Effect of some organic fertilizers and amendments on the quality of maiden trees of two apple cultivars

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Abstract

Production of organic maiden trees is considered difficult due to the high needs of nutrients required to obtain trees of good horticultural quality. In the framework of the EU-funded research project 'Development of innovative products and technologies for organic fruit production a specific work package is devoted to the development of methods of nursery production. Maiden trees of apple cultivars 'Topaz' and 'Ariwa' grafted on M26 rootstocks were produced with the use of a vegetal amino-acids *(BF Amin), a consortium of mycorrhizal fungi and plant growth promotion rhizobacteria (Micosat F12WP and Micosat FMS 200), and their quality was compared to plant grown with organic animal manure standard NPK or without fertilization.*

The application of BF Amin resulted in the highest trunk thickness and tree height for both cultivars. The product induced also an increase of the branching of the maidens and of the length of lateral shoots. Micosat also positively influenced the branching of the maidens in comparison to control and NPK treatments, but to a lower extent with respect to BF Amin. The two new biofertilizers seem to provide the plants with an adequate nutrient supply and could be utilized successfully for the application in organic apple nurseries.

Keywords: organic nursery, bioproducts application, apple maidens quality

Introduction

Fruit-growers have noticed that the quality of maiden trees has a decisive effect on their growth and fruiting during the first years in a newly-established orchard (Mika *et al*. 2003; Gudarowska and Szewczuk, 2004; Wociór and Kaplan 2005). It has been proven that each millimetre of increase in the trunk diameter of a maiden tree in the nursery results in a specific increase in the yield of the young tree in the orchard (Wociór and Kaplan 2005), which can result in an considerable increment of production per hectar. Therefore, fruit growers are looking for well developed maiden trees, with a suitably shaped, well branched crown (Shepherd 1979; Bielicki *et al*. 2002; Jaumień *et al*. 2004;).

Maiden trees that are not well fertilized in the nursery do not form lateral branches, or if they do, only very short ones. To stimulate the growth of maiden trees, many different mineral fertilizers with high nitrogen content can be used in conventional nurseries (Janisz *et al*. 2002; Wójcik 2003, 2009). In organically certified ones, however, the management of nitrogen nutrition is more difficult due to the restrictions deriving from either the EU legislation or International standards of organic production (Sas Paszt *et al*. 2010). Such difficulty is underlined by the possibility of planting organic fruit orchards with plants obtained in derogation to the EU regulations. In the framework of the EU-funded research project 'The development of innovative products and technologies for organic fruit production' a work package is devoted to the development of organic methods of fruit trees production. The aim of the research is to develop a nursery model suitable for commercial production of organic fruit trees.

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Conducting basic research with manual application of innovative products and determining their biological effectiveness (Grzyb *et al*. 2010).

The present paper reports the results of a trial established to evaluate the quality of maiden apple trees produced by applying various fertilizers and amendments.

Materials and methods

The study was conducted during the seasons 2009-2010 in an experimental nursery located in Mokra Lewa near Skierniewice, Poland. The experiment was set up in a randomized block design with four replications of ten plants for each treatment. In the first year, M26 apple rootstocks were planted and treated with the different products (see below), and in the second year the same applications were made on maiden trees after grafting in first year, the rootstocks with buds of the apple cultivars 'Topaz' and 'Ariwa'. The following fertilization treatments were applied:

1 Micosat (CCS Aosta Srl), a microbial consortium formed of mycorrhizal fungi and plant growth promoting rhizobacteria; two formulations were utilized during each season: 'Micosat F12 WP', applied during the first application period to the soil in granular form at a dose of 10 g m^2, (100 kg ha^{-1}) and 'Micosat F MS 200' applied during the second period to the leaves at a dose of 1 g m^2 (10 kg ha^{-1});
2 'BioFeed Amin' (Agro Bio Products B.V.), an vegetal amino-acids, applied to the soil at a concentration of 0.5% (0,05ml/m^2) (5 l ha^{-1}).

The treatments were compared to a control not receiving any fertilization (No fertilization) and to a standard fertilization with either an organic or a conventional fertilizer: 'Fertigo' (Ferm-O-Feed), granulated manure at a dose of 150 g m^2 (1500 kg ha^{-1}); NPK, at a dose of N – 60 kg ha^{-1}, P – 30 kg ha^{-1}, and K – 80 kg ha^{-1} (it is 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).

The soil with the plants treated with Micosat and BF Amin, before the application of these products, was scattered on the surface with half dose of granulated manure (i.e. 75 g m^2) All the preparations were applied to the soil twice: in the rootstock nursery in mid-May and again in mid-June, and in the nursery of maiden trees – in late April / early May and the second time in the first 10 days of June. After the application of the preparations, the soil around the plants was always thoroughly mixed with hoes by hands.

In autumn, before digging up the trees, the following parameters were measured: trunk diameter at a height of 30 cm above ground, tree height, the number of branched trees, the length and number of lateral shoots longer than 5 cm.

The data were analyzed statistically by ANOVA. Means were compared with Tukey's test at a significance level of $p < 0.05$. The percentage of branched trees was standardized using Bliss' transformation. In the tables, the data that do not differ significantly are marked with the same letters.

Results and discussion

The treatment of 'Topaz' maiden apple trees with Micosat and BF Amin significantly increased the trunk diameter in comparison to all controls (Zero fertilization, NPK and Manure) (Tab. 1A). No differences of the trees height between plants treated with Micosat and BF Amin and those receiving NPK and Manure were found (Tab. 1A). However, all the treatments induced a higher height in comparison to the zero fertilization treatment.

In view of what other authors have said about the effect of the quality of maiden trees on their subsequent fruiting in the orchard, the biopreparations BF Amin can be recognized as a product contributing to the production of high quality trees (Słowiński and Sadowski, 2000; Bielicki *et al*. 2002; Gudarowska and Szewczuk, 2004).

Maiden apple trees cv. 'Topaz' were in most cases branched, irrespective of the treatment applied (Tab. 1A). However, even though the analysis did not show statistical differences between treatments and the controls, the maidens treated with BF Amin and Micosat had a greater tendency towards better branching than the others. This also emerges from the analysis of the number of lateral shoots: trees treated with Micosat and BF Amin had almost twice the number of lateral shoots in comparison to zero fertilization and about 50% more than in trees fertilized with NPK or Manure. Furthermore, trees that had not been fertilized at all had only few, usually short lateral shoots, which resulted in a total length of about 30% in comparison to the fertilized trees. By contrast, Micosat, and especially BF Amin, significantly increased the number of shoots in the crown of the maidens in comparison to both kind of fertilizers (NPK and Manure) with a total length which was the same as of these two latter treatments (Tab 1A). Considering these two parameters together, even though we have not measured the diameter of the lateral shoots, we noticed that their size in trees receiving Micosat and BF Amin was higher than those of NPK and Manure treated plants. Considering the results obtained with the cultivar 'Ariwa', the type of fertilization did not have a major impact on the diameter of the maiden trees (Tab. 1B). Nevertheless, BF Amin induced an increase in their height. Similarly to 'Topaz', both Micosat and BF Amin induced a branching on a higher number of trees in comparison to the other treatments, though not statistically significant. BF Amin also significantly stimulated the branching and shoot development of the maiden trees of this apple cultivar. A similar effect, albeit on a slightly smaller scale, was also observed in the plants treated in the nursery with the preparation Micosat.

Several authors have studied the effect of the quality of maiden trees on their subsequent fruiting in the orchard (Słowiński and Sadowski 2000; Bielicki et al. 2002; Gudarowska and Szewczuk, 2004; Wociór and Kapłan, 2005). A well formed plant with branches of good size and length, as well as with an adequate diameter of the main shoot are assuring an early formation of the tree canopy and early yield. The results obtained with both the organic fertilizer (BF Amin) and the amendment (Micosat) used in this study, have shown that these products can allow to produce trees for both cultivars that meet the quality requirements for high-quality maiden trees, as specified by other authors involved in the production of trees in nurseries by conventional methods (Bielicki *et al*. 2002; Mika *et al*. 2003; Sadowski and Górski, 2005).

In assessing these results, it shall be considered that the amount of nutrients provided with the organic treatments is far below that applied with the chemical fertilizer (Tab 1). An vegetal amino-acids extracts are known to contain nutrients in organic forms that are much readily utilized by the plants (Sas *et al.* 2009), thus enhancing the efficiency of physiological processes and reducing the energetic need for the normal plant metabolism (Malusà *et al*. 2010). On the other hand, both arbuscular mycorrhizal fungi and PGPR are recognized to beneficially affect nutrient uptake of plants through several different mechanisms (Malusà *et al.* 2007; Bardi and Malusà 2012). However, the high nutrient requirements of tree nurseries are considered difficult to meet by using only organic fertilizers. For this reason, a specific derogation is foreseen in the EU Regulations that are ruling the organic farming system in the European Union, to allow the use of trees obtained with conventional methods also for establishing organic orchards. The preliminary results presented in the paper of ours are demonstrating that a fertilization management utilizing products with a different mechanism of action can allow a successful production of high quality plants. It shall also be mentioned that the health status of the plants after the application of the two organic products was particularly good, with no symptoms of deficiencies nor of diseases, likely due to their equilibrated growth.

Table 1. Effect of various fertilization treatments on plant growth parameters of apple maiden trees grown in an organic nursery (2010), means of 40 plants.

A – apple cultivar 'Topaz'

Treatment	**Trunk diameter** [mm]	Tree height [cm]	**Number of branched trees** [%]	**Number of lateral shoots**	Total length of lateral shoots# [cm]
Zero fertilization	11.8 a	114.8 a	70.0 a	2.6 a	37.5 a
NPK	12.7 ab	126.4 b	90.0 a	3.8 ab	97.5 b
Manure	12.6 ab	125.3 b	93.8 a	3.7 a	91.0 b
Micosat	13.0 b	127.7 b	95.0 a	4.9 bc	85.7 b
BF Amin	13.4 b	125.1 b	100.0 a	5.3 c	98.4 b

Note: # shoots longer than 5 cm

B – apple cultivar 'Ariwa'

Treatment	Trunk diameter [mm]	Tree height [cm]	Number of branched trees [%]	Number of lateral shoots	Total length of lateral shoots# [cm]
Zero fertilization	11.0 a	121.1 a	76.7 a	4.0 a	139.0 a
NPK	10.5 a	126.7 ab	66.9 a	4.6 ab	163.6 a
Manure	11.3 a	129.8 ab	85.0 a	4.7 ab	149.5 a
Micosat	11.3 a	130.5 ab	88.7 a	5.4 b	167.4 a
BF Amin	11.5 a	133.3 b	100.0 a	8.6 c	253.9 b

Note: # shoots longer than 5 cm

Conclusions

From these preliminary data, the following conclusions could be drawn:

1. The liquid fertilizer BF Amin could be used successfully in organic nursery production of apple trees, since it improves the quality of maiden trees, increasing both the number of branched maidens and the number of shoots in the crown, and markedly stimulating the growth of shoots.
2. The microbial consortium Micosat has improved the growth of the trees by enhancing the plant uptake capacity of nutrients, since it does not contain any nutrient elements. Its effect on plant growth parameters was less evident than that of BF Amin, but still better than the common organic fertilizer.
3. The application of manure, which was considered the "organic control", confirmed that such product can well sustain the growth of the plants similarly to plants fertilized with chemical fertilizers.

These results, from a first two-year cycle of tree production, are under verification in parallel trials currently carried out in three different nurseries together with a larger range of fertilizers and amendments allowed for organic production.

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