Elżbieta ROZPARA, Marcin PĄŚKO, Paweł BIELICKI, Lidia SAS PASZT, Agnieszka GŁOWACKA
Research Institute of Horticulture
ul. Konstytucji 3 Maja 1/3, 96-100 Skierniewice, Poland
e-mail: elzbieta.rozpara@inhort.pl

THE INFLUENCE OF SOME BIO-PRODUCTS ON THE GROWTH, YIELDING AND FRUIT QUALITY OF 'DEBRECENI BÖTERMÖ' SOUR CHERRY TREES CULTIVATED IN AN ORGANIC ORCHARD

Summary

Ecological fruit production in Poland is limited by, among other things, a shortage of biological preparations for the protection of fruit trees and shrubs from diseases and pests as well as a lack of bio-fertilizers needed to supplement periodic nutrient deficiencies, especially of nitrogen. In the present study, the effectiveness of several bio-fertilizers was assessed under the conditions of an organic sour cherry orchard. The products taking part in the assessment included: 'Fertigo' ecological manure, Micosat F12 WP, Micosat F MS 200, Humus UP, Humus Active, Aktywit PM, BF Quality, BF Amin, Tytanit, and Vinassa. The influence of the applied fertilizers on the growth of sour cherry trees of the cultivar 'Debreceni Bötermö', their fruiting and the quality of the harvested fruit was assessed. The experiment was conducted within the Eko-TechProdukt Project being implemented in 2009-2014 at the Research Institute of Horticulture in Skierniewice. The experimental trees, grafted on mahaleb cherry seedlings, were planted in the spring of 2009 at a spacing 4.0 x 2.5 m, and were fertilized every year with the fertilizers listed above. The study has shown a beneficial effect of the preparation Vinassa on the growth and fruiting of sour cherry trees.
***Key words**: ecological fruit production, sour cherry, bio-fertilizers*

WPŁYW KILKU BIOPREPARATÓW NA WZROST I OWOCOWANIE DRZEW ORAZ JAKOŚĆ OWOCÓW WIŚNI ODMIANY 'DEBRECENI BÖTERMÖ' W SADZIE EKOLOGICZNYM

Streszczenie

Produkcję owoców metodami ekologicznymi w Polsce ogranicza m.in. niedostatek środków produkcji, a zwłaszcza preparatów do ochrony roślin przed groźnymi chorobami i szkodnikami oraz bionawozów, niezbędnych do szybkiego uzupełnienia deficytu składników pokarmowych występującego często w sadach ekologicznych, a zwłaszcza deficytu azotu. W prezentowanych badaniach oceniano skuteczność kilku nowych bionawozów w odżywianiu roślin w ekologicznym sadzie wiśniowym. Przedmiotem badań były następujące bionawozy: Fertigo'(ekologiczny obornik), Micosat F12 WP, Micosat F MS 200, Humus UP, Humus Active, Aktywit PM, BF Quality, BF Amin, Tytanit i Vinassa. Badano ich wpływ na wzrost i rozwój drzewek wiśni odmiany 'Debreceni Bötermö', na wielkość plonów i jakość zbieranych owoców. Badania były prowadzone w latach 2009-2014 w Instytucie Ogrodnictwa w Skierniewicach w ramach projektu pt."Opracowanie innowacyjnych produktów i technologii dla ekologicznej uprawy roślin sadowniczych" (akronim EKOTECHPRODUKT). Projekt ten był współfinansowany przez Unię Europejską z Europejskiego Funduszu Rozwoju Regionalnego w ramach Programu Operacyjnego Innowacyjna Gospodarka, Umowa nr UDA-POIG.01.03.01-10-109/08-00. Drzewa szczepione na siewkach antypki posadzono wiosną 2009 roku w rozstawie 4x2,5 m i nawożono wymienionymi wyżej preparatami. Badania wykazały przydatność preparatu Vinassa w ekologicznej uprawie wiśni. Preparat ten miał korzystny wpływ na wzrost i owocowanie drzew.
***Słowa kluczowe**: ekologiczna produkcja owoców, wiśnia, bionawozy*

1. Introduction

The sour cherry is one of the most important fruit species in Poland. In terms of fruit production, it ranks second among fruit trees, behind the apple. With an annual production of sour cherries at a level of 170-200 thousand tonnes, Poland occupies a leading position among producers of this fruit in the world [13]. The main sour cherry variety grown in Poland is 'Łutówka' ('English Morello'). In commercial sour cherry orchards, it makes up about 80% of the trees [5, 7, 8, 9, 12, 18]. Among the advantages of 'Łutówka' as a commercial variety is a low tree-growth vigour, early coming into fruiting, and very high productivity. A disadvantage of this variety is high susceptibility of the trees to cherry leaf spot [4, 6]. For this reason, 'Łutówka' is not grown in organic orchards. Useful varieties for organic cultivation are those that are little susceptible to this disease, e.g. 'Kerezer' and its derivatives. Organic production of sour cherries in Poland is developing very slowly, and the reason for this is an insufficient number of biological preparations for eco-friendly protection of trees against diseases and pests, and of bio-fertilizers needed to supplement periodic deficiencies in nutrients, especially in nitrogen. These difficulties are the reason why the share of organically-grown sour cherries in the total production of this fruit in Poland amounts to a very small percentage. In order to increase the supply of organic sour cherries on the market, it is necessary to introduce into organic orchards sour cherry genotypes with low susceptibility to diseases and extend the range of plant protection products and bio-fertilizers permissible for use in organic orchards.

2. Aim of the study

The aim of this study was to assess the effect of fertilizing trees with new biopreparations on the growth, fruiting, and quality of sour cherry fruit of the cultivar 'Debreceni Bötermö' under organic orchard conditions.

3. Materials and methods

The study was conducted in 2009-2013 in the Experimental Orchard in Dąbrowice near Skierniewice (central Poland). One-year-old maiden trees of the sour cherry cultivar 'Debreceni Bötermö', grafted on mahaleb cherry seedlings, were planted in the spring of 2009 on a sandy-loam podsolic soil with a loamy subsoil. Kłosowski [14] has described this soil as loamy sands formed from light and medium boulder clay. The experimental plots were located on Class IVb soil of rye and potato complex. The average organic matter content of that soil was 1.3%.

The chemical composition of the soil 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 [15].

In the autumn of 2008, before establishing the orchard, the soil was fertilized with manure at a rate of 40 t/ha. The trees were planted in the spring of 2009 at a spacing 4.0 m x 2.5 m and were trained in spindle form by performing annually, after the fruit harvest, sanitary and formative pruning. Treatments related to the care and protection of plants were carried out in accordance with the recommendations for organic farming. For the first two years after planting, the soil over the entire area of the orchard was maintained as mechanical black fallow. In the third year, grass cover was introduced in the inter-rows, which in subsequent years was mowed several times a season. Weeds in the rows of trees were destroyed mechanically.

Beginning from the year 2010, the trees were fertilized with the following fertilizers: Fertigo ecological manure, Micosat F12 WP, Micosat F MS 200, Humus UP, Humus Active, Aktywit PM, BF Quality, BF Amin, Tytanit, and Vinassa. These fertilizers were applied annually in the spring. The description of the fertilizers and their doses are given in Table 1. One fertilization combination consisted of 8 trees that had been randomly selected for the experiment, in four replications, with two trees per plot. There were two control combinations: one consisting of trees growing on non-fertilized plots, and the other with trees fertilized with nitrogen fertilizers recommended in integrated fruit production. The fertilizers were applied annually twice: in early May and in mid-June. Nitrogen fertilizer (combination 2), Fertigo manure, Micosat F12 WP, Humus UP, Humus Active + Aktywit PM, BF Quality, BF Amin, and Vinassa were applied to the soil by hand, by spreading around the tree trunk over an area with a radius equal to that of the crown. Tytanit was applied to the leaves. In those combinations in which Micosat, BF Quality, BF Amin, Tytanit, and Vinassa were applied, the trees were additionally fertilized with granulated manure at 75 g/m^2.

3.1. Measurements and observations

Tree growth vigour was assessed by measuring the thickness of the trunk, which was carried out in the autumn after completion of growth, in a permanently marked place and without deformations. On the basis of these measurements, the cross-sectional area of the tree trunk was calculated. Fruit yield [kg] was recorded annually, separately for each tree.

Table 1. Description of the experimental combinations and the bio-fertilizers used
Tab. 1. Opis kombinacji doświadczalnych i badanych bionawozów

No.	Fertilization combination	Description of bio-fertilizer and annual dose per ha	Manufacturer
1	Control combination 1 – no fertilization	–	–
2	Control combination 2 – NPK fertilization	N – 100 kg/ha	–
3	Fertigo manure	natural fertilizer from chicken droppings Dose: 1500 kg/ha	Ferm-O-Feed Holland
4	Micosat	contains microbial inocula of mycorrhizal fungi and beneficial bacterial strains Dose: 10 kg/ha	CCS Aosta Sr Italy
5	Humus UP	organo-mineral product containing beneficial microorganisms and nutritive humus Dose: 20 l/ha	Przedsiębiorstwo Produkcyjno Handlowe Ekodarpol, Dębno, Poland
6	Humus Active [1] + Aktywit PM [2]	[1] organo-mineral product with stable active humus and a rich population of beneficial microorganisms Dose: 20 l/ha [2] product derived from molasses and compounds accelerating absorption by plants and facilitating water access to the smallest colloidal spaces; used only with preparations containing beneficial microorganisms Dose: 10 l/ha	Przedsiębiorstwo Produkcyjno Handlowe Ekodarpol, Dębno, Poland
7	BioFeed Quality	seaweed extract containing humic and fulvic acids Dose: 5 l/ha	Agro Bio Products B.V. Holland
8	BioFeed Amin	extract of plant amino acids Dose: 5 l/ha	Agro Bio Products B.V. Holland
9	Tytanit	liquid mineral plant-growth stimulator containing titanium available to plants Dose: 5 l/ha	Intermag, Poland
10	Vinassa	organo-mineral fertilizing substance containing NPK derived from molasses, free of sugars Dose: 5 l/ha	Mazowiecka Fabryka Drożdży, Józefów, Poland

Source: own work / Źródło: opracowanie własne

After the completion of the experiment, the fruiting efficiency index (in kg/cm^2) was calculated by dividing the total weight of the fruit harvested by the trunk cross-sectional area.

Mean fruit weight was calculated on the basis of a 4 kg sample taken from each experimental combination. Fruits from the same sample were then used to measure the soluble solids content by means of an Atago PAL-3 refractometer.

The results were analyzed statistically using univariate analysis of variance. Multiple comparisons of the means for the combinations were performed using Duncan's test at a significance level of $p < 0.05$. The results for the soluble solids content were transformed with the Bliss formula. In the tables, the data that do not differ significantly from one another are marked with the same letters.

3.2. 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 sour cherry 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 results are presented in Table 3. The strongest growth was shown by those sour cherry trees of the cultivar 'Debreceni Bötermö' that were fertilized in a traditional way with synthetic fertilizers (control combination 2 – NPK). The cross-sectional area of the trunk of those trees was significantly larger than in the other combinations. In 2013, the highest fruit yield was obtained from sour cherry trees in the combination in which Vinassa was applied; the same was in the case of the total yield for the 5-year period. In all the experimental combinations, fruiting was very poor, but on the trees treated with the biopreparation Vinassa it was significantly higher. Also, tree productivity, expressed by the fruiting efficiency index, was significantly higher for this bio-fertilizer. In the case of the weight of a single fruit there were significant differences between the combinations. The highest mean fruit weight was obtained for the trees growing in the combination with Vinassa and Humus UP. Also the fruit of the trees which were subjected to NPK fertilization and of those treated with Tytanit weighed, on average, significantly more than the fruit of the trees in the other combinations. There was no major impact of the individual biopreparations on the soluble solids content in sour cherry fruit.

Table 2. Characteristics of the climatic conditions in the Experimental Orchard in Dąbrowice, 2009-2013. Mean annual temperatures and precipitation

Tab. 2. Charakterystyka warunków klimatycznych w Sadzie Doświadczalnym w Dąbrowicach, w okresie prowadzenia badań. Średnie roczne temperatury i opady atmosferyczne

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 and fruit yield and quality of 'Debreceni Bötermö' sour cherry trees growing in ecological orchard depending on the applied biopreparations

Tab. 3. Wielkość drzew, plonowanie i jakość owoców wiśni odmiany 'Debreceni Bötermö' w ekologicznym sadzie w zależności od zastosowanego nawożenia

No.	Fertilization combination	TCSA* [cm^2]	Fruit yield [kg/tree]		Productivity index [kg/cm^2]	Mean fruit weight [g]	Soluble solids [%Brix]
			2013	2009-2013			
1	Control combination 1 – no fertilization	16.38 a	1.81 a	4.00 a	0.23 a	5.37 ab	15.30 a
2	Control combination 2 – NPK fertilization	22.78 b	1.83 a	4.14 a	0.18 a	5.63 c	15.56 a
3	Fertigo manure	15.65 a	1.66 a	3.92 a	0.24 a	5.33 a	15.56 a
4	Micosat	17.20 ab	2.31 a	5.12 ab	0.30 a	5.40 ab	15.55 a
5	Humus UP	15.23 a	2.56 ab	5.44 ab	0.36 a	5.78 d	15.90 a
6	Humus Active + Aktywit PM	17.33 ab	1.48 a	3.22 a	0.20 a	5.45 abc	15.44 a
7	BF Quality	14.70 a	2.25 ab	5.00 ab	0.34 a	5.53 bc	15.25 a
8	BF Amin	15.78 a	2.38 ab	5.08 ab	0.32 a	5.48 abc	15.25 a
9	Tytanit	16.48 a	2.23 ab	4.74 ab	0.29 a	5.60 c	15.53 a
10	Vinassa	12.50 a	3.13 b	6.76 b	0.54 b	5.80 d	15.63 a

*trunk cross-sectional area

Source: own work / Źródło: opracowanie własne

5. Discussion

The study has shown that the majority of the tested biopreparations had no major impact on the growth and fruiting of sour cherry trees of the cultivar 'Debreceni Bötermö'. Only the trees that were subjected to NPK fertilization grew considerably better. This is due to the fact that mineral fertilizers contain macroelements that are essential for the proper development of plants. Mineral fertilization is a treatment that compensates for any deficiencies in soil components and also satisfies the nutritional needs of plants [17]. Of the three macroelements (NPK), fruit trees take up the most nitrogen, less potassium and even less phosphorus [19]. It is nitrogen that is the basic building component of living cells. It promotes shoot growth, fruit yield, and fruiting regularity in fruit plants [21]. In the case of fruit yield and fruiting, our study has shown that the nitrogen in the mineral (NPK) fertilizer had no effect on these characteristics. A statement has been found in the literature which says that fruiting and yielding of trees and their growth depend to a greater extent on soil maintenance and proper agrotechnical treatments than on nitrogen fertilization [3]. The bio-fertilizer Vinassa was the only biopreparation that had a significant effect on higher yields of sour cherry trees, as well as on fruit weight. There are a few authors who have emphasized the beneficial effects of the preparation Vinassa on the development of the root system and the formation of other morphological parts of the treated plants [1, 2, 10, 11]. This product also affected fruit size and fruit weight. Apart from Vinassa, Humus UP also had a positive effect on these characteristics. Humic biopreparations are considered to be fertilizers that improve soil fertility by increasing the humus content of the soil and the presence of microorganisms in it [16, 20]. Our study demonstrates that it is necessary to search and test various products that can be used in organic orchards. Such studies should take several years because not only the biopreparations can affect the growth and fruiting of trees, but the weather pattern during the trials is very important too.

6. Conclusions

1. Most of the tested biopreparations had no major effect on the growth and fruiting of sour cherry trees of the cultivar 'Debreceni Bötermö'.
2. NPK fertilization resulted in better tree growth.
3. The greatest influence on fruiting and fruit yield was exerted by the preparation Vinassa.
4. The greatest influence on mean fruit weight was exerted by Humus UP and Vinassa.

7. References

[1] Chelariu E.L., Ionel A.: Results regarding the influence of fertilization with Vinassa Rompak upon the crop yield at Sante potato species 4th International Symp. Bul. USAMV Cluj-Napoca. Seria Agricultura, 2005, 61: 408.

[2] Chelariu E.L., Draghia L., Bireescu G., Bireescu L., Branza M.: Research regarding the influence of Vinassa fertilization on *Gomphrena globosa* species. Lucr. stintifice Ed. Ionescu de la Brad, lasi USAMV Seria Horticultura, 2009, 52: 615-620.

[3] Filipczak J., Olszewski T.: Różne spojrzenia na nawożenie azotem sadów jabłoniowych. Zeszyty Naukowe Instytutu Sadownictwa i Kwiaciarstwa, 2005, 13: 5-15.

[4] Głowacka A., Rozpara E.: Charakterystyka wzrostu i owocowania nowych, niemieckich odmian wiśni w warunkach klimatycznych centralnej Polski. Zeszyty Naukowe Instytutu Sadownictwa i Kwiaciarstwa, 2010, 18: 15-24.

[5] Grzyb Z.S.: Aktualny stan i perspektywy rozwoju oraz modele sadów wiśniowych i czereśniowych w Polsce na tle produkcji europejskiej. Konferencja – Nowoczesna technologia uprawy wiśni i czereśni. ISK Skierniewice, 6 czerwca 1995, 3-6.

[6] Grzyb Z.S: Wiśnie. Pomologia – aneks. Praca zbiorowa pod red. E. Żurawicza. Warszawa: PWRiL, 2003.

[7] Grzyb Z.S., Rozpara E.: Wiśnia. Zeszyty Pomologiczne. ISK Skierniewice, 1998, 35.

[8] Grzyb Z.S., Rozpara E.: Wiśnie. Warszawa: Hortpress, Sp. z o.o., 2009, 176.

[9] Grzyb Z.S., Piotrowski W., Bielicki P., Sas Paszt L.: Quality of apple maidens as influenced by the frequency of application of different fertilizers in the organic nursery – preliminary results. J. Fruit Ornam. Plant Res., 2012, 20(2): 41-49. DOI: 10.2478/v10290-012-0014-8.

[10] Grzyb Z.S., Piotrowski W., Sas Paszt L., Pąśko M.: Badania wstępne nad wpływem rożnych biopreparatów na zmiany odczynu i zawartość składników w glebie i liściach okulantów jabłoni i wiśni. Journal of Research and Applications in Agricultural Engineering, 2013, 58(3): 198-203.

[11] Grzyb Z.S., Piotrowski W., Bielicki P., Sas Paszt L., Malusà E.: Effect of different fertilizers and amendments on the growth of apple and sour cherry rootstocks in an organic nursery. Journal of Fruit and Ornamental Plant Research, 2012, 20(1): 43-53. DOI: 10.2478/v10290-012-0004-x.

[12] Jaroszewska A., Podsiadło C., Kowalewska R.: Analiza wykorzystania wody przez wiśnię, w różnych warunkach wodnych i nawozowych. Infrastruktura i Ekologia Terenów Wiejskich, 2011, 6: 165-173.

[13] Jadczuk-Tobjasz E., Bednarski R.: Wstępna ocena wzrostu i owocowania dziesięciu odmian wiśni. Zeszyty Naukowe Instytutu Sadownictwa i Kwiaciarstwa, 2007, 15: 17-27.

[14] Kłossowski W.: Analiza chemiczna gleby i liści jako metody badań potrzeb nawożenia jabłoni. Praca doktorska, Skierniewice, 1964.

[15] Olszewski T., Krawiec A.: Zmiany zawartości przyswajalnych form potasu i fosforu w glebie pod wpływem zróżnicowanego nawożenia NPK. XLVI Ogólnopolska Naukowa Konferencja Sadownicza „Nauka Praktyce". Skierniewice, 29-30 września 2010, 151.

[16] Piccolo A., Nardi S., Concheri G.: Structural characteristics of humus and biological activity. Soil Biol. Biochem., 1992, 24: 273-380.

[17] Podsiadło C., Meller E.: Wpływ mikronawadniania i nawożenia mineralnego na plonowanie wiśni oraz wybrane właściwości chemiczne gleby. Infrastruktura i Ekologia Terenów Wiejskich, 2013, 1/II: 89-96.

[18] Rozpara E.: Strategia dalszej intensyfikacji uprawy czereśni i wiśni w Polsce, X Ogólnopolskie Spotkanie Sadowników w Grójcu, ISK Skierniewice, 19-20 stycznia 2005, 115-120.

[19] Sadowski A., Ścibisz K.: Racjonalne nawożenie upraw sadowniczych. Prace Instytutu Sadownictwa i Kwiaciarstwa, 1992, 3-4: 24-28.

[20] Van Trump J.I., Sun Y., Coates J.D.: Microbial interactions with humic substances. Advances Appl. Microbiol., 2006, 60: 55-96.

[21] Wrona D., Wzrost, owocowanie i zawartość N w liściach jabłoni 'Jonagored' w zależności od jesiennego nawożenia azotem i podkładki. Acta Sci. Pol., Hortorum Cultus, 2004, 3(2), 153-160.

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