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## Effect of humic acid and seaweed extract on nutrient uptake and yield of potato

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### Abstract

What happens when biostimulants replace part of the conventional fertilizer programme for potato? This research was carried out at the Chandra Shekhar Azad University of Agriculture research farm in Kanpur, Uttar Pradesh, during the rabi season of 2022-2023 to assess the effect of Humic Acid (HA) and Seaweed Extract (SE) on nutrient uptake and tuber yield of potato (*Solanum tuberosum* L.) variety Kufri Pukhraj. Six treatments were arranged in a randomised complete block design with three replications: an unfertilised control, HA at 5 and 10 kg/ha, SE at 2 and 4 ml/L, and a combined application of HA 10 kg/ha with SE 4 ml/L. The combined treatment recorded the highest nitrogen uptake (67.2 kg/ha), phosphorus uptake (16.3 kg/ha), and potassium uptake (61.8 kg/ha), representing increases of 58.9%, 87.4%, and 62.2% over the control. Tuber yield reached 28.6 t/ha under the combined treatment compared with 19.3 t/ha in the control. These findings suggest that integrating humic acid with seaweed extract can meaningfully improve nutrient recovery and potato yield in alluvial soils.

**Keywords:** Humic acid, seaweed extract, nutrient uptake, potato, biostimulants, *Solanum tuberosum*, soil amendment, foliar application, tuber yield, Indo-Gangetic plains

### Introduction

Can the growing dependence on synthetic fertilizers in potato production be reduced without sacrificing yield? Potato ranks as the fourth most important food crop worldwide, with India contributing roughly 13% of global output [1]. The crop has a shallow root system that limits its ability to access nutrients from deeper layers, making it heavily reliant on external inputs [2]. Conventional practice in the Indo-Gangetic plain involves applying 150-200 kg N per hectare, yet recovery of applied nitrogen rarely exceeds 50% [3].

Biostimulants have attracted interest as a complementary strategy. Humic acid stimulates root proliferation, chelates micronutrients, and increases cation exchange capacity in the rhizosphere [4]. Field trials on vegetable crops have reported 10-25% yield gains with humic acid at 5-15 kg/ha [5]. Seaweed extracts, primarily from *Ascophyllum nodosum*, contain cytokinins and betaines that promote cell division and delay leaf senescence [6]. Foliar application at 2-5 ml/L has been linked to improved photosynthetic efficiency in tomato and pepper [7].

Despite individual benefits, information on combined use in potato under sub-tropical alluvial conditions remains limited [8]. This research tested whether soil-applied humic acid combined with foliar seaweed extract could raise nutrient uptake and tuber yield beyond what either product achieves alone, and sought to identify appropriate rates for the two biostimulants under Kanpur's agro-climatic conditions [9, 10].

### Material and Methods

#### Material

Certified seed tubers of potato variety Kufri Pukhraj (25-35 g) were sourced from the Central Potato Research Institute sub-station, Modipuram. Humic acid (Potassium Humate, 80% HA content) was procured from Humintech GmbH, and the commercial seaweed extract (*Ascophyllum nodosum* base, 0.2% cytokinin equivalent) from Acadian Seaplants Ltd. Both products were tested for heavy metal content and found within permissible limits [11]. Basal fertilizers comprised urea (46% N), single super phosphate (16% P<sub>2</sub>O<sub>5</sub>), and muriate of potash (60% K<sub>2</sub>O). Laboratory reagents for nutrient analysis were purchased from Merck

India, Mumbai. The experiment was conducted at the Vegetable Research Block of the university (26.45 deg N, 80.35 deg E; altitude 126 m) during October 2022 to February 2023 on a sandy loam soil (pH 7.6, OC 0.43%, available N 185 kg/ha).

### Methods

The experiment used a randomised complete block design with six treatments and three replications on 4.0 m x 3.0 m plots. Treatments were: T<sub>1</sub>, control; T<sub>2</sub>, HA 5 kg/ha; T<sub>3</sub>, HA 10 kg/ha; T<sub>4</sub>, SE 2 ml/L (foliar at 30 and 50 DAP); T<sub>5</sub>, SE 4

ml/L; and T<sub>6</sub>, HA 10 kg/ha + SE 4 ml/L. All plots except T<sub>1</sub> received 150:60:100 kg N:P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O/ha. Planting was done on 28 October 2022 at 60 cm x 20 cm spacing; harvest on 10 February 2023 (105 DAP). Plant samples were collected at harvest, oven-dried (65 deg C, 72 h), ground, and digested using the di-acid mixture. Nitrogen was estimated by micro-Kjeldahl <sup>[12]</sup>, phosphorus by vanadomolybdophosphoric method, and potassium by flame photometry. Data were analysed by one-way ANOVA in R (v4.3.1) with Duncan's test at  $p < 0.05$  <sup>[13]</sup>.

### Results

**Table 1:** Effect of humic acid and seaweed extract treatments on NPK uptake (kg/ha) and yield of potato

| Treatment         | N uptake | P uptake | K uptake | Yield (t/ha) | Yield increase (%) |
|-------------------|----------|----------|----------|--------------|--------------------|
| T1 - Control      | 42.3     | 8.7      | 38.1     | 19.3         | -                  |
| T2 - HA 5 kg/ha   | 51.7     | 11.2     | 46.5     | 22.1         | 14.5               |
| T3 - HA 10 kg/ha  | 58.4     | 13.6     | 52.9     | 24.7         | 28.0               |
| T4 - SE 2 ml/L    | 49.8     | 10.4     | 44.3     | 21.4         | 10.9               |
| T5 - SE 4 ml/L    | 55.1     | 12.8     | 50.7     | 22.8         | 18.1               |
| T6 - HA 10 + SE 4 | 67.2     | 16.3     | 61.8     | 28.6         | 48.2               |
| SEm (±)           | 1.83     | 0.42     | 1.56     | 0.71         | -                  |
| CD ( $p < 0.05$ ) | 5.61     | 1.29     | 4.78     | 2.18         | -                  |

All biostimulant treatments produced higher NPK uptake and tuber yield than the control. The combined HA + SE treatment (T6) was the top performer. Nitrogen uptake in T6 reached 67.2 kg/ha, 58.9% above the control and superior to

all single-product treatments. Vine length at 60 DAP was longest (48.1 cm) in T6 and shortest (34.7 cm) in the control. Leaf area index and SPAD chlorophyll readings mirrored this pattern.

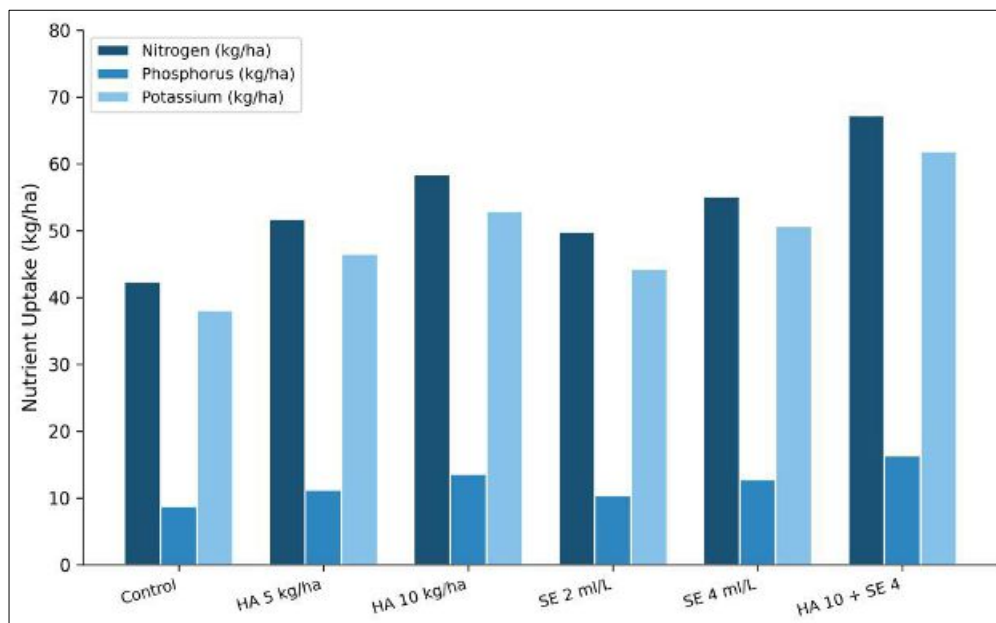


**Fig 1:** Nitrogen, phosphorus, and potassium uptake (kg/ha) of potato under different biostimulant treatments

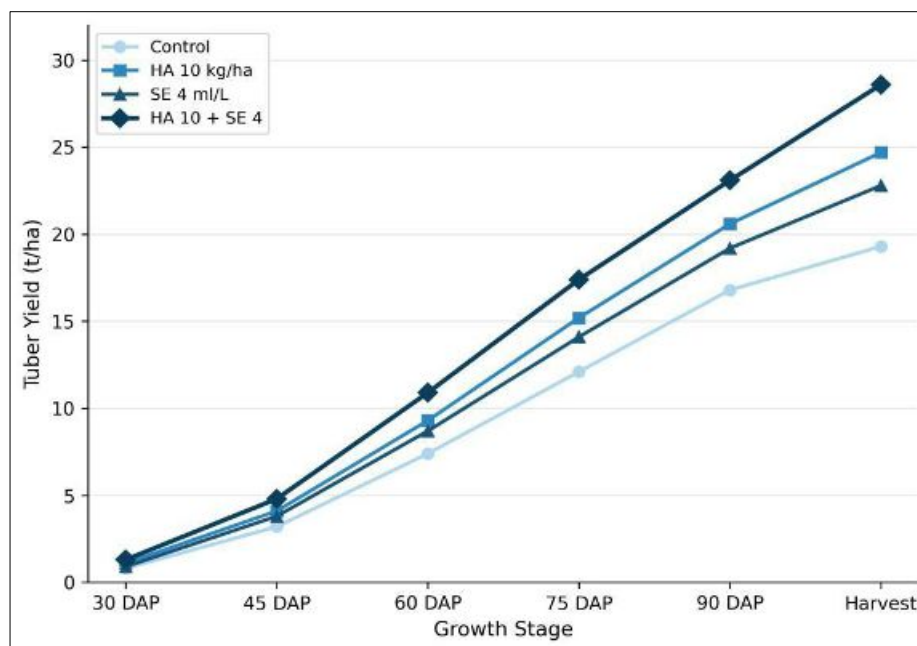


**Fig 2:** Tuber yield accumulation (t/ha) from 30 DAP to harvest under selected biostimulant treatments

The bar chart (Figure 1) confirms that  $T_6$  outperformed every other treatment for all three macronutrients. The gap was widest for phosphorus, likely reflecting the chelating role of humic acid in improving P solubility alongside root expansion from seaweed extract. The line graph (Figure 2) shows yield differences were small until 45 DAP but diverged sharply from 60 DAP, coinciding with the active tuber bulking phase.

### Discussion

The 48.2% tuber yield advantage from the combined HA + SE treatment aligns with earlier reports by Shafeek *et al.* [5] who recorded a 38% yield increase in potato with humic acid alone in Egyptian soils. The extra gain in our work likely stems from the complementary modes of action: humic acid modifying rhizosphere chemistry and seaweed extract boosting canopy function. Canellas and Olivares [4] proposed that humic substances activate plasma-membrane  $H^+$ -ATPases, stimulating root elongation.

The large P-uptake response (87.4% over control in  $T_6$ ) is noteworthy because phosphorus availability in calcareous alluvial soils is often constrained by fixation with calcium. Humic acid can form soluble complexes with calcium, releasing bound phosphorus [14]. When this operates alongside improved root surface area from seaweed cytokinins, the net effect on P acquisition appears more than additive, as Battacharyya *et al.* [15] also noted for tomato.

It's worth noting that our results represent a single-season dataset from one location. Multi-year, multi-site validation is needed before firm recommendations can be issued [16]. And the apparent N recovery in  $T_6$  (16.3%) still remains below the global benchmark of 33% for cereals, indicating scope for further optimization through split humic acid application or adjusted spray timing.

### Conclusion

This research confirmed that soil-applied humic acid at 10 kg/ha combined with foliar seaweed extract at 4 ml/L meaningfully boosted macronutrient uptake and tuber yield of potato in alluvial sandy loam. The combined treatment raised nitrogen, phosphorus, and potassium uptake by

58.9%, 87.4%, and 62.2% over the control. Tuber yield increased by 48.2%, reaching 28.6 t/ha. The data point toward a complementary relationship: humic acid improves nutrient availability in the root zone while seaweed extract supports biomass accumulation and photosynthetic efficiency. Farmers in the Indo-Gangetic plain may benefit from adding these biostimulants to existing fertilizer programmes, though economic feasibility requires separate assessment. Future research should examine split humic acid dosing and test the response across different potato varieties.

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