-22.32	31.31	8.53	529.4	49.0	12.8
2012	-24.85	34.56	8.39	391.8	25.4	10.0
2013	-21.38	37.81	8.10	422.8	34.8	13.94

Source: Own work / Źródło: opracowanie własne

Table 3. Tree size, fruit yield and fruit quality of the apple cultivar 'Ariwa' grown in the Ecological Experimental Orchard in Dąbrowice as influenced by the bio-preparations applied
Tab. 3. Wielkość drzew i plon oraz jakość owoców odmiany 'Ariwa' rosnącej w Ekologicznym Sadzie Doświadczalnym w Dąbrowicach w zależności od zastosowanych biopreparatów

No.	Fertilizer	TCSA* [cm^2]	Yield [kg/tree]		Productivity index [kg/cm^2]	Weight of 100 fruits [kg]	Fruits with dia.>7cm [%]	Fruits with blush area> 50% [%]
			2013	2009-2013				
1.	None (control)	9.57 a	1.26 a	3.18 ab	0.34 a	16.03 d	33.31 ab	100 a
2.	Fertigo manure	11.42 ac	0.58 a	4.09 abc	0.35 a	14.32 ab	34.07 b	100 a
3.	Micosat	15.00 bc	2.07 a	6.98 cd	0.48 ab	15.16 abc	33.08 ab	100 a
4.	Humus UP	13.07 abc	3.08 a	7.87 d	0.69 b	16.43 d	34.67 b	100 a
5.	Humus Active + Aktywit PM	9.67 a	2.66 a	6.26 bcd	0.67 b	15.18 abc	32.67 a	100 a
6.	BF Quality	14.37 abc	1.38 a	4.33 abcd	0.33 a	15.38 bc	31.25 a	100 a
7.	BF Amin	17.52 b	1.43 a	5.48 abcd	0.32 a	15.12 abc	32.08 a	100 a
8.	Tytanit	17.20 b	1.44 a	5.58 abcd	0.33 a	15.02 ab	31.85 a	100 a
9.	Vinassa	12.97 abc	1.09 a	4.98 abcd	0.38 ab	15.18 abc	35.21 c	100 a

***** *trunk cross-sectional area / ***- *pole poprzecznego przekroju pnia*

Source: Own work / Źródło: opracowanie własne

Nardi et al. [9] had found a positive effect of humic substances on the chlorophyll content of the leaves, and thereby on the intensity of photosynthesis. In practice, this action translated itself into higher yields. The results of our experiment confirm that effect. The highest amounts of 'Ariwa' apples were collected on those plots on which the trees were fertilized with the humic preparations (Humus UP, and a mixture of Humus Active + Aktywit PM). The quality of the fruit was favourably affected by the preparation Vinassa. There is very little information in the literature on this bio-preparation. In a nursery of rootstocks and maiden trees, it has been found to produce positive effects on the growth of rootstocks and young fruit trees [4, 5].

6. Conclusions

1. Preparations BF Amin and Tytanit improved tree growth.
2. Humic preparations Humus UP and Humus Active + Aktywit PM increased fruit yield.
3. Vinassa had the best effect on fruit quality.

7. References

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This work was funded by a grant from the European Regional Development Fund under the Operational Programme Innovative Economy, Agreement number: UDA - POIG.01.03.01-10-109/08-00.