



Effect of Bio-Stimulants on Quality Parameters of Garlic (*Allium sativum* L.) and Soil Health under Cultivation of South Eastern Rajasthan, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted at Vegetable Farm, Department of Vegetable Science, College of Horticulture and Forestry, Jhalawar (Rajasthan) during *rabi* season (2021-2022) on garlic (*Allium sativum* L.). The experiment was consisted ten treatments of bio-stimulants as soil drenching viz. (humic acid @ 4 g/L, humic acid @ 6 g/L., humic acid @ 8 g/L., seaweed extract @ 4 ml/L., seaweed extract @ 6 ml/L., seaweed extract @ 8 ml/L., vermiwash @ 10 ml/L, vermiwash @ 20 ml/L. and vermiwash @ 30 ml/L. and control) and laid out in randomized block design with three replications. The result of present study clearly indicates that quality parameters of garlic and soil

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health were improved with soil drenching of different bio-stimulants over control. The quality parameters of TSS (42.21 °Brix), dry matter content (42.54 %), crude protein content (7.05%), and pungency (10.39 μ mol/g), organic carbon (0.60) was significantly increased with application of humic acid @ 8 g/L over control. The maximum available nitrogen (342.74 kg ha⁻¹), phosphorus (17.47 kg ha⁻¹) and potassium (220.90 kg ha⁻¹) was recorded in the soil after harvest of garlic with application of humic acid @ 8 g/L over control.

Keywords: Garlic; humic acid; seaweed; bio-stimulants; soil drenching.

1. INTRODUCTION

Garlic (*Allium sativum* L.) crop is a member of the Alliaceae family. One of the most aromatic herbaceous annual spices. It is the second most widely spice crop of the cultivated *Allium* crops, next to onion in the world with a characteristic pungent smell. Garlic is originated in central Asia where it was extended to the mediterranean region in the pre-historic dates [1]. Garlic is medicinal herb with underground compound bulbs covered by outer white thin scales with simple smooth round stem surrounded by the bottom by tubular leaf sheath. India ranks second after China in area (247.52 thousand ha) and second in production (1259.27 thousand tonnes) of garlic with an average productivity of 5.09 metric tonnes per ha. The major garlic producing states of India are Madhya Pradesh, Orissa, Rajasthan, Karnataka, Uttar Pradesh and Gujarat. India is one of the garlic exporting countries of the world. In Rajasthan, garlic is grown extensively in the districts of Chittorgarh, Baran, Jodhpur, Jhunjhunu, Jhalawar, Udaipur, Kota, Dungarpur, Bundi, Jaipur and Sikar. The area under garlic cultivation in Rajasthan during 2021-22 was 3.93 lakh ha with production of 3208 metric tonnes [2]. At present ever increasing population is exerting tremendous pressure on agriculture to meet their nutritional food requirement across the world. In order to achieve the current demand of food requirement, farmers are relying more on chemical fertilizers to achieve higher productivity per unit area. However, the efficiency of the chemical fertilizers already reached a plateau due to their indiscriminate use and resulted in poor soil fertility status of the agriculture fields in addition to accumulation of toxic substances in the harvested produce. Also the cost of inorganic fertilizers is increasing enormously to an extent that they are not affordable by the small and marginal farmers. In this regard there is a need to identify the suitable substitute in place of chemical fertilizers which are economically cheaper and eco-friendly. In this juncture, the use of bio-stimulants plays an important role to

sustain the soil health as well as productivity of the crops [3]. The use of bio-stimulants such as humic acid, seaweed extract and vermiwash results in increasing growth, yield and quality of the crops. Bio-stimulants contain macro nutrients, essential micro nutrients, vitamins, amino acids, growth promoting regulators (IAA, GA and beneficial microorganisms) [4]. The bio-stimulants easily disperse in water and are readily available to plants compared to bulky organic manures. The humic acid, seaweed extract, jeevamrutha, beejamrutha, panchagavya, sanjivak, amrithpani, vermiwash, brahmastra, cow urine and enriched bio-digester bio-stimulants are easily available and eco-friendly, which contains beneficial microorganisms [5]. So looking to the importance of bio-stimulants and looking to the daily need of today's life it has become necessary to use these bio-stimulants to sustain human health as well as soil health. In view of the above facts and realizing the importance of bio-stimulants the present study to find out effect of bio-stimulants on quality of garlic and soil health.

2. MATERIALS AND METHODS

An experiment was conducted at Vegetable Farm, Department of Vegetable Science, College of Horticulture and Forestry, Jhalawar (Rajasthan) during *rabi* season (2021-2022) on garlic. According to Agro-ecological region map brought out by National Bureau of Soil Survey and Land Use Planning, Jhalawar falls in Agro-ecological region No.06. Geographically, is situated at between 23.200 N latitude and 75.350 E longitude at an altitude of 632.2 meters above MSL. The soil of experimental site was clay loam in texture (sand 23.6 %, silt 37.6 % and clay 39.8 %), slightly saline in reaction EC (0.54 dS m⁻¹) and pH 8.5. The experimental soil was medium in available nitrogen (217 kg ha⁻¹), phosphorus (16.93 kg ha⁻¹) and high in potassium (336 kg ha⁻¹) and low in DTPA extractable micronutrients (Zn 0.42 mg kg⁻¹, Fe 5.21 mg kg⁻¹, Cu 0.85 mg kg⁻¹ and Mn 2.90 mg kg⁻¹) with pH (7.6). In general, 100:50:50:50 kg ha⁻¹ NPK and S,

respectively, along with FYM @ 15 tonnes/ha is recommended. As a basal dose, complete dose of P, K and S and one-third dose of N should be applied along with FYM. Remaining one-third dose of N should be applied after a month of planting and one-third after 45 to 50 days. The experiment consisted ten treatments of bio-stimulants viz. Soil drenching of Humic acid @ 4 g/L, Soil drenching of Humic acid @ 6 g/L, Soil drenching of Humic acid @ 8 g/L, Soil drenching of Seaweed extract @ 4 ml/L, Soil drenching of Seaweed extract @ 6 ml/L, Soil drenching of Seaweed extract @ 8 ml/L, Soil drenching of Vermiwash @ 10 ml/L, Soil drenching of Vermiwash @ 20 ml/L and Soil drenching of Vermiwash @ 30 ml/L and control and laid out in randomized block design with three replications. Solution was prepared according to the treatments by dissolving it in water and soil drenching was done at 30 and 60 DAS.

3. RESULTS AND DISCUSSION

3.1 Effect of Bio-Stimulants on Quality Parameters

A perusal of data presented in Table 1 revealed that the quality attributes of garlic was significantly affected by the application of bio-stimulants. The findings indicated that TSS was significantly affected by different treatments. TSS ranged from 34.71 °Brix to 42.21 °Brix. Among the different treatments, maximum total soluble solid was recorded with application of soil drenching of humic acid @ 8 g/L. (42.21 °Brix), which was significantly superior over rest of the treatments while the minimum TSS (34.71 °Brix) was recorded in the control. The significantly highest dry matter content (42.54 %) was observed under application of humic acid @ 8g/l.

and lowest dry matter content (34.79%) was found under control. The humic acid@ 4 g/l. was found at par with humic acid @ 8g/l.. A keen observation of the data revealed that soil drenching of different bio-stimulants at different doses had significantly affected on crude protein content. The crude protein content was found maximum (7.29 per cent) with application of humic acid @ 8g/l. while, control recorded minimum crude protein content (5.42 per cent). The application of humic acid@ 4 g/l. was found at par with humic acid @ 8g/L. The pungency in garlic also influenced significantly with the drenching of humic acid. Treatment T3 (humic acid @ 8g/L) found with maximum pungency level (10.39 μ mol/g) and minimum pungency in bulb (6.45 μ mol/g) was observed in treatment T0 (control). Soil drenching of humic acid significantly increased the quality attributes like TSS, dry matter content, crude protein content and pungency of garlic bulb over control. The maximum values of quality parameters *i.e.* TSS (42.21 °Brix), dry matter content (42.54), crude protein (7.05 %) and pungency (10.39 μ mol/g) was recorded in treatment T3 (humic acid @ 8g/l) and minimum under control (T0). This might be due to application of humic acid helped in vigorous vegetative growth and imparted deep green colour to the foliage which favoured photosynthesis activity of the plants, so that there was greater accumulation of food material *i.e.*, carbohydrates and this leads to the more synthesis of TSS content. These results are in close agreement with findings of Yildirim [6] in tomato, Nursel and Fikret [7] in potato. However, the humic acid application caused an increase in the content of dry matter, starch, total carbohydrates and elemental values in the tuber tissues, may be due to application of humic acid might have the ability to increase the availability

Table 1. Effect of bio-stimulants Soil drenching on quality parameters of garlic

Treatments	Total Soluble Solids (°Brix)	Dry matter content (%)	Crude protein content (%)	Pungency in bulb (μ mol/g)
T ₁ : Control	34.71	34.79	5.42	6.45
T ₂ : Humic acid @ 4 g/L	38.99	38.63	6.17	9.31
T ₃ : Humic acid @ 6 g/L	40.09	41.59	6.65	9.91
T ₄ : Humic acid @ 8 g/L.	42.21	42.54	7.29	10.39
T ₅ : Seaweed @ 4 g/L.	36.74	35.27	6.08	7.62
T ₆ : Seaweed @ 6 g/L.	37.88	37.27	6.11	8.06
T ₇ : Seaweed @ 8 g/L.	40.00	39.12	6.20	9.85
T ₈ : Vermiwash @ 10 ml/L.	38.12	38.35	6.13	9.03
T ₉ : Vermiwash @ 20 ml/L.	38.34	38.58	6.16	9.12
T ₁₀ : Vermiwash @ 30 ml/L.	39.23	39.04	6.20	9.85
SEm \pm	0.61	1.05	0.27	0.09
CD (5%)	1.81	3.13	0.80	0.27

of other nutrients like nitrogen, phosphorus and potassium, probably due to higher rate of mineralization and favorable conditions for microbial and chemical activity [8]. Protein synthesis in garlic due to positive influences of humic acid like hormonal activities through their participation in cell respiration, photosynthesis, oxidative phosphorylation and various enzymatic reaction {Chen and Aviad, [9]; Muscolo et al., [10]}. A common assessment of pungency is made by measuring pyruvate formed as a stable primary compound from the enzymatic decomposition of flavour precursors and formed in a mole-for-mole relationship with flavour precursors and the concentration of humic acid development had positive increment in pungency. These results are in close agreement with findings of Manas et al., [11] in garlic.

3.2 Effect of Bio-Stimulants on Soil Health

A perusal of data presented in Table 2 revealed that the soil attributes of garlic was significantly affected by the application of bio-stimulants. The findings indicated that organic carbon in soil at the time of harvested of the crop recorded was found significant in all treatment of bio-stimulants. The maximum available Organic carbon (0.60) was found in treatment T3 and minimum (0.44) in treatment T0. The treatment T2 was found at par with T3. Soil drenching of humic acid @ 8g/L increased final OC by 27.66 per cent over the initial OC. Drenching of humic acid resulted in significant effect on available nitrogen in soil after harvest as compared to control. The maximum available nitrogen (342.74 kg/ha) was found in treatment T3 and minimum (337.30 kg/ha) in treatment T0 and the treatment T2 was found at par with T3 .Soil drenching of

humic acid @ 8g/L (T3) increased final N by 1.40 per cent over the initial N. The soil drenching of humic acid had significant effect on available phosphorus in soil after harvest as compared to control. The maximum available phosphorus (17.47 kg/ha) was found in treatment T3 and minimum (15.03 kg/ha) was recorded in treatment T0, respectively. The treatment T1 and T2 were found at par with treatment (T3). The soil drenching of humic acid @ 8g/L increased final phosphorus by 17.54 percent over the initial P₂O₅. Soil drenching with humic acid resulted in significant effect on available potassium in soil after harvest as compared to control. The maximum available potassium (219.90 kg/ha) and minimum (214.25 kg/ha) was observed in treatment T3 and T0, respectively after harvest. The treatment T3 was found highly superior among all the treatments. Soil drenching of humic acid @ 8g/L increased final K₂O by 1.42 per cent over the initial K₂O. Application of humic acid significantly influenced the soil nutrient status after harvest the garlic crop. Data as regard to the effect of humic acid (@ 8g/L) on soil parameters like organic carbon (0.60%), N (343.48 kg ha⁻¹), P₂O₅ (18.44 kg ha⁻¹), K₂O (220.90 kg ha⁻¹) were found influenced over control. The increase in the availability of nitrogen, phosphorus and potassium in soil after harvest of garlic might be due to the proper decomposition and mineralization of humic acid. Humic acid supplied available nitrogen, phosphorus and potassium directly to the plants after being decomposed and mineralized and also had solubilizing effects on fixed form of nutrients. In fact, all the available nutrients in soil are not utilized by the plant and rest remained in soil which increased their availability after harvest. Humic acid (HA) is the active constituent of organic humus, which can play a very

Table 2. Effect of bio-stimulants on soil health after harvest of garlic crop

Treatments	Organic carbon (%)	Available N (kg/ha)	Available P ₂ O ₅ (kg/ha)	Available K ₂ O (kg/ha)
Initial value	0.47	338.0	14.86	213.2
T1: Control	0.44	337.7	15.03	214.2
T2: Humic acid @ 4 g/L.	0.54	339.8	16.64	217.4
T3: Humic acid @ 6 g/L.	0.59	340.4	16.91	217.7
T4: Humic acid @ 8 g/L.	0.60	342.7	17.47	220.9
T5: Seaweed @ 4 g/L.	0.50	338.1	16.11	216.2
T6: Seaweed @ 6 g/L.	0.51	338.3	16.14	216.5
T7: Seaweed @ 8 g/L.	0.52	339.2	16.37	217.3
T8: Vermiwash @ 10 ml/L.	0.46	337.3	15.72	215.2
T9: Vermiwash @ 20 ml/L.	0.46	337.3	15.84	215.8
T10: Vermiwash @ 30 ml/L.	0.49	337.3	16.01	215.8
SEm ±	0.02	0.95	0.36	1.0
CD (5%)	0.06	2.81	1.06	2.9

important role in soil conditioning and plant growth [12]. Physically, it promotes good soil structure and increases the water holding capacity of the soil; biologically it enhances the growth of useful soil organisms, while chemically it serves as an adsorption and retention complex for inorganic plant nutrients [13]. Humic acid increases the porosity of soil and improve growth of root system which leads to increase the shoot system. Humic acid degrade soil, improve its physical, chemical, biological and nutritional characteristics by degrading clay particles and increasing water holding capacity [9]. These results are in close conformity with findings of Selim et al., [14] in potato.

4. CONCLUSION

It is concluded that the quality and soil parameters of garlic showed considerable increment due to soil application of Humic acid @ 8g/L and Humic acid @ 6g/L. Hence this dose of bio-stimulants proved as beneficial for increasing quality and good soil health. These levels of bio-stimulants may be passed on to the farmers for obtaining higher monetary returns of zone Vth of Rajasthan.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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