Effect of new organic fertilizers on growth of strawberry cv. Elsanta Preliminary results.

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Abstract

Vegetatively propagated plants of the strawberry cultivar 'Elsanta' were grown for 12 weeks in rhizoboxes filled with mineral soil. Two organic fertilizers (a plant extract and a compost extract) and an inoculum of soil beneficial microrganisms added to dry manure were compared to an untreated (not fertilized) control and to standard N-P-K fertilization.

Plants treated with the organic fertilizers showed a similar shoot biomass production, about 50% higher in comparison to control. The increased biomass production was due to increased leaf area since the number of leaves per plant did not show any difference between the organic fertilizers and the untreated control.

Carbon allocation to produce root biomass was similar for plants treated with all the organic fertilizers and significantly higher in comparison to roots of control plants. A modification of the root morphology in organically fertilized plants was visually evident and was reflected in higher total root length and higher number of root tips in comparison to chemically fertilized plants. A different growth behavior among the plants treated with the organic fertilizers was found, but can be considered equilibrated in all cases The use of the organic fertilizers, even though containing a low amount of mineral nutrients, allowed the growth of the strawberry plants at a level comparable to that of chemically fertilized plants.

Keywords: organic fertilization, root structures, strawberry

Introduction

Organic farming is considered an important factor of the Polish and EU strategy for the development of the agricultural sector and the production of organic fruits is increasing in the last years (Anon. 2007). However, the limited availability of classical organic fertilizers (i.e. manure) also in not specialized farms, and scarce information about the effects of new kinds of organic fertilizers like plant extracts (Sas-Paszt et al. 2007) or microbial inocula (Malusa et al. 2007) are serious bottlenecks threatening the future development of the sector. The aim of the study, carried out within the framework of a project intended to develop new products and technologies for organic fruit production in Poland, was to evaluate the effect of new organic fertilizers obtained from different sources on the growth of strawberry plants.

Materials and Methods

Frigo-plants of strawberry cultivar 'Elsanta' were grown in a greenhouse for 12 weeks in rhizoboxes filled with 1.85 kg of a podsolic soil collected from an uncultivated field of the experimental organic orchard of the Research Institute of Pomology and Floriculture. Its main characteristics were: pH 5, organic matter content 1.5%; P content 51 mg P kg^{-1}, K content 158 mg K kg^{-1}.

Four treatments were compared to untreated (not fertilized) plants:

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a) a standard NPK soil fertilization: 4 g NH_4NO_3*plant^{-1}, 3 g triple-superfosfate*plant^{-1} and 6 g K_2SO_4*plant^{-1}.

b) a mixture of beneficial fungi and bacteria (Micosat, CCS Aosta s.r.l.) containing:

- spores, hyphae and root fragments colonized by AM fungi of five *Glomus* species (*G. mosseae* Taxter sensu Gerd. & Trappe, *G. intraradices* Schenk & Smith, *G. caledonium* (Nicolson et Gerdemann) Trappe et Gerdemann, *G. viscosum* Nicolson and *G. coronatur* Giovannetti),
- *Trichoderma viride* Pers.
- three rhizosphere bacteria species (*Bacillus subtilis*, *Pseudomonas fluorescens*, *Streptomyces* spp.) with a total concentration of 10^6 cells·g^{-1} of substrate.

The product contains 40% C, 0.15% N, 431 mg*kg^{-1} P and 9558 mg*kg^{-1} K. It was applied at planting to the soil near the root system (10 g*plant^{-1}) and than three times during the growing period (each application with 5 g*plant^{-1}).

c) an extract from vermicompost (Humus UP, Ekodarpol), containing 0.65% C, 0.03% N, 30.8 mg*kg^{-1} P and 4535 mg*kg^{-1} K. The product was applied to the soil at planting as a 2% solution (15 ml*plant^{-1}) and than three times during the growing period (1% solution, 15 ml*plant^{-1}).

d) an extract from several seaweed species reinforced with humic and fulvic acids (BioFeed Quality, Agrobio Products B.V.), containing 0.6% C, 0.07% N, 32.6 mg*kg^{-1} P. The product was applied to the plants five times during the growth period as a 0.5% solution (25 ml*plant^{-1}).

The plants treated with the microorganisms inoculum and the seaweed extract received before planting a basic soil fertilization (12 g*plant^{-1}) with dry manure (containing 1% N, 0.3% P and 1% K). The total amount of mineral nutrients applied for each treatment is shown in Table 1.

Each treatment was applied to 10 plants grown in 5 rhizoboxes placed on a completely randomized design.

At the end of the growing period dry biomass was determined separately for roots and shoots. Root growth parameters (total root length, root diameter and total number of root tips) were measured by an image analysis system with a Hewlett Packard scanner, controlled by WinRhizo software (Regent Instruments Inc.).

The results were statistically evaluated by analysis of variance and comparison of means was done at $P \leq 0.05$ with the Newman-Keuls test.

Table 1: Equivalent amount of mineral elements applied per hectar with the different treatments (kg).

	N	P	K
Control	0.00	0.00	0.00
NPK	60	26	100
Micosat	24	2	6.5
Humus UP	<0.1	<0.1	<0.2
BF Quality	5	1.5	5

Results

Plants treated with the organic fertilizers showed a shoot biomass production similar to the chemically fertilized plants (Tab. 2). Fertilized plants had about 50% higher shoot biomass production in comparison to control. The increased biomass production in the fertilized plants was not due to a higher number of leaves per plant since it was on average 13 for all treatments and control plants (Tab. 2).

Root biomass was about two to three fold higher in fertilized plants with respect to untreated control plants (Tab. 3). The total root length was similar in plants treated with the organic products and the untreated control plants, but more than two-fold higher in comparison to chemically fertilized plants. The number of root tips was also similar between the plants receiving the organic fertilizers and the control, which had more than twice tips with respect to NPK treated plants (Tab. 3). No differences were found as regard the diameter of the roots between the fertilized and control plants nor between the different kinds of fertilizers (Tab. 3).

A different growth behavior was observed between plants treated with the inoculum and the vermicompost extract in comparison to the control and the other fertilizers. In the former treatments the shoot/root ratio was about 1, while it was around 1.5 for the control, and NPK and seaweed extract treatments (Fig. 1a). The specific root length was similar to control in all fertilized plants except those treated with the vermicompost extract (Fig. 1b).

Table 2: Shoot dry weight and number of leaves of strawberry plants cv. Elsanta grown under different fertilization management: not fertilized (Control), chemical standard fertilizer (NPK) and three different organic fertilizers. Means ± SEM, letters show significant difference for P<0.05.

	D.W. (g)	Leaf Number
Control	3.54 ± 0.2 a	15.3 ± 1.5 a
NPK	5.05 ± 0.6 b	13.0 ± 2.0 a
Micosat	5.89 ± 0.7 b	13.0 ± 0.6 a
Humus UP	5.89 ± 0.7 b	11.3 ± 2.1 a
BF Quality	5.89 ± 0.7 b	14.0 ± 2.6 a

Table 3: Root growth parameters of strawberry plants cv. Elsanta grown under different fertilization management: not fertilized (Control), chemical standard fertilizer (NPK) and three different organic fertilizers. Means ± SEM, letters show significant difference for P<0.05.

	D.W. (g)	Total Root Length (m)	Root Diameter (mm)	Root Tips Number
Control	0.9 ± 0.2 a	35.8 ± 3.1 b	0.67 ± 0.06 a	6739 ± 788 a
NPK	2.27 ± 0.1 b	13.5 ± 5.9 a	0.67 ± 0.03 a	2808 ± 585 b
Micosat	2.73 ± 0.2 b	33.2 ± 3.7 b	0.64 ± 0.01 a	6256 ± 858 a
Humus UP	2.63 ± 0.3 b	29.4 ± 5.4 b	0.65 ± 0.01 a	6217 ± 735 a
BF Quality	1.77 ± 0.2 ab	33.2 ± 2.4 b	0.61 ± 0.02 a	7004 ± 1041 a

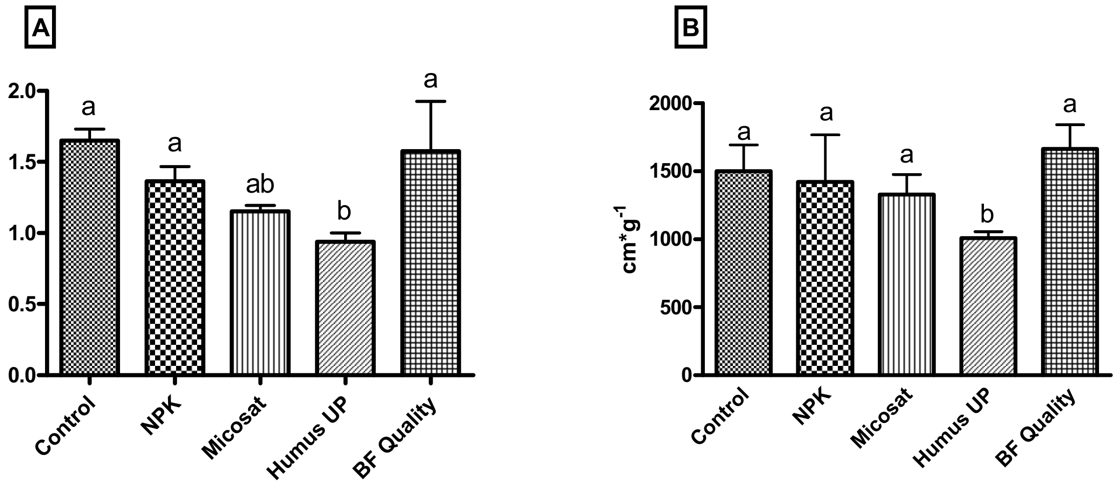

Figure 1: Shoot/root ratio (a) and specific root length (b) of strawberry plants cv. Elsanta grown under different fertilization management: not fertilized (Control), chemical standard fertilizer (NPK) and three different organic fertilizers. Vertical bars represent SEM, letters show significant difference for P<0.05.

Discussion and Conclusions

The application of the organic fertilizers produced from different sources and the inoculum of different beneficial microorganisms allowed obtaining a growth of the strawberry plants similar to that of plants fertilized with a standard synthetic fertilizer. It must be underlined that the amount of the macronutrients provided with the organic fertilizers is several fold lower than that applied with the chemical fertilizer. However, the organic substances present in the vermicompost and seaweed extract as well as the growth promotion activity of the rhizosphere beneficial microorganisms could sustain the growth of the strawberry plants. The carbon allocation between shoots and roots of the chemical fertilizer and of the seaweed extract was similar to untreated plants, with the majority of the plant biomass represented by leaf tissues, while a more equilibrated shoot/root ratio was shown by the inoculated and compost treated plants (Fig. 1). Application of a vermicompost on strawberries resulted in increased of up to 37% in leaf area and 37% in plant shoot biomass and the effect was confirmed also by higher yield performance (Arancon et al. 2004).

The morphological structure of the root system was similar in all plants treated with organic products or growing into the untreated soil. Plants grown under chemical fertilization produced shorter and less branched roots than organically fertilized plants. Nevertheless, the diameter of the roots was not affected by the kind of fertilizer. The overall differences in root morphology can account, at least partially, for the good plant growth found even with limited mineral nutrients provided by the organic fertilizers. This result could be due to better exploitation of the resources in the soil and of the higher soil microbial activity found at the end of the trial (Głuszek pers. comm.).

There is a great variability in the nitrogen availability from different sources of organic fertilizers (Pang and Letey 2000). The repeated application of the organic fertilizers during the growth period could increase their efficacy due to lower leaching of N mineralized. Incubation studies with an array of organic fertilizers had shown that for a seaweed extract the N availability was steady for a period of 6 weeks, with nearly 50% of the nitrogen contained in the fertilizer becoming available for the plants, a higher amount in comparison to the other organic fertilizers (Stutterheim pers. com.). It is known that the timing in supplying nitrogen to berry crops is critical for buds and fruit set, and the nitrogen release rates for organic fertilizers may not match the nitrogen needs of the crop. Field trials are undergone to verify these preliminary results which would suggest that the tested products are feasible organic fertilizers for strawberry production.

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References

Anonymous (2007). Action Plan for Organic Food and Agriculture in Poland for the years 2007-2013. Ministry of Agriculture and Rural Development, Warsaw, Poland.

Arancon, N. Q., Edwards, C. A., Bierman, P., Welch, C., Metzger, J. D. (2004). Influences of vermicomposts on field strawberries: 1. Effects on growth and yields. *Bioresource Technology* **93**:145-153.

Malusa, E., Sas Paszt, L., Popińska, W., Żurawicz, E. (2007). The effect of a substrate containing arbuscular mycorrhizal fungi and rhizosphere microorganisms (*Trichoderma*, *Bacillus*, *Pseudomonas* and *Streptomonas*) and foliar fertilization on growth response and rhizosphere pH of three strawberry cultivars. *Intern. J. Fruit Science* **6**: 25-41.

Pang, X. P. and Letey, J. (2000). Organic farming: challenge of timing nitrogen availability to crop nitrogen requirements. *Soil Sci. Soc. Am. J.* **64**: 247–253.

Sas Paszt, L., Żurawicz, E., Filipczak, J., Głuszek, S. (2007). Rola rizosfery w odżywianiu roślin truskawki. *Postępy Nauk Rolniczych* **6**:27-36.