Plant Archives Vol. 26, Supplement 2, 2026 pp. 1548-1552 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-2.184

INFLUENCE OF BROCCOLI GROWTH, YIELD AND QUALITY THROUGH COMBINE EFFECT OF BIOSTIMULANT AND INORGANIC FERTILIZER (*Brassica oleracea* L. *var. italica*)

Tannu Sri[1], Sangeeta Kumari[2*], Rishabh Kumar[1], Shiv Nath Das[3] and N. Y. Azmi[4]
[1]Department of Horticulture (Vegetable Science), Bihar Agricultural University, Sabour, Bihar, India
[2]Department of Horticulture (Vegetable Science), Agricultural Research Institute, Patna, Bihar, India
[3]Department of Agronomy, Betelvine Research Centre, Islampur, Nalanda, Bihar, India
[4]Department of Soil Science & Agricultural Chemistry, Agricultural Research Institute, Patna, Bihar, India
*Corresponding author E-mail: sangeeta6b@gmail.com
(Date of Receiving : 17-03-2026; Date of Revision : 24-04-2026; Date of Acceptance : 25-05-2026)

ABSTRACT

Using biostimulants as an alternative to traditional chemical fertilization raising consumer knowledge has aided in bringing up environmental and food safety concerns developing an appropriate strategy for the application of alternatives to traditional chemical fertilizers in agriculture. So, this research was carried out to evaluate the impact of various biostimulants along with different doses of nitrogen on the performance of broccoli at Agricultural Research Institute, Patna. The experiment was carried out in the year 2024–2025 during the winter season (*Rabi*) using the Randomized Block Design with three replications and eight treatments, including a control. The results showed that the treatment T_4 (90 kg N/ha + Humic Acid @ 2 L/ha) recorded superior performance in terms of plant height 25 days, 50 days and at harvest (25.72 cm, 49.06 cm, 60.87 cm), no. of leaves per plant 25 days, 50 days and at harvest (8.53, 21.64. 24.10), dry matter production 25 days, 50 days and at harvest (6.59 g/plant, 65.01 g/plant, 89.09 g/plant), Leaf Area index (LAI) at 25, 50 DAP and at harvest (0.16 , 0.37, 0.47), Crop growth rate at 25-50 DAP and 50 DAP to harvest (2.34 g m^{-2} day^{-1} & 1.00 g m^{-2} day^{-1}), Days to 50% head initiation (54), days to head maturity (64), diameter of head (17.11 cm), fresh weight of head (382.76 g/plant), fresh head yield (17513.10 kg/ha), fresh biological yield (33120.08 kg/ha), protein content in head (2237.50 mg/100g) and TSS (13.16 ºbrix), indicating the potential of biostimulants to compensate for reduced nitrogen inputs and minimum was recorded in T_1 (control). The study concludes that integration of biostimulants, particularly Humic Acid at 2 L/ha with 90 kg N/ha, is effective in enhancing the growth, higher yield, and quality of broccoli while promoting sustainable nutrient management.
Keywords **:** Seaweed extract, Humic acid, Jeevamrut, Broccoli

Introduction

Broccoli (*Brassica oleracea* L. *var. italica*) is an important winter-season vegetable belonging to the family Brassicaceae (Islam *et al*., 2023). Broccoli is valued for its high nutritional content, especially in vitamins A, C, and K, dietary fiber, minerals, and health-promoting bioactive components including glucosinolates and polyphenols (Valverde *et al*., 2015). They counteract cancer and other diseases in an effective way (Ordiales *et al.*, 2017). Due to increasing consumer awareness of health benefits, the demand for broccoli is steadily rising in both domestic and international markets. To meet this demand, maximising yield and quality through efficient nutrient management practices is essential.

Nitrogen is a critical macronutrient that plays a essential role in plant growth and development, while phosphorus promotes root growth and provides energy by producing ATP (Noura *et al*., 2021 and Sofi *et al*., 2025). Additionally, potassium is essential for osmotic control, enzyme activation, and glucose metabolism (Nieves-Cordones *et al.*, 2016). Furthermore,

various factors affect broccoli growth, with fertilizer application becoming the most significant. However, the excessive use of inorganic fertilizers can lead to adverse environmental impacts such as nitrate leaching, soil degradation, and greenhouse gas emissions. In this context, integrating organic and biological inputs such as biostimulants could be regarded as a potent and sustainable nutritional crop supplementation which may mitigate the environmental problems arise from excessive fertilization (Halpern *et al*., 2015) and enhance nutrient use efficiency, improve crop performance, and maintain soil health.

Biostimulants such as seaweed extract, humic acid, and Jeevamrut are known to promote plant growth, stimulate microbial activity, improve nutrient uptake, and enhance plant tolerance to abiotic stress. Seaweed extract contains various growth regulators, micronutrients and polysaccharides which improves sprouting (Carvalho *et al*., 2013), increasing vegetative growth (DongLin and Yasunori, 2003), enhance the chlorophyll content (Thirumaran *et al*., 2009), as well as the amount of production (Shehata *et al.*, 2011). Humic acid enhances micronutrient availability in soil as a chelating agent and increase nutrients uptake to the plants (Yang *et al*., 2021) also improved crop growth status by enhancing growth promoting hormones like cytokinin and auxin, which help in the metabolic process of nutrients, stress resistance, and photosynthesis activity (Canellas *et al*., 2020 and Jindo *et al*., 2020). Jeevamrut, a traditional fermented liquid organic formulation it contains beneficial microorganisms which ensure the mineralization of organic matter or humus to mobilize fixed nutrients (Reddy *et al.*, 2021) improves microbial diversity, acts as a nutrient reservoir that can improve soil fertility and crop productivity (Ray *et al.*, 2020).

The present study was undertaken to evaluate the combined effect of biostimulants and varying levels of nitrogen on the growth, yield, and quality of broccoli. By integrating these biostimulants with reduced nitrogen doses, this research aims to identify a balanced nutrient management strategy that can improve productivity and quality while reducing chemical fertilizer dependence. The findings are expected to contribute to the development of sustainable broccoli production systems with better economic and environmental outcomes.

Materials and Methods

The field experiment was conducted at the research farm of Agricultural Research Institute, Patna under Bihar Agricultural University, Sabour, Bihar, during the Rabi season of 2024–25. The experimental site is geographically located at 25°58'38.83" N latitude and 85°13'22.02" E longitude and falls under the Agro-climatic Zone IIIB (South Bihar Alluvial Zone) of Bihar. The experimental plot had well-drained sandy loam soil of pH 7.2 with good fertility and a levelled surface. The climate of this place is tropical to subtropical in nature and is characterised by very dry summers, moderate rainfall and very cold winters. The variety used for the study was Hybrid Saki, a commercially popular cultivar of broccoli. The experiment was laid out in a Randomized Block Design (RBD) with three replications and eight treatments, totalling 24 plots. The spacing between the plants and rows was maintained at 45 cm × 45 cm, and each plot had a dimension of 3.15 m × 2.25 m. Treatment details were T_1– Control (without fertilizer), T_2– 120 kg N/ha (100% RDN), T_3 – 90 kg N/ha + Seaweed Extract @ 10 L/ha, T_4 – 90 kg N/ha + Humic Acid @ 2 L/ha, T_5 – 90 kg N/ha + Jeevamrut @ 250 L/ha, T_6 – 60 kg N/ha + Seaweed Extract @ 20 L/ha, T_7 – 60 kg N/ha + Humic Acid @ 4 L/ha, T_8 – 60 kg N/ha + Jeevamrut @ 500 L/ha. All cultural and plant protection practices were adopted uniformly across all treatments. Five randomly selected plants were tagged in order to keep records of the growth, yield, and quality characteristics of each treatment. The growth and yield attributes data were collected with proper instruments or methods to assess the treatment effects. The quality attributes were calculated by standard methods like total soluble solids (TSS) measured with the help of digital refractometer, the nitrogen content of broccoli was used to calculate the protein content, which was then expressed as a percentage. The following formula is used to determine the protein:

Protein % = Nitrogen % × 6.25.

To determine the significance of treatment differences, the data was statistically analyzed using RBD standard procedures.

Result and Discussion

Growth and yield attributes

According to the current study's findings, effect of biostimulants in combination with inorganic fertilizer considerably raised the plant height, number of leaves per plant, dry matter production, days to head maturity, diameter of head, fresh weight of head, fresh head yield, fresh biological yield in comparison to the control. (Table 1, 2 & 3). The maximum value of growth parameters i.e. plant height 25 days, 50 days and at harvest (25.72 cm, 49.06 cm, 60.87 cm), number of leaves per plant 25 days, 50 days and at harvest (8.53, 21.64. 24.10), dry matter production 25 days, 50

days and at harvest (6.59 g/plant, 65.01 g/plant, 89.09 g/plant), Leaf Area index (LAI) at 25, 50 DAP and at harvest (0.16 , 0.37, 0.47), Crop growth rate at 25-50 DAP and 50 DAP to harvest (2.34 g m^{-2} day^{-1} & 1.00 g m^{-2} day^{-1}), Days to 50% head initiation (54), days to head maturity (64), diameter of head (17.11 cm), fresh weight of head (382.76 g/plant), fresh head yield (17513.10 kg/ha), fresh biological yield (33120.08 kg/ha), were recorded with the treatment (T_4) 90 kg N/ha + Humic Acid @ 2 L/ha and minimum plant height 25 days, 50 days and at harvest (20.43 cm, 42.52 cm, 55.04 cm), number of leaves per plant 25 days, 50 days and at harvest (6.80, 17.23, 19.33), dry matter production 25 days, 50 days and at harvest (2.16 g/plant, 43.04 g/plant, 65.98 g/plant), Leaf Area index (LAI) at 25, 50 DAP and at harvest (0.09, 0.14, 0.29), Crop growth rate at 25-50 DAP and 50 DAP to harvest (1.64 g m^{-2} day^{-1} & 0.67 g m^{-2} day^{-1}), Days to 50% head initiation (62.00) days to head maturity (69.00), diameter of head (13.16 cm), fresh weight of head (190.83 g/plant), fresh head yield (9140.57 kg/ha), fresh biological yield (18028.57 kg/ha), were recorded under T_1 (control), respectively.

Humic acid appears to have a positive effect on the root zone and plant system by improving the nutritional environment. Therefore, more nutrients were available, especially in the crop root zone, when humic acid was applied to the soil in varying amounts. Nutrient uptake and accumulation in the vegetative plant parts may have risen due to increased nutrient availability in the root zone and enhanced metabolic activity at the cellular level, which ultimately led to improved plant development characteristics. Humic acid's potential to maintain nutrient availability throughout the growing season could be responsible for its positive effects on yield and yield characteristics. The increase in these parameters can be explained by the possibility that plants treated with humic acid grew quickly and developed a healthy green color as a result of increased chlorophyll content synthesis. This could have led to an increased net assimilation rate because of increased photosynthetic activity. Adding humic acid compounds to the soil promoted root development (Cooper, 1998), as well as the initiation, branching, and proliferation of root hairs. This could have been due in part to improved nutrient uptake. These results are in conformity with the findings of Ibrahim and Mohamed (2024), Al-Eezzi and Ai-ibry (2022), Al-Zubaidi and Abbawi (2022), Raheem & Tofiq (2018) in broccoli.

Table 1 : Effect of biostimulants in combination with inorganic fertilizer on plant height, no. of leaves per plant and dry matter production of broccoli.

Treatment	Plant height (cm)			No. of leaves per plant			Dry matter production (g/plant)		
	25 DAT	50 DAT	At Harvest	25 DAT	50 DAT	At Harvest	25 DAT	50 DAT	At Harvest
T1	20.43	42.52	55.04	6.80	17.23	19.33	2.16	43.04	65.98
T2	24.61	47.24	59.45	7.89	20.71	22.56	4.06	59.05	85.01
T3	25.15	48.62	60.14	8.14	21.02	23.67	6.15	61.08	88.87
T4	25.72	49.06	60.87	8.53	21.64	24.10	6.59	65.01	89.09
T5	24.11	46.89	58.36	7.38	20.42	21.74	5.06	58.09	84.79
T6	22.37	44.02	56.85	7.04	18.57	20.55	3.43	53.09	80.87
T7	23.58	45.31	57.33	7.11	19.36	21.29	3.82	54.07	82.02
T8	21.48	43.48	56.15	6.34	18.22	20.13	2.76	51.03	79.98
SE(m) ±	0.84	1.76	2.05	0.36	0.74	0.72	0.22	3.77	4.01
C.D	2.57	5.40	6.30	1.11	2.33	2.22	0.67	11.55	12.29
C.V	6.21	6.73	6.25	8.47	6.74	5.81	8.98	8.49	8.47

Table 2 : Effect of biostimulants in combination with inorganic fertilizer on leaf area index, crop growth rate & days to 50 % head initiation of broccoli.

Treatment	Leaf Area Index (LAI)			Crop Growth Rate (g m^{-2} day^{-1})		Days to 50 % head initiation
	25 DAT	50 DAT	At Harvest	25-50 DAP	50 DAP – Harvest	Days
T1	0.09	0.14	0.29	1.64	0.67	62
T2	0.14	0.33	0.44	2.20	0.83	55
T3	0.15	0.34	0.46	2.21	0.94	55
T4	0.16	0.37	0.47	2.34	1.00	54
T5	0.12	0.33	0.43	2.12	0.86	57
T6	0.13	0.31	0.39	1.99	0.83	60

T7	0.12	0.29	0.36	2.01	0.84	59
T8	0.09	0.25	0.36	1.93	0.83	61
SE(m) ±	0.06	0.13	0.21	0.10	0.04	2.04
C.D	0.17	0.39	0.64	0.30	0.13	6.19
C.V	7.41	7.24	8.96	8.47	8.64	6.15

Table 3 : Effect of biostimulants in combination with inorganic fertilizer on days to head maturity, diameter of head, fresh weight of head, fresh head yield & fresh biological yield protein content in head & TSS of broccoli.

Treatment	Days to head maturity	Diameter of head (cm)	Fresh weight of head (g/plant)	Fresh head yield (kg/ha)	Fresh biological yield (kg/ha)	Protein content in head (mg/100g)	TSS (ºbrix)
T1	69	13.16	190.83	9140.57	18028.57	2000.00	7.11
T2	65	15.85	368.55	15949.30	32400.09	2181.25	11.06
T3	65	16.43	377.23	16392.10	32990.06	2187.50	12.54
T4	64	17.11	382.76	17513.10	33120.08	2237.50	13.16
T5	66	15.12	335.12	14277.90	30014.28	2168.75	10.55
T6	67	14.07	289.61	12006.40	26842.85	2118.75	8.86
T7	66	14.78	311.52	13106.40	27100.07	2162.50	9.38
T8	68	13.05	268.17	12008.56	20942.85	2068.75	8.39
SE(m) ±	2.35	0.61	14.11	687.92	1389.02	42.38	0.22
C.D	7.14	1.88	43.23	2106.83	4253.98	129.81	0.69
C.V	6.15	7.13	7.74	8.63	8.69	3.43	3.84

Quality attributes

The protein content in head and TSS increased significantly with the application of biostimulants in combination with inorganic fertilizer over control (Table 3). The maximum values of quality attributes i.e. protein content in head (2237.50 mg/100g) and TSS (13.16 ºbrix) were recorded with the treatment (T_4) 90 kg N/ha + Humic Acid @ 2 L/ha and minimum protein content in curd (2000.00 mg/100g) and TSS (7.11 ºbrix) was recorded under T_1 (control).

Applying humic acid in combination with 90 kg nitrogen per hectare significantly improved the quality parameters of broccoli, particularly in terms of protein content, and total soluble solids (TSS). The enhancement in protein content can be attributed to the improved nitrogen use efficiency facilitated by humic acid. Humic substances enhance root development and increase the availability and uptake of nutrients, especially nitrogen, which plays a crucial role in amino acid and protein biosynthesis. As observed in similar studies, humic acid application leads to higher nitrate reductase activity and better translocation of nitrogen, thereby promoting greater protein accumulation in plant tissues. In the present study, this synergistic effect likely contributed to the notable increase in broccoli protein content.

The rise in TSS under the combined treatment can be attributed to improved carbohydrate metabolism and translocation resulting from enhanced nutrient uptake and photosynthesis. Total soluble solids are indicative of the sugar and organic acid content, both of which are essential quality traits in broccoli. This aligns with the results of El-Bassiouny *et al*. (2012), who reported increased TSS in crops treated with humic acid and nitrogen due to better physiological performance and nutrient assimilation.

Overall, the combined application of humic acid and 90 kg N ha^{-1} creates a favourable environment for plant growth and metabolism, leading to significant improvements in broccoli quality traits. These findings underscore the potential of combining organic and inorganic nutrient sources for sustainable crop quality enhancement. The outcomes align with the findings of Ertan Yildirim (2007) in tomato, Saif El-Deen *et al*. (2011) in sweet potato, Nursel col keskin and Fikret akinerdem (2021) in potato, AA Abdulla and AO Esmai (2023) in broccoli.

Conclusion

Based on the findings and the discussion, it can be concluded that application of 90 kg N/ha + Humic Acid @ 2 L/ha (T_4) was found to be outstanding, being superior to rest of the treatment in respect to all growth, yield parameters having highest yield of 17513.10 kg/ha followed by the treatment (T_3) 90 Kg N/ha + seaweed extract @ 10L/ha and quality parameters. Therefore, the treatment, (T_4) 90 kg N/ha + Humic Acid @ 2 L/ha may be recommended for higher yield performance of broccoli. Moreover, the inputs being organic, so soil health is also not adversely affected.

References

Abdulla, A. A. and Esmai, A. O. (2023). Combination influence of humic acid and chelated iron on yield and quality of broccoli (*Brassica oleracea* L.) in Erbil, Iraqi Kurdistan Region. *Zanco Journal of Pure and Applied Sciences*, **35**(1), 126–135.

Al-Eezzi, Y. and Al-Alawy, H. (2022). Effect of fulvic acid and seaweed on the growth and yield of broccoli. *Journal of Pharmaceutical Negative Results*, **13**(S01), 583–587.

Al-Zubaidi, B. H. and Abbawi, W. A. (2022). Effect of cultivar, fulvic acid and the interaction between their on some physical and chemical properties and yield of broccoli (*Brassica oleracea* var. italica). *University of Thi-Qar Journal of Agricultural Research*, **11**(1), 70–78.

Bechtaoui, N., Rabiu, M. K., Raklami, A., Oufdou, K., Hafidi, M. and Jemo, M. (2021). Phosphate-dependent regulation of growth and stresses management in plants. *Frontiers in Plant Science*, **12**, 679916.

Canellas, L. P., Canellas, N. O., da Silva, L. E. S., Irineu, L., Olivares, F. L. and Piccolo, A. (2020). Plant chemical priming by humic acids. *Chemical and Biological Technologies in Agriculture*, **7**(1), 12.

Carvalho, M. E. A., Castro, P. D. C., Novembre, A. D. C. and Chamma, H. M. C. P. (2013). Seaweed extract improves the vigor and provides the rapid emergence of dry bean seeds. *American-Eurasian Journal of Agricultural and Environmental Sciences*, **13**(8), 1104–1107.

Cooper, R. J., Liu, C. and Fisher, D. S. (1998). Influence of humic substances on rooting and nutrient content of creeping bentgrass. *Crop Science*, **38**(6), 1639–1644.

El-Nemar, M. A., El-Desuki, M., El-Bassiony, A. M. and Fawzy, Z. F. (2012). Response of growth and yield of cucumber plants (*Cucumis sativus* L.) to different foliar applications of humic and bio-stimulators. *Australian Journal of Basic and Applied Sciences*, **6**(3), 630–637.

Ertan, Y. (2007). Foliar and soil fertilization of humic acid affect productivity and quality of tomato. *Acta Agriculturae Scandinavica Section B—Soil and Plant Science*, **57**(2), 182–186.

Halpern, M., Bar-Tal, A., Ofek, M., Minz, D., Muller, T. and Yermiyahu, U. (2015). The use of biostimulants for enhancing nutrient uptake. *Advances in Agronomy*, **130**, 141–174.

Hawall, I., Raheem, S. M. and Tofiq, G. K. (2018). Growth and yield of broccoli (*Brassica oleracea* L. var. Corato) as affected by humic acid application. *Journal of Plant Production*, **9**(9), 739–741.

Ibrahim, E. A., Ebrahim, N. E. and Mohamed, G. Z. (2024). Mitigation of water stress in broccoli by soil application of humic acid. *Scientific Reports*, **14**(1), 2765.

Islam, M. S., Hossain, M. F. and Pervin, S. (2023). Enhancing broccoli (*Brassica oleracea* var. italica) growth, yield and water productivity through irrigation and mulching techniques in local climate. *Asian Journal of Agricultural and Horticultural Research*, **10**(4), 440–454.

Jindo, K., Canellas, L. P., Albacete, A., Figueiredo dos Santos, L., Frinhani Rocha, R. L., Carvalho Baia, D., Oliveira Aguiar Canellas, N., Goron, T. L. and Olivares, F. L. (2020). Interaction between humic substances and plant hormones for phosphorous acquisition. *Agronomy*, **10**(5), 640.

Keskin, N. C. and Akinerdem, F. (2021). The effect of humic acid applications on growth and quality properties of potato (*Solanum tuberosum* L.). *Journal of the Institute of Science and Technology*, **11**(2), 1559–1567.

Nieves-Cordones, M., Al Shiblawi, F. R. and Sentenac, H. (2016). Roles and transport of sodium and potassium in plants. In *The Alkali Metal Ions: Their Role for Life* (pp. 291–324). Springer International Publishing.

Ordiales, E., Iglesias, D. J., Alarcón, M. V., Zajara, L., Gil, J., Gutiérrez, J. I. and Salguero, J. (2017). Characteristics defining broccoli cultivars from different seed producers. *International Journal of Agronomy*, **2017**, 1–9.

Ray, P., Lakshmanan, V., Labbé, J. L. and Craven, K. D. (2020). Microbe to microbiome: A paradigm shift in the application of microorganisms for sustainable agriculture. *Frontiers in Microbiology*, **11**, 622926.

Reddy, A. V. V. and Menon, S. (2021). A study on role of Jeevamruth in natural farming: A replacement for synthetic fertilizers. *Journal of Emerging Technologies and Innovative Research*, **8**(5), 89–93.

Saif El-Deen, U. M., Ezzat, A. S. and El-Morsy, A. H. A. (2011). Effect of phosphorus fertilizer rates and application methods of humic acid on productivity and quality of sweet potato. *Journal of Plant Production*, **2**(1), 53–66.

Shehata, S. M., Abdel-Azem, H. S., Abou El-Yazied, A. and El-Gizawy, A. M. (2011). Effect of foliar spraying with amino acids and seaweed extract on growth, chemical constitutes, yield and its quality of celeriac plant. *European Journal of Scientific Research*, **58**(2), 257–265.

Sofi, S. O., Talabani, S. K., Sleman, S. M., Faraj, S. H. G. and Halshoy, H. S. (2025). Impact of bio-based and synthetic phosphorus application on growth, yield, and protein profile of two chickpea genotypes. *Agricultural Research*, **14**(1), 97–108.

Thirumaran, G., Arumugam, M., Arumugam, R. and Anantharaman, P. (2009). Effect of seaweed liquid fertilizer on growth and pigment concentration of *Cyamopsis tetrogonolaba* (L.) Taub. *American-Eurasian Journal of Agronomy*, **2**(2), 50–56.

Valverde, J., Reilly, K., Villacreces, S., Gaffney, M., Grant, J. and Brunton, N. (2015). Variation in bioactive content in broccoli (*Brassica oleracea* var. italica) grown under conventional and organic production systems. *Journal of the Science of Food and Agriculture*, **95**(6), 1163–1171.

Yang, F., Tang, C. and Antonietti, M. (2021). Natural and artificial humic substances to manage minerals, ions, water, and soil microorganisms. *Chemical Society Reviews*, **50**(10), 6221–6239.