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How do Biostimulants Support Sweet Potato Production in an Organic and Sustainable Farming System?

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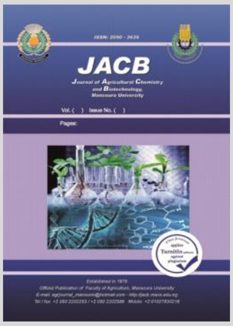

ABSTRACT

A pot experiment was carried out at the Experimental Farm of Environ. & Bio-Agriculture Dept, Fac. Agric., Al-Azhar Univ., Nasr City, Cairo, Egypt, during the summer season of 2022 to study the impact of some Plants biostimulants (PGPR, AMF, Chlorella extract, EM, and vermi tea) on growth, chemical composition and yield in *Ipomoea batatas L* plants. Sweet potato grown organically. Results could be summarized as follows: All treatments using biostimulants increased all vegetative growth parameters of sweet potato plant. As for chlorophyll A, B and total chlorophyll, the use of biostimulants, especially vermi tea (Treatment No. 7), had positive results. As for the chemical properties, treatment 9 (compost with mycorrhiza inoculation, PGPR and chlorella extract gave the best value for carotenoids), and both treatment 7 (compost & vermi tea) and treatment 10 (compost with mycorrhizal inoculation, PGPR, chlorella extract and vermi tea) gave the best value. Ascorbic acid value. As for fats, there were no differences between the control (the recommended dose of chemical fertilizer) and between treatments 5 (compost + chlorella extract), treatment 8 (compost, mycorrhiza, PGPR and vermi-tea). Regarding protein, treatments 3 (compost with inoculation with mycorrhiza) and treatment 4 (compost with PGPR) were the best, and treatment 3 was better for fiber. Regarding sugars, treatments 3, 4, 7 and 8 were the best, and treatment 10 was superior to all treatments in the percentage of starch. As for moisture, the highest moisture content was using treatment 2 (compost alone), and treatment 10 and it outperformed all treatments.

***Keywords*:** Organic farming, Compost, EM, Vermi tea, Biostimulants

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is a high-carbohydrate root crop that is also high in protein, fat, calcium, and carotene. It provides a significant amount of food, animal feed, and industrial raw materials (Neela, & Fanta 2019). The crop ranks seventh in worldwide food crop production and third in root crop production after potatoes and cassava (Fan *et al.* 2012 & Hossain 2020). In Egypt, around 31,000 feddans of sweet potato are grown each year, producing around 450,000 tons (Agricultural Statistics Bulletin 2019).

Biostimulants are natural materials or beneficial microbes that are added to the soil or plant and give positive effects on the growth, quantity and quality of the resulting crop. In addition to this, biostimulants work to resist environmental stresses to which plants are exposed, such as lack of water, high soil salinity and high temperatures (Du Jardin 2015). Biostimulants are not fertilizers because they do not deliver nutrients to plants directly. However, biostimulants may aid nutrient uptake by promoting metabolic processes in the soil and plants as well as providing a habitat for the establishment of arbuscular mycorrhizal fungi that carry nutrients to the host plant is one example of such an activity (Tavarini *et al.* 2018).

AM fungi are biostimulants that can be found in all soil habitats (Al Hadidi & Pap 2020). The fungal hyphae may obtain the most critical nutrients for the host plants, such as phosphate, nitrogen, potassium, and sulphate, via several transporters (Wang *et al*. 2017). With the use of cyanobacteria as biostimulants, several studies indicate that increased nutrient availability is not the only mechanism contributing to enhanced plant growth in inoculated soils (Garlapati *et al.* 2019 & Singh 2016). As well as normal fertilization and balanced mineral nutrition, biomolecules secreted by cyanobacteria, including osmolality, phenols, proteins, vitamins, carbohydrates, amino acids and plant sugars, function in plant growth (Singh *et al.* 2011 & 2014).

Beneficial microorganisms such as plant growth promoting rhizobacteria (PGPR) which are applied to seeds or soil aiming to increase soil fertility and plant growth via increasing the biological activities in the rhizosphere (Gao *et al.*, 2020). These microorganisms can promote plant growth through nitrogen fixation, phytohormone, phosphate and potassium solubilization (Bashan and de- Bashan, 2005). Besides, organic fertilizers such as compost, vermi tea, etc., play a significant role in soil fertility and plants productivity (Gao *et al.*, 2020).

Therefore, this research aims to study the ability of biostimulants to improve on the growth and productivity of sweet potato. We hypothesized that treating sweet potato plants with bio-stimulants and organic stimulants and their combinations would improve sweet potato growth and productivity as well as tuber quality traits under a bio-organic cultivation system.

MATERIALS AND METHODS

A pot experiment was performed in 2022 at the Farm of Environment and Bio-agriculture Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt. The experimental soil sample was analysis for physical and chemical according to Page *et al.* (1982) and Klute (1986). Some physical and chemical characteristics are shown in Table (1)

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Table 1. Initial physical and chemical properties of the experimental soil.

Properties	
Texture analysis	
Sand (%)	88.5
Silt (%)	10.5
Clay (%)	1.00
Soil texture	Sandy
pH soil-water suspension ratio (1:2.5)	8.61
EC (dsm^{-1}) soil-water extract ratio (1:5)	0.82
Saturation point (SP)	20
Soluble cations (meq/100g)	
Ca^{++}	2.5
Mg^{++}	1.5
Na^{+}	3.85
K^{+}	0.32
Soluble anions (meq/100g)	
CO_3^{--}	-
HCO_3^{-}	0.5
Cl^{-}	4.5
SO_4^{-}	3.17

Sweet potato seedlings

Sweet potato (Ipomoea batatas, L.) cv. Beauregard seedlings were obtained from a private nursery in Mutobas City, Kafr El-Sheikh Governorate, Egypt.

Fertilization

Mineral fertilizers (control)

The soil received the full recommended amount of NPK (control). Nitrogen was provided at a rate of 200 kg/ fed added as ammonium sulphate (20.5% N) in two equal doses after 30 and 60 days from transplanting. Phosphorus was applied at a rate of 250 kg/ fed as super phosphate (15 % P2O5), and Potassium was added at a rate of 100 kg/ fed as potassium sulphate (48% K2O). Phosphorus and Potassium were applied along with nitrogen fertilizers.

Organic fertilizers (Compost)

Compost was obtained from El-Fairuz company, Belbeis, El-Sharkia Governorate. Compost was applied at the rate of 200g per pot. Some physical, chemical and biological properties of the compost are shown in Table (2)

Table 2. Physical, chemical, and biological properties of the organic stimulants.

Properties	Unit	Compost
Cubic meter weight	Kg	710
Moisture	%	35
pH (1:10)		7.8
EC (1:10)	dSm^{-1}	3.4
Total nitrogen	%	1.2
Ammonium nitrogen	ppm	86
Nitrate nitrogen	ppm	51
Organic matter (OM)	%	50.01
Organic carbon	%	29.0
Ash	%	49.99
C:N ratio		24:1
Total phosphorus (P_2O_5)	%	1.24
Total potassium (K_2O)	%	2.68
Total potassium humate	%	-
Humic acid	%	-
Fulvic acid	%	-
Weed seeds		Nil
Plant pathogenic nematode		Nil
Non-phytopathogenic nematode		1000
Fungi		
Fusarium	cfu/g	Nil
Rhizoctonia	cfu/g	Nil
Pythium	cfu/g	Nil
Phytophthra	cfu/g	Nil
Alternaria	cfu/g	Nil

-, Not applicable, cfu, colony forming unit

Biostimulants

Vermi tea

Vermicompost was obtained from the Farm of Environment and Bio-agriculture Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt. Vermi tea was performed by soaking vermi compost in water at a ratio of 1:10 with an aeration source for 12 hours. It was filtered and used at a rate of 3 ml per plant per day for a month, then once every day and every other day for a month, then once every two days for a month. Vermi tea was applied at the rate of 3 ml per pot daily up to 15 days, then day after day for a month, then every two days for a month. The physical, chemical, and biological properties of the used stimulants were shown in Table 3.

Table 3. Physical, chemical, and biological properties of vemi tea.

Properties	Vermi tea
Cubic meter weight	-
Moisture	-
pH (1:10)	7.64
EC (1:10)	0.36
Total nitrogen	0.35
Ammonium nitrogen	-
Nitrate nitrogen	-
Organic matter (OM)	-
Organic carbon	0.01
Ash	-
C:N ratio	35:1
Total phosphorus (P_2O_5)	54
Total potassium (K_2O)	179
Total potassium humate	0.19
Humic acid	0.08
Fulvic acid	0.02

Plant Growth Promoting Rhizobacteria (PGPR)

These rhizobacteria contain the following strains: *Azotobacter chrococcum* MF135558, *Bacillus subtilis* MF497446, and *Bacillus circulans* ARC-SWERI- 2 were kindly obtained from the Agricultural Microbiology lab, Agricultural Microbiology Department, Faculty of Agriculture, Mansoura University. *A. chrococcum* MF135558 is a high nitrogen fixer (Hauka *et al*., 2017) and effectively produced indole acetic acid (El-Sawah *et al*., 2018). *B. subtilis* MF497446 is a high phosphate solubilizer (El-Sawah *et al*., 2021). *B. circulans* ARC-SWERI- 2 is a high phosphate solubilizer and potassium releaser (Gao *et al*., 2020). Each bacterial strain was grown on its specific cultivation medium. *A. chrococcum* MF135558 was grown on Ashby's liquid medium (Abd-El-Malek and Ishac, 1968) up to 3-7 days at 30 ^{0}C. *B. subtilis* MF497446 and *B. circulans* ARC-SWERI- 2 were grown on nutrient broth medium (Skerman, 1967) up to 3 days at 30 ^{0}C.

Arbuscular Mycorrhizal Fungi (AMF)

AMF inoculum containing a mixture of different spores of *Glomus clarum* (Niclson & Schenck), *Funneliformis mosseae* (Walker & Schuessler) and *Gigaspora margarita* (Becker & Hall) was obtained from the Department of Agricultural Microbiology, Faculty of Agriculture, Mansoura University, Egypt. The AMF spores were left to multiply according to the method of Gao *et al.* (2020) and then used as mycorrhizal inoculum.

Chlorella vulgaris

The green alga *Chlorella vulgaris* belonging to Chlorophyta was obtained from Algal Biotechnology Unit, National Research Centre (NRC), Giza, Egypt and was grown on $BG11_0$ according to Rippika *et al*., 1979.

Effective microorganisms (EM)

EM was obtained from the Environmental Affairs Agency, Egyptian Ministry of Environment. used at a rate of 3 ml per plant daily up to 15 days, then once every day and every other day for a month, then once every two days for a month.

Inoculation methods

Each bacterial strain was grown to the maximum density at an appropriate time up to 108 cfu/ml for A. chrococcum MF135558 and 109 cfu/ml for B. subtilis MF497446 and B. circulans ARC-SWERI- 2 in specific cultivation media as mentioned above. To make the inoculum mixes, equal quantities were combined. For 30 minutes, seedlings were immersed in microbial inoculants. As an adhesive, Arabic gum (16%) was used. Each plant in the pot received an additional 10 ml culture (Gao et al., 2020).

For mycorrhizal application, each hill was infected with 5 g of trapped soil. Before transplanting, the inoculum was deposited 5 cm below the soil's surface. The non-mycorrhizal treatments received equal volumes of autoclaved inoculum to supply the same nutrients (El-Sawah et al., 2021).

Chlorella vulgaris was applied at the rate of 3ml per pot daily for up to 15 days, then day after day for a month, then every two days for a month.

Experimental design:

Sweet potatoes seedlings were transplanted on 17th May 2021. The soil was distributed in 50 sterile pots, 30 cm diameter, and 40 cm height, and 16 kg per pot. The experiments were arranged as a completely randomized design with five replicates, each pot representing one replicate. One plant was transplanted in each pot. Irrigation was performed as needed by supplying the amount of water required to fill the field capacity. All plants were harvested 145 days after transplanting. The treatments were presented in Table. 3.

Table 4. Treatments of the experiment.

T1	The recommended dose of chemical fertilizer (control)
T2	Compost
T3	Compost + AMF
T4	Compost + PGPR
T5	Compost + Chlorella
T6	Compost + EM
T7	Compost + vermi tea
T8	Compost + PGPR+AMF+ vermi tea
T9	Compost + PGPR + AMF+ Chlorella
T10	Compost +AMF+ PGPR +Chlorella + vermi tea

PGPR, Plant growth promoting rhizobacteria; AMF, Arbuscular mycorrhizal fungi; EM, Effective microorganisms.

Measurements:

Randomly, three plants from each treatment were chosen and used to measure plant height, number of branches/plant, number of leaves/plant, leaf area, and chlorophyll content. The chlorophyll content was determined according to Lichtenthaler (1987). At the end of the mature stage, the plants were harvested to determine the number of tubers/plant, tuber weight, tuber height, and tuber circumference. Carotenoids were measured according to Lichtenthaler (1987). Ascorbic acid was measured according to (Al-Majidi and Alqubury, 2016). Fat, moisture, protein, ash, and fiber were measured according to NIRA (2013). Starch and total sugars were measured by the method of Chow and Landhäusser (2004).

Statistical analysis

The results were presented as means ± standard deviation (SD). The data were analyzed using a one-way analysis of variance (ANOVA) using the statistical software SPSS v25.0 and the means were separated using Duncan's test ($P \leq 0.05$).

RESULTS AND DISCUSSION

Data in Table (5) show the effect of some biostimulants (PGPR, AMF, Chlorella extract, EM, and Vermi tea) on the vegetative growth of Ipomoea batatas L plants. Sweet potato was grown organically. The control treatment gave the best value for both plant height (cm) and the number of leaves for each plant. On the other hand, there were no significant differences between the control and other biostimulant treatments with regard to the number of branches for each plant and the leaf area (cm2) for each plant. The chlorophyll a, chlorophyll b, total chlorophyll, and carotenoids contents in sweat potato leaves reported in Table (6) clearly showed that the T 7 (Compost + Vermi tea) gave the best value for chlorophyll A, B, total and carotenoids, as the values were recorded as follows: 0.4419, 0.1154, 0.5874 and 0.1898, respectively. This could be because vermi tea contains minerals like N, P, K, Ca, and beneficial microorganisms. It is crucial for plant growth and development, contributing to roots and root growth, increasing soil organic matter, and preserving environmental quality (Sundararasu & Jeyasankar 2014).

Table 5. Growth of the vegetative sweet potato plant under efficiency some bio stimulants after 90 days from transplanting

Treatments		Plant height (cm)	Number of branches/plant	Number of leaves/plant	Leaf area (cm^2)
T1	Control	203.00±6.08a	4.66±1.15a	75.00±4.00a	26.75±3.92a
T2	Compost	179.00±3.60b	3.66±0.57a	53.00±6.08bc	25.08±5.12a
T3	Compost + AMF	178.66±7.76b	4.00±0.00a	47.33±2.51c-e	25.83±2.88a
T4	Compost + PGPR	142.33±11.23d	3.66±1.15a	57.66±2.51b	24.25±5.34a
T5	Compost + Chlorella	127.00±7.54e	4.33±0.57a	47.66±5.13c-e	24.00±1.73a
T6	Compost + EM	115.33±5.50f	3.33±0.57a	40.66±9.29e	24.00±3.04a
T7	Compost + vermi tea	156.33±3.21c	4.00±1.00a	43.00±4.58de	21.66±1.44a
T8	Compost + AMF+PGPR+ vermi tea	153.00±3.60cd	4.33±0.57a	46.66±2.88c-e	25.83±2.88a
T9	Compost + AMF+ PGPR + Chlorella	179.33±7.02b	3.66±0.57a	44.66±3.21c-e	28.41±1.58a
T10	Compost +AMF+ PGPR +Chlorella + vermi tea	154.66±8.32c	4.00±1.00a	51.66±6.65b-d	22.66±4.75a

Data are means ± SD; different letters within the same column indicate significant differences between means according to Duncan's multiple-range tests. AMF, Arbuscular mycorrhizal fungi; PGPR, Plant growth promoting rhizobacteria; EM, Effective microorganisms.

With regard to the tuber specifications, the results shown in Table (7) indicated that T 7 was the best in each of the number of tubers per plant, tuber length (cm) and tuber circumference (cm). The values were as follows: 5.33 tubers per plant, 15 cm and 13 cm for tuber length and circumference, respectively. In terms of tuber weight, the results shown in Table 6 also indicated that T 4 (Compost + PGPR) and T 5 (compost + chlorella extract) were the best, recording 655 (g) and 626 (g) for each pot, respectively. The PGPR used in this study had significant positive effects on the growth, productivity and quality of the sweet potato plant indirectly through reducing the impact of diseases by producing antibiotics and induction of systemic resistance as well as through competing for nutrients and habitats (Egamberdieva & Lugtenberg 2014).

Table 6. Contents of sweat potato plant leaves (chlorophyll a, chlorophyll b, total chlorophyll, and carotenoids) under using some bio stimulants after 90 days from transplanting.

Treatments		Chlorophyll a (mg/L)	Chlorophyll b (mg/L)	Total chlorophyll (mg/L)	Carotenoids (mg/L)
T1	Control	0.3347±0.052cd	0.1106±0.294a	0.4454±0.081bc	0.1341±0.014d-f
T2	Compost	0.3386±0.011c	0.0944±0.036ab	0.4331±0.045bc	0.1318±0.005ef
T3	Compost + AMF	0.3290±0.010cd	0.1068±0.105a	0.4359±0.020bc	0.1364±0.008d-f
T4	Compost + PGPR	0.4153±0.020b	0.0802±0.008ab	0.4955±0.027b	0.1603±0.008b
T5	Compost + Chlorella	0.3831±0.003b	0.0327±0.024c	0.4126±0.028c	0.1440±0.001c-e
T6	Compost + EM	0.2922±0.036d	0.0530±0.028bc	0.3452±0.013d	0.1211±0.009f
T7	Compost + vermi tea	0.4719±0.025a	0.1154±0.006a	0.5874±0.023a	0.1898±0.005a
T8	Compost + AMF+PGPR+ vermi tea	0.3376±0.015c	0.0783±0.037ab	0.4159±0.046c	0.1397±0.008de
T9	Compost + AMF+ PGPR + Chlorella	0.3893±0.005b	0.7175±0.009a-c	0.4690±0.022bc	0.1589±0.011bc
T10	Compost +AMF+ PGPR +Chlorella + vermi tea	0.3720±0.016bc	0.0551±0.002bc	0.4271±0.015bc	0.1481±0.004b-d

Data are means ± SD; different letters within the same column indicate significant differences between means according to Duncan's multiple-range tests. AMF, Arbuscular mycorrhizal fungi; PGPR, Plant growth promoting rhizobacteria; EM, Effective microorganisms.

Table 7. Properties of sweet potato tubers under using some bio stimulants.

Treatments		Number of tuber/plant	Tuber weight (g)	Tuber height (Cm)	Tuber Circumference (Cm)
T1	Control	3.33±0.57c	321.33±75.11d	9.33±2.51c	7.00±2.00d
T2	Compost	3.66±0.57bc	350.00±20.00d	11.33±1.52bc	8.00±2.00cd
T3	Compost + AMF	4.33±0.57a-c	610.00±20.00ab	14.66±1.15a	12.83±0.28a
T4	Compost + PGPR	5.00±1.00ab	655.00±47.69a	14.83±0.76a	12.16±1.04ab
T5	Compost + Chlorella	5.00±1.00ab	626.66±55.07a	14.66±1.15a	10.00±1.50bc
T6	Compost + EM	4.00±1.00a-c	428.33±36.17cd	12.66±0.57ab	9.66±1.52b-d
T7	Compost + vermi tea	5.33±0.57a	578.33±112.50ab	15.00±1.73a	13.00±1.00a
T8	Compost + AMF+PGPR+ vermi tea	4.33±0.57a-c	430.33±44.04cd	12.33±0.57ab	9.00±1.00cd
T9	Compost + AMF+ PGPR + Chlorella	4.33±0.57a-c	504.00±60.10bc	10.66±1.15bc	9.33±1.52b-d
T10	Compost +AMF+ PGPR +Chlorella + vermi tea	4.00±1.00a-c	498.33±106.45bc	12.33±1.52ab	10.50±2.17a-c

Data are means ± SD; different letters within the same column indicate significant differences between means according to Duncan's multiple-range tests. AMF, Arbuscular mycorrhizal fungi; PGPR, Plant growth promoting rhizobacteria; EM, Effective microorganisms.

For crude protein, total sugars, total carbohydrates and starch(%) the results indicated in Table (8) that the T 3 & 4 gave the highest percentage of crude protein, recording 11.42 & 11.62%, respectively, while T3,T4,T7 and T8 they gave the best values of total sugars % and there were no significant differences between them. The control gave the best percentage of carbohydrates, amounting to 73.26%, and T 10 (compost + AMF + PGPR + Chlorella + Vermi tea) had the highest value of starch, reaching 15.62%. The beneficial effects of arbuscular mycorrhizal fungi on P, N, K, Mg, Cu, Zn, Ca, Fe, Cd, and Ni absorption (Pellegrino and Bedini, 2014). Arbuscular mycorrhizal symbiosis can influence biochemical and physiological processes such as resistance to oxidative damage, better water usage efficiency, gas exchange rate, and osmotic regulation (Gai *et al.,* 2006).

Table 8. Contents of protein, total carbohydrates, total sugar, and starch of sweat potato tubers under using some bio stimulants

Treatments	Protein (%)	Total Carbohydrates (%)	Total Sugar (%)	Starch (%)
T1 Control	8.56±0.27d	73.26±0.40a	3.06±0.03e	11.15±0.03g
T2 Compost	8.67±0.04d	70.23±0.21c	4.74±0.06b	13.76±0.18d
T3 Compost + AMF	11.42±0.07a	65.96±0.17f	5.23±0.08a	14.52±0.10bc
T4 Compost + PGPR	11.62±0.17a	69.56±0.36d	5.17±0.29a	13.63±0.15d
T5 Compost + Chlorella	6.68±0.27e	72.25±0.19b	4.17±0.05cd	13.04±0.65e
T6 Compost + EM	8.72±0.34d	70.65±0.17c	4.10±0.02d	12.40±0.07e
T7 Compost + vermi tea	10.99±0.44b	65.00±0.56g	5.24±0.06a	14.16±0.06c
T8 Compost + AMF+PGPR+ vermi tea	8.66±0.10d	70.73±0.11c	5.27±0.08a	13.48±0.09d
T9 Compost + AMF+ PGPR + Chlorella	10.39±0.05c	68.58±0.75e	4.39±0.27c	14.84±0.07b
T10 Compost +AMF+ PGPR +Chlorella + vermi tea	10.57±0.11c	69.17±0.05de	4.36±0.16cd	15.62±0.07a

Data are means ± SD; different letters within the same column indicate significant differences between means according to Duncan's multiple-range tests. AMF, Arbuscular mycorrhizal fungi; PGPR, Plant growth promoting rhizobacteria; EM, Effective microorganisms.

According to Table (9) T9 gave the highest value of B-carotene for sweet potato root tuber, which was 23.10 (mg / g). On the other hand, T 10 gave the highest value for Vitamin C which was 10.20 (mg/g). These results may be due to algal biomass such Chlorella vulgari which contains macro and micronutrients, growth regulators, polyamines, carbohydrates, proteins, amino acids, and vitamins implemented for improving vegetative growth (Abd El Moniem and Abd-Allah, 2008). As well as the roles of mycorrhiza and PGPR previously mentioned.

Finally, with regard to the content of sweet potato tubers of fat, fiber, moisture and ash, the results (Table 10) indicate that T5 and T8 gave a value for the percentage of fats, which amounted to 2.35 & 2.45%, respectively. While T3,T2 and T7 gave the best value for fiber, moisture and ash, reaching 6.17, 7.83 and 8.17% for each of them, respectively. These results agree with Pellegrino and Bedini, 2014, Gai et al., 2006, Egamberdieva & Lugtenberg 2014 and Abd El Moniem and Abd-Allah, 200

Table 9. Contents of carotenoids and ascorbic acid of sweat potatoes tubers under using some bio stimulants.

Treatments		Carotenoids(mg/g)	Ascorbic acid (mg/g)
T1	Control	17.88±0.54g	8.15±0.05f
T2	Compost	22.30±0.08b	9.14±0.04d
T3	Compost + AMF	19.59±0.29e	9.31±0.09c
T4	Compost + PGPR	20.39±0.37d	9.65±0.04b
T5	Compost + Chlorella	21.25±0.15c	9.24±0.14cd
T6	Compost + EM	19.34±0.08e	9.23±0.10cd
T7	Compost + vermi tea	21.38±0.25c	10.16±0.04a
T8	Compost + AMF+PGPR+ vermi tea	22.34±0.16b	8.69±0.08e
T9	Compost + AMF+ PGPR + Chlorella	23.10±0.43a	8.30±0.12f
T10	Compost +AMF+ PGPR +Chlorella + vermi tea	18.61±0.42f	10.20±0.05a

Data are means ± SD; different letters within the same column indicate significant differences between means according to Duncan's multiple-range tests. AMF, Arbuscular mycorrhizal fungi; PGPR, Plant growth promoting rhizobacteria; EM, Effective microorganisms

Table 10. Contents of fats, fiber, moisture, and ash of sweat potato tubers under using some bio stimulants.

Treatments	Fats (%)	Fiber (%)	Moisture (%)	Ash (%)
T1 Control	2.50±0.10a	4.15±0.05fg	5.74±0.12cd	5.66±0.13g
T2 Compost	2.20±0.26b	3.64±0.13h	7.83±0.11a	7.64±0.01d
T3 Compost + AMF	2.40±0.10ab	6.17±0.05a	5.52±0.13d	8.55±0.10b
T4 Compost + PGPR	1.80±0.10c	4.03±0.16g	5.59±0.10d	7.50±0.26d
T5 Compost + Chlorella	2.53±0.20a	5.75±0.09b	6.45±0.07b	6.30±0.05f
T6 Compost + EM	1.86±0.11c	4.40±0.19e	6.59±0.08b	6.80±0.25e
T7 Compost + vermi tea	1.90±0.10c	5.40±0.08c	6.70±0.09b	9.55±0.09a
T8 Compost + AMF+PGPR+ vermi tea	2.45±0.05a	4.36±0.06ef	5.86±0.12c	8.19±0.04c
T9 Compost + AMF+ PGPR + Chlorella	1.83±0.05c	4.72±0.19d	6.58±0.34b	7.71±0.10d
T10 Compost +AMF+ PGPR +Chlorella + vermi tea	2.30±0.10ab	4.15±0.14fg	7.69±0.07a	8.17±0.04c

Data are means ± SD; different letters within the same column indicate significant differences between means according to Duncan's multiple-range tests. AMF, Arbuscular mycorrhizal fungi; PGPR, Plant growth promoting rhizobacteria; EM, Effective microorganisms

CONCLUSION

Biostimulants are acquired in the current agricultural system from various communities of naturally existing microbes and the biochemical products created by them, such as organic acid, proteins, enzymes, and hormones. When these compounds interact with the plant-soil continuum, they increase the availability or uptake of important nutrients that are provided as fertilizers or that are already present in soil or crop residues. On the other hand, biostimulants work to confront the environmental stresses that the plant is exposed to, such as soil salinity and drought, especially this time with the effects of climate change. Accordingly, the study recommends the importance of using biostimulants in sweet potato production in an organic and sustainable farming system.

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كيف تدعم المحفزات الحيوية إنتاج البطاطا الحلوة في نظام الزراعة العضوية والمستدامة؟

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الملخص

تم إجراء تجربة أصص بالمزرعة البيئية التجريبية العضوية بقسم الزراعة الحيوية ، كلية الزراعة ، جامعة الأزهر ، مدينة نصر ، القاهرة ، مصر ، خلال الموسم الصيفي 2022 لدراسة تأثير بعض المحفزات الحيوية للنباتات والتى تشمل: بكتيريا المجال الجذرى المشجعه لنمو النبات (PGPR) ، فطريات الميكوريزا (AMF)، مستخلص طحلب الكلوريلا ، ميكروبات ذات تأثير (EM)، والشاي الدودي وذلك على النمو والتركيب الكيميائي و المحصول في *نباتات* *Ipomoea batatas* L. البطاطا الحلوة المنزرعة عضويا . ويمكن تلخيص النتائج على النحو التالي :أدت جميع المعاملات بإستخدام المحفزات الحيوية إلى زيادة جميع صفات النمو الخضري لنبات البطاطا الحلوة (طول النبات - عدد الأوراق - مساحة الورقة - العدد والوزن والطول والمحيط للدرنة- الكلوروفيل) خاصة الشاي الدودي (المعاملة رقم 7). وكان أيضا لإستخدام المحفزات الحيوية نتائج إيجابية من ناحية الصفات الكيمائية , فالمعاملة 9 (السماد مع التلقيح الفطري ، PGPRومستخلص الكلوريلا أعطت أفضل قيمة للكاروتينات) ، وكلا المعاملة 7 (السماد والشاي الدودي) والمعاملة 10 (السماد مع التلقيح الفطري ، PGPR ، مستخلص الكلوريلا والشاي الدودي) أعطت أفضل قيمة لحمض الأسكوربيك ، أما بالنسبة للدهون ، فلا توجد فروق فى معاملة الكونترول (الجرعة الموصى بها من السماد الكيميائى) وبين المعاملات 5 (السماد + مستخلص الكلوريلا) ، 8 (السماد العضوي ، الفطريات ، PGPRوالشاي الدودي).وفيما يتعلق بالبروتين ، كانت المعاملة 3 (السماد مع التلقيح بالميكوريزا) والمعاملة 4 (السماد مع PGPR) هي الأفضل وكانت المعاملة 3 أفضل للألياف, أما بالنسبة للسكريات كانت المعاملات 3 و 4 و 7 و 8 هي الأفضل ، وكانت المعاملة 10 (السماد مع التلقيح الفطري ، PGPR، مستخلص الكلوريلا والشاي الدودي) متفوقة على جميع المعاملات في نسبة النشا .وعند تقدير نسبة الرطوبة ، فقد تفوقت نسبة الرطوبة بإستخدام المعاملة 2 (الكمبوست بمفرده) ، وكذلك المعاملة 10 (السماد مع التلقيح الفطري ، PGPR، مستخلص الكلوريلا والشاي الدودي).وبالتالي ، توصى الدراسة الحالية من خلال النتائج التى تحصلنا عليها باستخدام محفزات النمو الحيوية والعضوية كاستراتيجية مفيدة وفعالة وقليلة التكلفة لتحقيق مفهوم الزراعة العضوية المستدامة.