Effect of organic fertilizer on growth of strawberry cultivar Sonata

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Keywords: *Fragaria,* berries, Bioklad fertilizer, organic farming, sustainable agriculture

Abstract

Organic agriculture is acquiring increased attention in Armenia with numerous projects and initiatives prioritizing production of ecologically clean agricultural products. Application of organic fertilizers is one of the key factors supporting sustainable organic production of fruits and vegetables, which requires knowledge of fertilization regimes adapted to crop types for achieving optimum productivity. The present study evaluates the effect of the organic fertilizer "Bioklad" (Bioklad LTD) on growth and development of strawberry plantlets. Three concentrations of the organic fertilizer, 1:400. 1:200 and 1:100 dilutions of the concentrate were tested. Plantlets of the cultivar 'Sonata' were grown for nine weeks in pots under controlled conditions in a phytotron. Yield, biomass and total phenolic content were not significantly different between Bioklad application treatments. Nevertheless, the Bioklad at the intermediate dilution 1:200 was most optimal for strawberry growth. The analysis of chemical composition of leaves indicated that nitrogen content was higher in plants grown at the lowest dilution (1:100) of Bioklad. In addition, plantlets had the lowest phenolic content at this treatment. Based on the presented results of Bioklad's effect on strawberry plantlets growth, cost/value insight of this organic fertilizer has been estimated.

INTRODUCTION

Organic agriculture has been considered an important factor for the development of the agricultural sector in Armenia. In the recent years there have been numerous projects and initiatives prioritizing production of ecologically clean agricultural products (Darbinyan and Rundgren, 2018). One of the key elements introducing sustainable organic production of fruits and vegetables is application of organic fertilizers, which requires knowledge of nutrient management regimes adapted to particular crop types for achieving optimum productivity.

The strawberry crop (*Fragaria* x *ananassa* Duch.) is important globally, including Armenia. It is appreciated for its aroma and vitamin contents, color, juicy texture, sweetness and the phenolics and flavonoid content (Hakkinen and Torronen, 2000, Mazzoni et al., 2020). Strawberry has a fast growth (two - three months) and is highly influenced by fertilization (Medeiros et al., 2015). The market of organic fertilizers in Armenia is limited and scarce information about effects of new organic fertilizers is a serious bottleneck for future development of organic production. In this work we report the results of a pot trial under controlled conditions testing three different dilutions of the organic fertilizer Bioklad, on growth of strawberry plantlets.

MATERIAL AND METHODS

Experimental Setup

Plantlets (3-4 leaves) of 'Sonata' cultivar were grown in 9 cm plastic pots, filled with a 1:1 (v:v) mixture of peat (sphagnum peat moss, organic matter 90%, pH 5.5-6.5, electric conductivity 30 mS/m, P 50 mg/L, K 250 mg/L, N 850 mg/L) (Tjerbo, Norway) and M3 0 - 5 mm granulated vermiculite (RHP, The Netherlands) for 9 weeks at controlled conditions of 18 °C and 74 % of relative air humidity in a phytotron under natural light conditions at the Climate Laboratory, NIBIO/UiT Tromsø, Norway (69°39'13.2"N,18°54'50.5"E). The organic fertilizer "Bioklad" (Bioklad LTD) (see Table 1 for content) was applied in three concentrations: a) 1:400 (v/v) dilution (2.5mL L^{-1}); b) 1:200 (v/v) dilution (5mL L^{-1}); and c) 1:100 (v/v) dilution (10mL L^{-1}) of the commercially available concentrate. The solutions were applied in the amount of 80 mL three times a week. For control experiments standard NPK fertilization (YaraTera Kristalon brown 3-11-38) with and without additional nitrogen supplementation (0,65g/L CalciNit) was used. Complementary water irrigation was organized for keeping the plants sufficiently moisturized throughout the experimental period. In total 22-24 plants per treatment were used.

Table 1. Nutrient Composition of "Bioklad" fertilizer.

Basic elements	Amount (per dry weight)
pH	6,8 - 8,0
C/N	7 - 15%
Humidity	93 - 95%
Organic matter	min 70%
Humus	25 - 30%
N	2,6 - 5,1%
P_2O_5	2,2 - 5%
K	2,2 - 5,5 %
CaO	3 - 7%
MgO	1,2 - 2,1%
Fe	1,2 - 2%
Microelements	S, Cu, Zn, Ni, Mn, Na, B, Mo, Co, Cr etc. 19 basic amino acids

Growth and yield measurements

Throughout the experimental period new runners were removed as soon as they developed to reduce the bias of runner formation and growth on total dry matter accumulation (Pritts and Worden, 1988). Even though the plants were first year plantlets, number of flowers occur and berries were collected for quality analysis. Plants were harvested for growth analysis after 9 weeks treatments and total fresh weight of aerial part was measured. Plant material was dried at 60 °C to constant weight, and dry weight was recorded. Chemical composition of leaves from dry plant material was analyzed at Soil Science and Plant Diagnostics Laboratory of Mediterranean Agronomic Institute of Chania (MAICh).

Total phenolic compound content

Extraction of samples and analyses of total phenolics content were performed as described by Vasco et al. (2008) with some modifications. Dried leaves of strawberry (0.5 g) were extracted with 20 mL of methanol:water mixture (50:50 v/v) for 1 hour at room temperature, and centrifuged at 4000 rpm for 15 min and the first supernatant was collected. The samples were then extracted with 20 mL of acetone:water mixture (70:30 v/v) and centrifuged at the same conditions. Total volumes of both collected supernatants were made up to 50 mL in volumetric flasks with distilled water.

The total phenolics content was measured using a modified Folin and Ciocalteu method (Vasco et al., 2008). An aliquot (0,5 mL) of the extract, blank or standard, was placed in a 25 ml flask. Folin-Ciocalteu reagent (0,5 mL) was added and the mixture was allowed to react for 3 min under continuous stirring. Ten mL of sodium carbonate solution (75 g L^{-1}) was added, mixed well, and volume was made up to 25 mL with distilled water. Absorbance was measured at 750nm using SmartSpec™ Plus Spectrophotometer (BioRad, USA) after 1 h at room temperature. Gallic acid was used as a standard, and the total phenolic content was expressed as gallic acid equivalents (GAE). The measurements were performed in triplicates.

Statistical analysis

Analysis of variance (ANOVA) was used for data analysis using Microsoft Excel.

RESULTS AND DISCUSSION

The results showed that fresh and dry biomass, as well as TPC were higher in the plants grown on the intermediate concentration (1:200) followed by the lowest concentration of Bioklad (1:400), however the observed differences were not statistically significant under either treatment (Table 2, Fig. 1). Reduced amounts of biomass observed in plants at the highest concentration of Bioklad (1:100) treatment were most probably associated with too high levels of available nitrogen. Andriolo et al. (2011) got similar results and showed that number of leaves and shoot mass decreased by effect of increasing N concentrations in the nutrient solution. Similar results were shown by Janisch et al. (2012), who reported that increasing N concentration in the nutrient solution reduces growth of crown, roots and leaf area index of strawberry stock plants. Reduced biomass at the highest concentration of Bioklad was also associated with lower content of total phenolics. This is in line with previous reports that an excessive nitrogen supplementation reduces the accumulation of phenolic compounds, which are highly relevant to the quality of fruit (Taghavi et al., 2014). Strawberries that were grown on NPK with additional nitrogen supplementation showed similar biomass production with organically grown plants. Drastic decrease in growth of plantlets on NPK without additional nitrogen supplementation was most probably associated with insufficient available nitrogen.

Table 2. Average of fresh weight (FW) and dry weight (DW) the plants aerial part grown in different concentrations of the organic Bioklad fertilizer ± standard deviation of the mean. NPK and NPK+N are included as positive controls. Values represent the mean of 5 replications. Different letters indicate significant differences at $p < 0.05$.

Treatment	**FW (g)**	**DW (g)**
Bioklad 1:400	21.0 ± 6.8^{a}	6.6 ± 2.4^{ab}
Bioklad 1:200	22.6 ± 3.9^{a}	7.2 ± 1.3^{a}
Bioklad 1:100	20.4 ± 9.8^{a}	5.7 ± 2.7^{ab}
NPK	10.6 ± 1.3^{b}	5.1 ± 1.2^{b}
NPK+N	22.5 ± 7.0^{a}	5.9 ± 2.1^{ab}

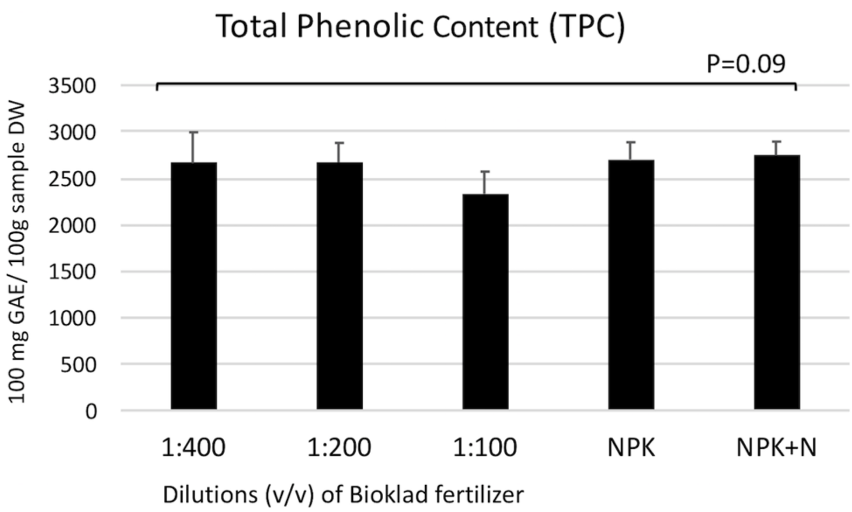

Fig. 1. Total phenolic content (TPC) in strawberries grown in different concentrations of the

organic Bioklad fertilizer, NPK and NPK+N. Error bars represent standard deviation of the mean of 5 replications.

There was no significant effect on strawberry yield and average size of berries between the treatments (Table 3). However, the total amount and number of berries per plant was highest at the intermediate concentration of the organic fertilizer. Number of berries at the lowest Bioklad levels was not much different from the intermediate treatment, however, berries were slightly smaller. Larger fruit size at the highest concentration of Bioklad could be explained by higher levels of nitrogen in this treatment, as low availability of nitrogen has been reported to affect the size of fruits (Deng & Woodward, 1998).

Table 3. Yield per plant, calculated as ratio of total fruit yield in g to the mean of fresh weight per treatment, number of harvested fruits and the average fruit weight ± standard deviation of the mean. Different letters indicate significant differences at $p < 0.05$.

Treatment	**Fruits per plant**	**Number of fruits**	**Fruit size (g)**
Bioklad 1:400	5.6	27	4.4 ± 2.0^{ab}
Bioklad 1:200	6.6	29	5.1 ± 1.7^{ab}
Bioklad 1:100	5.9	21	5.7 ± 3.6^{ab}
NPK	13,8	33	4.4 ± 2.1^{b}
NPK+N	6.9	32	4.9 ± 1.6^{ab}

Analysis of chemical composition of leaves showed some increase in macronutrient by increasing amounts of Bioklad from 1:400 dilution to 1:200, however, these differences were not significant, except the P content, which was 1.6 times lower in plants at the lowest concentration (Fig. 1). No significant differences were found in K, Ca, Mg and P content between Bioklad 1:200 and Bioklad 1:100 treatments. The amount of K in the plants grown on mineral fertilization was twice higher than ones at Bioklad-treated plants. Nitrogen level in Bioklad 1:100-treated leaves was around 1,5 times exceeding the values in other treatments (Fig. 2). These data are in line with the effects on biomass, TPC, and yield of strawberries, described above.

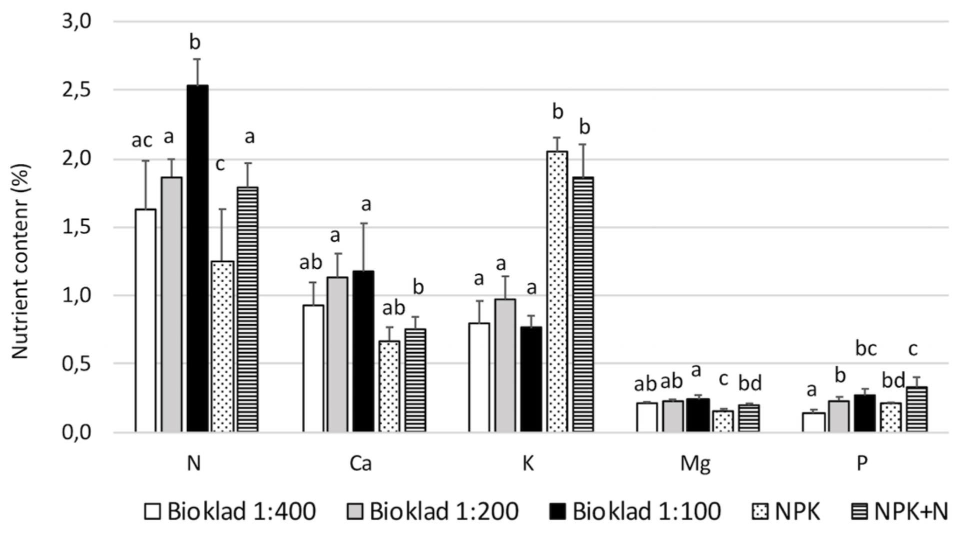

Fig. 2. Macronutrient content in strawberry leaves grown on organic fertilizer Bioklad. NPK and NPK+N are included as positive controls. Values represent the mean of 5 replications. Error bars represent standard deviation of the mean. Different letters indicate significant differences for each microelement at $p < 0.05$.

Economically, the cost of the fertilizer consumed during the experiment was around US$ 0.01, 0.02 and 0.04 for 1L in Bioklad 1:400, Bioklad 1:200 and Bioklad 1:100 treatments, respectively. For the 9-week experiment 2160 ml of each solution was used, which makes the cost per treatment 0.02, 0.05 and 0.09 US$ in total. The price was estimated based on prices for the 20L Bioklad concentrate solution (http://bioklad.info/shop/).

CONCLUSIONS

According to our findings, Bioklad 1:200 treatment was optimal for strawberry plantlets growth and development. This concentration was generally advised by the manufacturer for growing fruits and vegetables. Bioklad 1:400 concentration could also be used for being more cost efficient. Depending on the type of soils used, supplementation could be recommended to optimize the nutrient level in the plants with this concentration of Bioklad.

ACKNOWLEDGEMENTS

This work was supported by the "Norway-Armenia cooperation in plant molecular biology and biotechnology for agricultural development" project (CPEA-LT-2016/10092), funded by the Eurasia program, Norwegian Agency for International Cooperation and Quality Enhancement in Higher Education (DIKU) and SIS – Teknobær – NFR strategic project NIBIO. We would like to thank Mr. Artur Movsisyan for donating the Bioklad fertilizer for the pilot research experiments within the educational project.

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