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IMPACT OF BIOSTIMULANTS ON GROWTH AND PRODUCTIVITY OF ORGANIC STRAWBERRIES

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Abstract: Organic strawberry production is faced with several biotic and abiotic stresses that compromise crop productivity and berry quality. In order to improve yield and berry quality, we have compared the potential beneficial effects of seven biostimulant treatments 1- control without biostimulant (CONTROL), 2- seaweed extract (SEAWEED), 3- mycorrhiza Rhizoglomus irregular (MYC), 4- mix of three bacteria, Azospirillum brasilense, Gluconacetobacter diazotrophicus, and Bacillus amyloliquefaciens (BACT), 5- combination of MYC+BACT, 6- MYC+BACT with a low fertilization (MYC+BACT/LF), and 7- citric acid-based (CITRIC) within a complete randomized block design with five replicates. Our results showed that some biostimulants did impact the soil relative abundance of fungi and soil CO_2 efflux, while no effect was observed for the microbial activity (FDA) compared with the control. Leaf chlorophyll content and the chlorophyll fluorescence were not significantly affected by biostimulants. MYC decreased the number of flowering stalks (-18%) compared with control plants, while citric acid increased their dry root biomass (+35%). However, biostimulants did not affect the mineral content of leaves. Little effect of biostimulants on crop productivity was observed compared with control plants. However, MYC+BACT increased ºBrix (+11%), total polyphenols (+40%) and anthocyanins (+26%) of the berries compared with control. The use of a lower fertilization reduced plant growth and yield.

Introduction: Organic strawberry (*Fragaria x ananassa* Duch.) production often suffers from lower yield compared to conventional farming. This is generally related to a low nutrient availability for the crop and limited tools to control pest infestation[1]. On the other hand, biostimulants may help the plant to assimilate required nutrients and improve plant resilience to abiotic and biotic stresses[2]. This study aimed to investigate the effect of five plant biostimulants on the growth, development, productivity, and quality of organic strawberry plants grown in greenhouse.

Material and methods: The experiment was performed in a greenhouse complex located at Laval University, Quebec, Canada (Lat. 46°78' N; long. 71°28' W) from February 5th to July 11th, 2018. The treatments were 1- Control without biostimulant (CONTROL), 2- Seaweed extract (Acadian seaweed; soil application; SEAWEED), 3- Mycorrhiza (*Rhizoglomus irregular*; MYC), 4- *Azospirillum brasilense*, *Gluconacetobacter diazotrophicus* and *Bacillus amyloliquefaciens* (BACT), 5- Mix of treatments 3 and 4 (MYC+BACT), 6- MYC+BACT with low fertilization (MYC+BACT/LF) and 7- Citric acid (Fungout®, AEF GLOBAL; CITRIC). The experiment defined as randomized complete block design with five replicates. Strawberries (cv Monterey) were grown in organic substrate (OM4 40 NF Wood with 40 % wood fibers + 50% peat + 10 % compost, Berger) and under natural light supplemented with HPS lamps providing a PPFD of 162 µmol/m²/s at the plant level, for a photoperiod of 16 hours (from 8 am to 24 pm), with CO_2 concentration between 600-700 µL L^{-1}, day/night temperature 18/13 ± 0.8 °C. Bumblebees as a natural pollinator (Biobest®, Ontario, Canada) were used to improve flower pollination inside the greenhouse. Plants were fertilized daily with liquid organic fertilizers (0.3% of Nature's Source (3-1-1), and 5.5 g of poultry manure pellets (Acti-sol 5-3-2) were applied to all treatments twice a month, except in treatment six.

Chlorophyll fluorescence (Fv/Fm maximum quantum efficiency of photosystem II and performance index) parameters, chlorophyll content (SPAD) and plant growth parameters (crown diameter and number of leaves, flowering stalks and crowns) were measured every month on three plants per experimental unit. Fruits were harvested once/ twice a week and classified in marketable and unmarketable fruits according to their shape and size. Soluble sugar content (°Brix) was evaluated monthly, while total polyphenols and anthocyanins were measured 3 times (July, August, September). Soil samples were collected to determine the soil microbial activity (FDA)[3]. At the end of the experiment, leaf area, fresh and dry biomass of the stems, leaves, and roots were measured on three plants per experimental unit. All data were analyzed by a two-way model of analysis of variance (ANOVA) using the MIXED procedure of SAS software (version 9.4, SAS Institute Inc. Cary, NC) with replicates as a random effect. Data were compared using LSD when effects were significant at a 5% confidence level ($P \leq 0.05$).

Results: Soil activity- Microbial activity (FDA) of the soil was not influenced by biostimulants, while low fertilization reduced its activity (Table 1). However, seaweed, MYC, BACT, MYC+BACT increased soil CO_2 efflux compared with control.

Physiological parameters- Our results showed that leaf Chlorophyll fluorescence (Fv/Fm and P Index) and Chlorophyll content (SPAD) were not influenced by biostimulants (Table 1). However, the low fertilization treatment (MYC+BACT/LF) induced lower values of P index and Chlorophyll content compared to the other treatments.

Plant growth- Table 1 showed that biostimulants had little impact on growth parameters, except for the number of flowering stalks that decreased by 14% for MYC compared with control, although the number of leaves (P=0.085) and of flowering stalks (P=0.082) tended to be higher than control for the citric acid treatment. Moreover, citric acid increased fresh (+32%) and dry (+35%) biomass of roots compared with control plants. The highest leaf area was observed in the SEAWEED treatment (10% higher than control; P=0.107), while shoot biomass of plants treated with citric acid tended to be higher than control plants (P=0.128, +18%). A low fertilization (MYC+BACT/LF) decreased the number of leaves and crowns, leaf area and shoot biomass compared to the control.

Yield and quality- Figure 1 showed that yield parameters were little influenced by the studied biostimulants compared with control, except for MYC+BACT (P<0.01) and citric acid (P=0.073) that increased the total number of fruits. A lower yield was observed for plants grown under low fertilization compared to the control. In terms of quality, MYC+BACT increased ºBrix (+11%), total polyphenols (+40%) and anthocyanins (+26%) of the berries compared with control (Table 1).

Discussion- Results of the present study showed that crop development and yield of organically grown strawberries were little affected by the studied biostimulants. However, although not significant at P<0.05, foliar citric acid application tended to increase yield of berries. On the other hand, the use of a mixture of mycorrhiza and bacteria (MYC+BACT) increased the ºBrix, polyphenols and anthocyanins of the berries compared to the control and the use of mycorrhiza or the bacteria alone, while citric acid tended to increase the anthocyanin content (*P*=0.068). Our results agree with study showing the positive effects of inoculation with plant growth prompting bacteria[4] on the sugar and anthocyanin concentration of strawberry plants cv. Elyana. Besides, we observed that citric acid and seaweed extract had the capacity to increase root biomass and leaf area, respectively. Similar results were reported in roses [5, 6].

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Image:

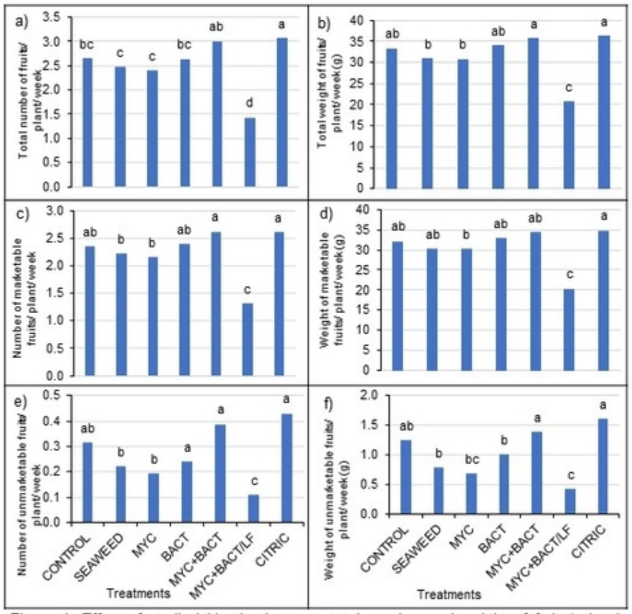

Figure 1. Effect of studied biostimulants on total number and weight of fruits/ plant/ week (a, b), number and weight of marketable fruits/ plant/ week (c, d) as well as number and weight of unmarketable fruits/ plant/ week (e, f) during experiment, winter 2018. Different letters indicate a significant difference (P<0.05) among treatments by LSD test (n=55).

Image 2:

Table 1: Effect of studied biostimulants on physiological parameters (Fv/Fm, P Index, and chlorophyll content (SPAD)), growth parameters (Number of leaves, number of flowering stalks, number of crowns, and diameter of crowns), Brix, microbial activity (FDA), leaf area, shoot and root fresh and dry biomass.

Treatments	Fv/Fm	P Index	SPAD	Number of leaves	Number of flowering stalks	Number of crowns	Diameter of crowns (mm)	Brix	FDA (µg/h/g dry soil)	Leaf Area (cm² plant⁻¹)	Shoot fresh biomass	Shoot dry biomass	Root fresh biomass	Root dry biomass
CONTROL[z]	0.805	2.952a	38.1a	15.40ab	4.69abc	3.38ab	40.34	8.88b	885.0a	2347.5ab	125.44ab	29.7a	46.2bc	6.72bc
SEAWEED	0.808	3.104a	37.3a	13.92bc	4.45bcd	3.20abc	33.62	9.25ab	881.8a	2591.3a	136.66ab	29.54a	47.0bc	6.62bc
MYC	0.805	2.801a	38.2a	15.02b	4.02d	3.15bc	38.03	8.80b	906.8a	2179.8ab	116.34b	26.93a	43.1bc	6.39bc
BACT	0.803	2.840a	37.7a	15.11b	4.90ab	3.39ab	36.96	8.95b	758.6ab	2343.7ab	120.65ab	27.93a	42.3bc	5.99bc
MYC+BACT	0.804	2.960a	37.2a	15.33ab	4.87abc	3.35ab	36.74	9.88a	898.55a	2055.8b	111.1b	26.13a	49.9ab	6.98ab
MYC+BACT/ LF	0.801	2.348b	34.4b	12.82c	4.26cd	2.88c	29.72	8.83b	555.85b	1172.5c	62.902c	14.99b	38.1c	4.98c
CITRIC	0.808	2.981a	38.1a	17.01a	5.25a	3.58a	39.34	9.44ab	830.04a	2492.7ab	147.83a	32.45a	60.99a	9.04a
Biostimulant	ns	***	***	***	*	*	ns	*	*	***	***	***	***	***

[z]CONTROL= without biostimulant; SEAWEED= seaweed extract; MYC= mycorrhiza *Rhizoglomus irregulare*; BACT= three bacteria *Azospirillum brasilense*, *Gluconacetobacter diazotrophicus*, and *Bacillus amyloliquefaciens*; MYC+BACT= combination of treatments MYC and BACT; MYC+BACT/LF= combination of treatments MYC and BACT with low fertilization; CITRIC= citric acid-based formulation (Fungout® AEF GLOBAL Inc., foliar spray with pH=6.2).
[y]***, Significantly different at P<0.001; **, significantly different at P<0.01; *, significantly different at P<0.05; ns, not different at P>0.05.
[x]means with different letters are significantly different at P<0.05.

Disclosure of Interest: None Declared

Keywords: bacteria, Brix, citric acid, fluorescein diacetate, Monterey, mycorrhiza