**Impact of Biostimulant Soil Application on Improving Soil Properties and Nutrient Availability in Sweet Potato Field**

**Abstract**

An experiment conducted at the vegetable farm, Department of Vegetable Science, College of Horticulture and Forestry, Jhalrapatan City, Jhalawar during rabi season 2020-21. The experiment consisted of twelve treatment combinations having four levels each of Humic acid (0, 10, 20 and 30 ml/l) and Seaweed (0, 1 and 2 ml/l) in Factorial Randomized Block Design with three replications, while Humic acid was applied through soil application and seaweed was applied through foliar application. There was significant effect of biostimulants (Humic acid and seaweed) treatment on soil parameters (*i.e.* soil pH, Ec, Bulk density, Particle density and available NPK & Organic carbon) of sweet potato field alone and combination over control. The individual and combined application of humic acid at 30 ml/l significantly affected the soil pH 7.65, soil Ec 0.42, bulk density 1.32, particle density 2.62, available nitrogen 314.66 kg/ha, phosphorus 24.37 kg/ha, potassium (279.68 kg/ha) and maximum soil organic carbon (0.64 %) were recorded as compared to control.

**Key word**: Bio stimulants, Soil attributes, Humic acid, Seaweed and Sweet potato.

**1. Introduction**

The Sweet potato (*Ipomoea batatas* L*.*) is a dicotyledonous plant that belongs to the family Convolvulaceae. Sweet potato is a hexaploid plant with basic chromosome number *x*=15 (2*n* = 6*x* = 90). Sweet potato popularly known as “SakarKand” in India. It is grown as a starchy food crop throughout the tropical, sub-tropical and frost-free temperate climatic zones in the world. It is believed to have originated in Central America and the North Western part of South America.

In India, sweet potato occupies an area over 106.21 thousand hectares with production of 1121.33 thousand tonnes and productivity of 10.56 MT/ha.(DA&FW, 2021). In India, it is cultivated in almost all the states but major contribution comes from four states namely Odisha, Kerala, West Bengal and Uttar Pradesh. Odisha is the largest producer of sweet potato in India. In Rajasthan it cultivates over an area of 7.11 thousand hectares with production of 15.274 MT (Raj. Agril. Stat., 2021-22).

The term biostimulants refers to substances of biological origin or microorganisms which, when applied to plants either via root drench, foliar spray, or a combination of both, is intended to stimulate natural processes in the plant that is responsible for efficient plant nutrient use efficiency and growth processes and/or an increase in the tolerance to abiotic and biotic stress, irrespective of the plant-beneficial nutrient content of the substances.Humic acid (HA) is considered non-essential fertilizers but it is soil enhancer and soil improver. It physically modifies the soil, biologically stimulates plant growth and chemically changes the fixation properties of soil. Humic acid is the final products of the decomposition of organic residuals and take part in important reactions that occur in soils, influencing fertility by improving physical and biological conditions and by producing physiologically active substances (Canellas *et al*., 2008).

Seaweeds are the macroscopic marine algae. They are used as food for human, fodder for cattle, as a substitute of chemical fertilizer and source of various fine chemicals. Besides this, it is used for obtaining many industrial products such as agar, alginate (Khan *et al*. 2009). In recent years, natural seaweeds are being used as substitute of synthetic fertilizer fertilizers. Seaweed extracts are marketed as liquid fertilizers and bio-stimulants because they contain multiple growth regulators such as cytokine’s (Durand *et al*. 2003), auxins (Sahoo, 2000), gibberellins (Strik and Staden, 1997) and various macro and micronutrients necessary for plant growth and development.

**2. Material and methods**

**2.1. Experimental sites**

The present investigation was conducted at an experimental vegetable farm, Department of Vegetable Science, College of Horticulture and Forestry, Jhalrapatan City, Jhalawar during 2020-21.

**2.2 Location and climate**

Jhalawar district is located at 23°4’ to 24°52’ N-Latitude and 75°29’ to   
76°56’ E-Longitude in South Eastern Rajasthan. Agro-climatically, the district falls in Zone V and is known as Humid South Eastern Plain.

**2.3 Soil condition**

The physico-chemical characteristics of the black cotton-textured clay loam soil at the experimental site were examined using representative samples taken from different areas and the mechanical, physical and chemical were analyzed.

**2.4 Experimental materials**

Sweet potato vine measuring 20-30 cm lengths were brought from primary nursery and then it was maintained in the secondary nursery for further growth. After 50-60 days after transplanting, they were transplanted in the main field according to the respective treatments.

The experiment consisted of 12 treatment combinations involving 2 biostimulants (Humic acid and seaweed) with four levels of Humic acid @ 0, 10, 20 and 30 ml/ soil drenched and three levels of Seaweed @ 0, 1 and 2ml/litter as a foliar spray. The details of treatments are given below:

List 1. Details of treatments

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
| S. No. | Treatment Notation | Treatment’s combination | Treatment Details |
|  | T0 | H0 + S0 | 0 ml H + 0 ml S (Control) |
|  | T1 | H0 + S1 | 0 ml H + 1 ml S |
|  | T2 | H0 + S2 | 0 ml H + 2 ml S |
|  | T3 | H1 + S0 | 10 ml H + 0 ml S |
|  | T4 | H1 + S1 | 10 ml H + 1 ml S |
|  | T5 | H1 + S2 | 10 ml H + 2 ml S |
|  | T6 | H2 + S0 | 20 ml H + 0 ml S |
|  | T7 | H2 + S1 | 20 ml H + 1 ml S |
|  | T8 | H2 + S2 | 20 ml H + 2 ml S |
|  | T9 | H3 + S0 | 30 ml H + 0 ml S |
|  | T10 | H3 + S1 | 30 ml H + 1 ml S |
|  | T11 | H3 + S2 | 30 ml H + 2 ml S |

**2.5 Treatment Application**

The humic acid was applied to the soil after dissolving in water according to the treatments after 45 and 90 days of transplanting. While the distilled water was taken for spraying in the control treatment. The seaweed was sprayed after dissolving directly in distilled water. The spray of seaweed treatments was done after 45 and 90 days of transplanting. The recommended dose of N, P205 and K2O were 50, 60 and 50 kg/ha. The whole quantity of organic manure (Vermicompost @ 10 t/ha), K2O, P2O5 and half quantity of nitrogen was incorporated into the soil at the last ploughing. The remaining quantity of nitrogen was top-dressed in furrows about 15-20 cm away from vines at the time of earthing up.

**2.6 Soil parameters were studied in experiment given below with methodology-:**

Soil pH was determined using a 1:2 soil-water suspension with a glass electrode pH meter (Jackson, 1973), while electrical conductivity (EC) was measured in a 1:2.5 soil-water suspension using an EC meter (Elico CL 180) and values were converted to saturation paste EC (Dasog, 1975). Bulk density was calculated by the core sampling method for 0–15 cm depth (Piper, 1950), dividing the mass of oven-dry soil by the volume of the soil core. Particle density was measured by boiling soil in water to remove air, then determining the mass and volume of solid particles. Organic carbon was assessed using Walkley-Black’s (1934) chromic acid wet oxidation method, while available nitrogen was determined by the alkaline potassium permanganate method (Subbiah and Asija, 1956). Available phosphorus was analyzed using Olsen’s method (1954) with a 0.5 M NaHCO₃ extract and available potassium was measured by flame photometry following extraction with neutral ammonium acetate (Metson, 1956). All measurements were calculated using standard formulas and reagents specific to each property.

**2.7 Statistical Analysis**

The experiment's data was statistically examined using the analysis of variance technique, as recommended by Panse *et al*. (1995).

**3. Results and Discussion**

The results revealed that the application of humic acid significantly influenced soil properties, enhancing nutrient availability and soil quality after harvest. Treatment H3 (30 ml humic acid) was the most effective, recording the lowest soil pH (7.65) and electrical conductivity (0.42 dS m⁻¹), while control (H0) showed the highest pH (7.83) and EC (0.51 dS m⁻¹). Bulk density (1.32 mg m⁻³), particle density (2.62 mg m⁻³), organic carbon (0.64%), nitrogen (314.66 kg N ha⁻¹), phosphorus (24.37 kg P₂O₅ ha⁻¹) and potassium (279.68 kg K₂O ha⁻¹) were all significantly higher in H3, demonstrating improved soil conditions. Similarly, seaweed application positively impacted soil properties, with treatment S2 (2 ml seaweed) enhancing nutrient levels and reducing bulk density compared to the control (S0). Combined application of humic acid and seaweed, particularly H3S2, maximized nutrient availability, including nitrogen (314.76 kg N ha⁻¹), phosphorus (24.56 kg P₂O₅ ha⁻¹) and potassium (279.90 kg K₂O ha⁻¹), highlighting synergistic effects. These improvements are attributed to humic acid's role in nutrient solubilization, enhanced decomposition and improved soil structure, as well as its interaction with soil minerals to increase porosity and water-holding capacity. The findings align with studies by Chen and Aviad (1990); Selim *et al*. (2009); Khaled and Fawy (2011) emphasizing humic acid’s ability to enhance soil physical, chemical and biological properties, ultimately promoting plant growth.

The increase in the availability of nitrogen, phosphorus and potassium in soil after harvest of sweet potato 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 (Rigi *et al*., 2014; Munawar Ali and Wanti Mindari, 2016).

Humic Acid (HA) is the active constituent of organic humus, which can play a very important role in soil conditioning and plant growth (Bendetti, 1996). 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 (Brannon and Sommers, 1985). Humic acid increases the porosity of soil and improve growth of root system which leads to increase the shoot system (Garcia *et al*, 2008). Mataroiev (2002) describe the role of humats in improving soil physical and chemical characteristics by reaction with soil minerals then improving watery, aerial soil characteristics and nutrient mineral adsorption. Humic acid degrade soil, improve its physical, chemical, biological and nutritional characteristics by degrading clay particles and increasing holding water capacity.

**Table 1. Effect of humic acid and seaweed on soil pH after harvest.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Seaweed**  **Humic acid** | **S0** | **S1** | **S2** | **Mean** |
| **H0** | 7.85 | 7.84 | 7.82 | 7.83 |
| **H1** | 7.82 | 7.76 | 7.74 | 7.77 |
| **H2** | 7.73 | 7.74 | 7.72 | 7.73 |
| **H3** | 7.66 | 7.65 | 7.64 | 7.65 |
| **Mean** | 7.76 | 7.75 | 7.73 |  |
|  | **S.Em±** | | **C.D. at 5%** | |
| **H** | 0.08 | | 0.02 | |
| **S** | 0.07 | | 0.02 | |
| **H ×S** | 0.01 | | NS | |

**Table.2 Effect of humic acid and seaweed on soil EC after harvest.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Seaweed  Humic acid | **S0** | **S1** | **S2** | **Mean** |
| **H0** | 0.51 | 0.51 | 0.51 | 0.51 |
| **H1** | 0.50 | 0.48 | 0.47 | 0.48 |
| **H2** | 0.46 | 0.45 | 0.43 | 0.45 |
| **H3** | 0.42 | 0.42 | 0.42 | 0.42 |
| **Mean** | 0.47 | 0.47 | 0.46 |  |
|  | **S.Em±** | | **C.D. at 5%** | |
| **H** | 0.003 | | 0.009 | |
| **S** | 0.003 | | 0.008 | |
| **H ×S** | 0.005 | | NS | |

**Table.3 Effect of humic acid and seaweed on soil bulk density after harvest.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Seaweed  Humic acid | **S0** | **S1** | **S2** | **Mean** |
| **H0** | 1.38 | 1.38 | 1.36 | 1.37 |
| **H1** | 1.35 | 1.36 | 1.32 | 1.34 |
| **H2** | 1.34 | 1.35 | 1.34 | 1.34 |
| **H3** | 1.32 | 1.33 | 1.33 | 1.32 |
| **Mean** | 1.34 | 1.35 | 1.33 |  |
|  | **S.Em±** | | **C.D. at 5%** | |
| **H** | 0.005 | | 0.015 | |
| **S** | 0.004 | | 0.013 | |
| **H ×S** | 0.009 | | NS | |

**Table.4 Effect of humic acid and seaweed on soil particle density of soil after harvest.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Seaweed  Humic acid | **S0** | **S1** | **S2** | **Mean** |
| **H0** | 2.64 | 2.64 | 2.62 | 2.63 |
| **H1** | 2.62 | 2.64 | 2.63 | 2.63 |
| **H2** | 2.64 | 2.62 | 2.61 | 2.62 |
| **H3** | 2.62 | 2.62 | 2.62 | 2.62 |
| **Mean** | 2.63 | 2.63 | 2.62 |  |
|  | **S.Em±** | | **C.D. at 5%** | |
| **H** | 0.003 | | 0.008 | |
| **S** | 0.002 | | 0.007 | |
| **H ×S** | 0.005 | | 0.014 | |

**Table 5. Effect of humic acid and seaweed on soil available N of sweet potato field.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Seaweed  Humic acid | **S0** | **S1** | **S2** | **Mean** |
| **H0** | 309.92 | 310.58 | 311.25 | 310.58 |
| **H1** | 312.40 | 312.68 | 312.78 | 312.62 |
| **H2** | 313.37 | 313.53 | 313.39 | 313.43 |
| **H3** | 314.59 | 314.64 | 314.76 | 314.66 |
| **Mean** | 312.57 | 312.85 | 313.04 |  |
|  | **S.Em±** | | **C.D. at 5%** | |
| **H** | 0.14 | | 0.37 | |
| **S** | 0.09 | | 0.26 | |
| **H ×S** | 0.18 | | 0.53 | |

**Table 6. Effect of humic acid and seaweed on soil available P2O5after harvest.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Seaweed  Humic acid | **S0** | **S1** | **S2** | **Mean** |
| **H0** | 21.23 | 21.73 | 22.01 | 21.66 |
| **H1** | 22.51 | 22.63 | 22.67 | 22.60 |
| **H2** | 22.82 | 23.14 | 23.34 | 23.10 |
| **H3** | 24.16 | 24.40 | 24.56 | 24.37 |
| **Mean** | 22.68 | 22.97 | 23.15 |  |
|  | **S.Em±** | | **C.D. at 5%** | |
| **H** | 0.030 | | 0.09 | |
| **S** | 0.026 | | 0.07 | |
| **H ×S** | 0.053 | | 0.15 | |

**Table 7. Effect of humic acid and seaweed on soil available K2O after harvest.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Seaweed  Humic acid | **S0** | **S1** | **S2** | **Mean** |
| **H0** | 275.27 | 276.27 | 276.86 | 276.11 |
| **H1** | 277.33 | 277.56 | 277.71 | 277.53 |
| **H2** | 277.91 | 278.37 | 278.81 | 278.36 |
| **H3** | 279.57 | 279.63 | 279.90 | 279.68 |
| **Mean** | 277.49 | 277.95 | 278.32 |  |
|  | **S.Em±** | | **C.D. at 5%** | |
| **H** | 0.08 | | 0.25 | |
| **S** | 0.07 | | 0.22 | |
| **H ×S** | 0.19 | | 0.44 | |

**Table.8 Effect of humic acid and seaweed on soil available organic carbon after harvest.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Seaweed    Humic acid | **S0** | **S1** | **S2** | **Mean** |
| **H0** | 0.47 | 0.48 | 0.50 | 0.48 |
| **H1** | 0.50 | 0.52 | 0.55 | 0.52 |
| **H2** | 0.56 | 0.58 | 0.60 | 0.58 |
| **H3** | 0.62 | 0.65 | 0.67 | 0.64 |
| **Mean** | 0.54 | 0.55 | 0.58 |  |
|  | **S.Em±** | | **C.D. at 5%** | |
| **H** | 0.003 | | 0.01 | |
| **S** | 0.003 | | 0.09 | |
| **H ×S** | 0.006 | | NS | |

**4. Conclusion**

The application of humic acid and seaweed extract significantly improved soil physical and chemical properties, enhancing nutrient availability and organic carbon content. The treatment H3 (30 ml humic acid) demonstrated the most substantial improvements in reducing soil pH and electrical conductivity while increasing bulk density, particle density and the availability of essential nutrients such as nitrogen, phosphorus and potassium. The combined treatment H3S2 (30 ml humic acid and 2 ml seaweed extract) exhibited synergistic effects, further maximizing nutrient availability and soil quality compared to individual treatments. These findings underscore the potential of humic acid and seaweed extracts as effective soil amendments for improving soil health, optimizing nutrient management and supporting sustainable agricultural practices.

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**6. Author contribution**

All authors contributed significantly to the research. Hardat Kaswan conducted the field experiment, collected data, performed the analysis and drafted the initial manuscript. Dr Kavita A., supervised the research, provided guidance on experimental design and methodology and contributed to interpreting the results. Jitendra Gurjar, contributed to the experimental setup, provided expertise in the application of bio-stimulants, assisted in the statistical analysis and reviewed the manuscript. Sunita Choudhary, assisted with the field experiment, offering insights on soil and plant interactions while reviewing and editing the manuscript. Their combined efforts were crucial in achieving the study's objectives and producing meaningful results.

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