Mysore J. Agric. Sci., 60 (2) : 83-91 (2026)

Impact of Bio-Stimulants on Biomass Production, Soil Properties and Nutrient uptake by Brinjal (*Solanum melongena* L.)

A. J. Chaitra[1], A. P. Mallikarjuna Gowda[2], K. N. Srinivasappa[3], Kavita Kandpal[4] and B. Manjunath[5]
[1,3&4]Department of Horticulture, College of Agriculture,[2]Zonal Agricultural Research Station,
[5]AICRP on pigeonpea, UAS, GKVK, Bengaluru - 560 065
e-Mail : chaitujayram@gmail.com

Authors Contribution

A. J. Chaitra : Expermentation, design, manuscript writing and data analysis

A. P. Mallikarjuna Gowda : Conceptualization, guidance result interpretation and manuscript editing

K. N. Srinivasappa ; Kavita Kandpal & B. Manjunath : Provided laboratory facilities, guidance, editing and design

Corresponding Author :
A. J. Chaitra

Received : December 2025
Accepted : February 2026

Abstract

Field experiment was conducted at Zonal Agricultural Research Station, University of Agricultural, GKVK, Bengaluru during *Rabi* 2023-2024 to evaluate the effect of bio-stimulants onbiomass production, soil properties and nutrient uptake in brinjal. The experiment consisted of soil and foliar application of seaweed extract, chitosan, humic acid, amino and Arka microbial consortium. The experiment was laid out in RCBD with 11 treatments and replicated thrice. Maximum fresh shoot weight (1036.08 g plant^{-1}), root weight (378.28 g plant^{-1}), total fresh biomass (1414.36 g plant^{-1}), dry shoot weight (716.62 g plant^{-1}) root weight (243.63 g plant^{-1}), total dry biomass (894.53 g plant^{-1}), root length (15.42 cm), uptake of nitrogen (323.02 kg ha^{-1}), phosphorous (31.47 kg ha^{-1}) and potassium (144.12 kg ha^{-1}) was observed with of combination of RDF and foliar application of seaweed extract @ 5 ml/L. while, minimum fresh shoot weight (1795.18 g plant^{-1}), root weight (289.21 g plant^{-1}), total fresh biomass (1084.39 g plant^{-1}), dry shoot weight (516.95 g plant^{-1}), root weight (164.11 g plant^{-1}), total dry biomass (689.26 g plant^{-1}), root length (11.67 cm), uptake of nitrogen (247.62 kg ha^{-1}), phosphorous (19.15 kg ha^{-1}) and potassium (107.22 kg ha^{-1}) was recorded in control. Meanwhile, higher available nitrogen (311.05 kg ha^{-1}), phosphorous (40.24 kg ha^{-1}) and potassium (92.86 kg ha^{-1}) in soil was registered in untreated control. Whereas, RDF + Foliar application of seaweed extract @ 5ml/L recorded lesser available nitrogen (235.64 kg ha^{-1}), phosphorous (38.02 kg ha^{-1}) and potassium (78.10 kg ha^{-1}) in soil.

Keywords : Brinjal, RDF, Bio-stimulants, Seaweed extract, Foliar application

Brinjal (*Solanu mmelongena* L.) belongs to the family Solanaceae. It is economically significant among small-scale farmers and extensively utilized in cuisines (Ashoka *et al*., 2020). Though, the crop is perennial, it is generally cultivated as an annual crop. It has bushy, branching habit with slightly lobed leaves. Plant grows up to 2 to 4 feet, the blossoms are star-shaped and can be white, purple or yellow depending on the cultivar. Brinjal has slightly bitter taste and a spongy texture, which renders it flexible for cooking. It is used in a wide range of foods, including curries, stir-fries, dishes and dips. Overall, it is a nutritious vegetable that can be consumed in a variety of savory dishes. It is a good source of vitamins such as ascorbic acid, vitamin K, niacin, vitamin B_6 and pantothenic acid and rich in minerals like Ca, Mg, P, K and Fe. Besides, it is highly beneficial for regulation of blood sugar levels and for liver problems (Shukla and Naik, 1993). In India, it is being cultivated in an area of 6.81 lakh hectares with a production of 12.98 million tonnes and an average productivity of 19.05 million tonnes per hectare. The major brinjal producing States are West Bengal, Orissa, Bihar, Gujarat, Maharashtra, Andhra Pradesh and Karnataka (Anonymous, 2022-2023).

Bio-stimulants have been underrated for many years as they do not exhibit rapid changes as fertilizers and pesticides. However, it has gained the attention recently due to their prodigious potential and improvements. These are substances or micro organisms applied to plants to enhance nutrition efficiency, improve biotic and abiotic stress tolerance and promote desirable crop quality traits, irrespective of nutrient content. More broadly, they encompass any beneficial plant agent that functions independently of soil amendments, pesticides or fertilizers. The bio-stimulant category comprises diverse components, including humic and fulvic acids, protein hydrolysates and nitrogen-containing compounds, seaweed extracts, botanical derivatives, chitosan, inorganic chemicals and beneficial microorganisms such as fungi and bacteria (Reddy *et al.*, 2023).

The bio-stimulants represent a transformative approach to sustainable agriculture by enhancing the intrinsic physiological processes of plants rather than directly supplying nutrients. (Nasim *et al.*, 2024). The improvement in nutrient uptake directly enables enhanced biomass production and increased nutrient concentration in plants. Understanding these correlations is essential for optimizing crop production particularly for high-value crops such as brinjal (eggplant), where bio-stimulants can address both productivity constraints and nutritional quality deficiencies that plague conventional practices. Application of bio-stimulants has impact on several metabolic activities, such as respiration, photosynthesis, nucleic acid synthesis and ion uptake (Sharanya *et al.*, 2022). The objective of this study is to assess the efficacy of different bio-stimulants on biomass production, soil physicochemical properties nutrient content and uptake by brinjal plants.

Material and Methods

Field study was conducted at 'E' Block of Zonal Agricultural Research Station, GKVK, Bengaluru during *Rabi*, 2023-2024. The experimental site is located at an altitude of 924 meters above mean sea level at longitude of 77° 34' East.The land with red sandy loam soil having uniform fertility was selected.

The experiment included 11 treatments laid out in RCBD with three replication. Treatments involved soil and foliar application of bio-stimulants *viz* T_1: Control, T_2: RDF + Soil application of Sea weed extract based bio-stimulant @5m/l, T_3: RDF + Soil application of Chitosan based bio-stimulant @20ml/l, T_4: RDF+ Soil application of Humic acid based bio-stimulant @ 4ml/l, T_5: RDF + Soil application of Amino acid based bio-stimulant @3ml/l, T_6: RDF + Soil application of Arka microbial consortium based bio-stimulant @10ml/l, T_7: RDF + Foliar application of Sea weed extract based bio-stimulant @5ml/l, T_8: RDF + Foliar application of Chitosan based bio-stimulant @20ml/l, T_9: RDF + Foliar application of Humic acid based bio-stimulant @4ml/l, T_{10}: RDF + Foliar application of Amino acid based bio-stimulant @3ml/l, T_{11}: RDF+ Foliar application of Arka microbial consortium based bio-stimulant @10ml/l.

The brinjal hybrid Green long seeds developed by MAHYCO Company were procured, nursery was raised and 30 days old seedlings were transplanted at 90 cm row to row 60 cm plant to plant. The soil was fertilized with 180: 150: 120 kg NPK/ha and 25 t/ha FYM before transplanting. Full quantity of FYM and 50 per cent of the N and full dose of P and K were applied as basal dose before transplanting of seedlings. The remaining 50 per cent of N was applied as top dressing at 30 days after transplanting. The different bio-stimulants were applied to crop at 15, 30, 45 and 60 days after transplanting, maintaining the volume of 1500l/ha for soil application and 750 l/ha for foliar application.

At harvest, five plants (destructive sampling in border rows) were removed from each plot. The shoot and root portions were separated and the weight of each component was recorded as fresh shoot and root weight and total dry matter was also quantified. The plant samples were then air dried until they attained a constant weight that was recorded as dry shoot weight and root weight. The plant samples from each treatment were dried and ground into a fine powder and analysed to estimate nitrogen, phosphate and potassium contents (Jackson, 1973). Prior to the start of the experiment and following the last harvest, representative soil samples were taken from the experimental plot at a depth of 15cm and analysed for pH, EC and OC (Piper, 1966), available nitrogen (Subbiah and Aija, 1956), phosphorus and potassium (Jackson, 1973).

Results and Discussion

Biomass Production

The maximum fresh shoot weight (1036.08 g plant^{-1}), fresh root weight (378.28 g plant^{-1}) and total fresh biomass (1414.36 g plant^{-1}) was registered with RDF + Foliar application of seaweed extract @ 5ml/L which was *at par* with RDF + Foliar application of chitosan @ 20ml/L (1021.03 g plant^{-1}, 371.34 g plant^{-1} and 1392.37 g plant^{-1}, respectively). While, control recorded minimum shoot, root and total fresh biomass 795.18, 289.21, 1084.39 g plant^{-1} during *rabi* 2023, respectively (Table 1).

RDF + Foliar application of seaweed extract @ 5ml/L recorded maximum dry shoot weight (715.62 g plant^{-1}), dry root weight (243.63 g plant^{-1}), total dry biomass (894.53 g plant^{-1}) which was found to be *onpar* with RDF+ Foliar application of chitosan @ 20ml/L (711.47 g plant^{-1}, 240.94 g plant^{-1} and 889.34 g plant^{-1}, shoot, root and total dry biomass, respectively). The lowest dry biomass was produced in control (516.95 g plant^{-1}, 164.11 g plant^{-1}, 689.26 g plant^{-1}, shoot, root and total dry biomass, respectively) during *rabi* season 2023 (Table 2).

Seaweed extract enhances biomass by supplying endogenous phytohormones (auxins, cytokinins, gibberellins) that stimulate cell division and expansion in meristematic tissues, leading to increased leaf area and stem elongation. Polysaccharides and

Table 1

Effect of bio-stimulants on fresh biomass yield in brinjal (*Solanum melongena* L.) during *Rabi*, 2023

Treatments	Fresh biomass (g plant^{-1})		
	Shoot	Root	Total fresh biomass
T_1 - Control	795.18 c	289.21 d	1084.39 c
T_2 - RDF + Soil application of Seaweed extract @ 5m/l	907.34 b	331.56 bc	1238.90 b
T_3 - RDF+ Soil application of Chitosan @ 20ml/l	891.23 b	329.86 bc	1221.09 b
T_4 - RDF+ Soil application of Humic acid @ 4ml/l	887.39 b	324.43 bc	1211.82 b
T_5 - RDF+ Soil application of Amino acid @ 3ml/l	871.34 bc	314.96 cd	1186.3 bc
T_6 - RDF+ Soil application of Arka microbial consortium @10ml/l	879.36 bc	319.36 bc	1198.72 bc
T_7 - RDF+ Foliar application of Seaweed extract @ 5ml/l	1036.08 a	378.28 a	1414.36 a
T_8 - RDF+ Foliar application of Chitosan @ 20ml/l	1021.03 a	371.34 a	1392.37 a
T_9 - RDF+ Foliar application of Humic acid @ 4ml/l	943.49 b	345.13 b	1288.62 b
T_{10} - RDF+ Foliar application of Amino acid @ 3ml/l	928.24 b	338.12 bc	1266.36 b
T_{11} - RDF+ Foliar application of Arka microbial consortium @ 10ml/l	939.47 b	341.54 bc	1281.01 b
S.Em. ±	25.53	8.68	34.20
CD@ 5%	75.31	25.62	100.88

TABLE 2

Impact of bio-stimulants on dry biomass yield in brinjal *(Solanum melongena* L.) during *Rabi,* 2023

Treatments	Dry biomass yield (g $plant^{-1}$)		
	Shoot	**Root**	**Total fresh biomass**
T_1 - Control	516.95 ^{c}	164.11 ^{d}	689.26 ^{c}
T_2 - RDF + Soil application of Seaweed extract @ 5m/l	579.14 ^{bc}	195.49 ^{bc}	789.53 ^{b}
T_3 - RDF + Soil application of Chitosan @ 20ml/l	568.46 ^{bc}	193.05 ^{bc}	781.94 ^{b}
T_4 - RDF + Soil application of Humic acid @ 4ml/l	562.18 ^{bc}	178.91 ^{bcd}	772.19 ^{b}
T_5 - RDF + Soil application of Amino acid @ 3ml/l	530.77 ^{bc}	172.32 ^{d}	758.24 ^{bc}
T_6 - RDF + Soil application of Arka microbial consortium @10ml/l	535.54 ^{bc}	177.87 ^{cd}	765.06 ^{bc}
T_7 - RDF + Foliar application of Seaweed extract @ 5ml/l	715.62 ^{a}	243.63 ^{a}	894.53 ^{a}
T_8 - RDF + Foliar application of Chitosan @ 20ml/l	711.47 ^{a}	240.94 ^{a}	889.34 ^{a}
T_9 - RDF + Foliar application of Humic acid @ 4ml/l	656.45 ^{a}	229.52 ^{a}	820.56 ^{b}
T_{10} - RDF + Foliar application of Amino acid @ 3ml/l	586.46 ^{b}	197.38 ^{b}	803.12 ^{b}
T_{11} - RDF + Foliar application of Arka microbial consortium @ 10ml/l	592.15 ^{b}	227.47 ^{a}	812.09 ^{b}
S.Em. ±	19.30	5.86	23.14
CD@ 5%	56.93	17.30	68.26

betaines in seaweed extracts improve water retention and osmoprotection, maintaining turgor pressure under stress and promoting vigorous shoot growth. Enhanced nutrient uptake particularly nitrogen and potassium *via* upregulated transporter gene expression further supports biomass accumulation. Similar trends were reported in tomato by Khan *et al.* (2021) and in pepper by Hamid *et al.* (2022).

The enhanced nitrogen assimilation leads to increased accumulation of amino acids, particularly glutamate and aspartate, which serve as building blocks for protein synthesis. Studies show that chitosan treatment results in higher N-protein content, which is essential for various metabolic enzymes and structural proteins required for shoot growth. This improved nitrogen metabolism directly supports the synthesis of new tissues and biomass accumulation. Comparable results were observed in eggplant by Liaqat *et al.* (2019) and in chilli by Ramesh *et al.* (2018).

Root Length

Among various treatments, root length was maximum with RDF + Foliar application of seaweed extract @ 5ml/L (15.42 cm) and was *at par* with RDF + Foliar application of chitosan @ 20ml/L (15.37 cm). Whereas, minimum root length (11.67 cm) was noticed in untreated plants (Table 3).

Seaweed extract enhances root elongation by supplying endogenous auxins and cytokinins that stimulate cell division in root apical meristems and promote lateral root initiation. Enhanced phosphorus and micronutrient uptake, mediated by seaweed-induced expression of root transporter genes, supports root metabolic activity and biomass accumulation. Similar findings in root length were reported by Subramaniyan *et al.* (2023) and Dookie *et al.* (2021) in tomato.

The cationic nature of chitosan improves rhizosphere nutrient availability and uptake, particularly of nitrogen and calcium, which are critical for root expansion and development. The elicitor properties

TABLE 3

Effect of bio-stimulants on root length in brinjal (*Solanum melongena* L.) during *Rabi*, 2023

Treatments	Root length (cm)
T_1 - Control	11.67 [d]
T_2 - RDF + Soil application of Seaweed extract @ 5m/l	13.46 [c]
T_3 - RDF + Soil application of Chitosan @ 20ml/l	13.37 [c]
T_4 - RDF + Soil application of Humic acid @ 4ml/l	13.26 [c]
T_5 - RDF + Soil application of Amino acid @ 3ml/l	13.03 [cd]
T_6 - RDF + Soil application of Arka microbial consortium @10ml/l	13.11 [cd]
T_7 - RDF + Foliar application of Seaweed extract @ 5ml/l	15.42 [a]
T_8 - RDF + Foliar application of Chitosan @ 20ml/l	15.37 [ab]
T_9 - RDF + Foliar application of Humic acid @ 4ml/l	14.01 [bc]
T_{10} - RDF + Foliar application of Amino acid @ 3ml/l	13.84 [c]
T_{11} - RDF + Foliar application of Arka microbial consortium @ 10ml/l	13.98 [bc]
S.Em. ±	0.45
CD @ 5%	1.34

TABLE 4

Nutrient content in brinjal plant (*Solanum melongena* L.) as influenced by bio-stimulants during *Rabi,* 2023

Treatments	N (%)	P (%)	K (%)
T_1 - Control	1.94	0.15	0.84
T_2 - RDF + Soil application of Seaweed extract @ 5m/l	1.93	0.16	0.85
T_3 - RDF + Soil application of Chitosan @ 20ml/l	1.92	0.18	0.87
T_4 - RDF + Soil application of Humic acid @ 4ml/l	1.92	0.18	0.83
T_5 - RDF + Soil application of Amino acid @ 3ml/l	1.91	0.13	0.83
T_6 - RDF + Soil application of Arka microbial consortium @ 10ml/l	1.96	0.19	0.82
T_7 - RDF + Foliar application of Seaweed extract @ 5ml/l	1.95	0.17	0.85
T_8 - RDF + Foliar application of Chitosan @ 20ml/l	1.96	0.19	0.86
T_9 - RDF + Foliar application of Humic acid @ 4ml/l	1.94	0.14	0.87
T_{10} - RDF + Foliar application of Amino acid @ 3ml/l	1.91	0.16	0.83
T_{11} - RDF + Foliar application of Arka microbial consortium @ 10ml/l	1.94	0.14	0.84
S.Em. ±	-	-	-
CD@ 5%	NS	NS	NS

TABLE 5

Effect of bio-stimulants on nutrient content in brinjal fruit (*Solanum melongena* L.)

Treatments	N (%)	P (%)	K (%)
T_1 - Control	1.81	2.30	2.33
T_2 - RDF + Soil application of Seaweed extract @ 5m/l	1.82	2.34	2.32
T_3 - RDF+ Soil application of Chitosan @ 20ml/l	1.86	2.34	2.35
T_4 - RDF+ Soil application of Humic acid @ 4ml/l	1.85	2.33	2.35
T_5 - RDF+ Soil application of Amino acid @ 3ml/l	1.83	2.32	2.34
T_6 - RDF+ Soil application of Arka microbial consortium @10ml/l	1.88	2.33	2.34
T_7 - RDF+ Foliar application of Seaweed extract @ 5ml/l	1.87	2.35	2.37
T_8 - RDF+ Foliar application of Chitosan @ 20ml/l	1.89	2.37	2.32
T_9 - RDF+ Foliar application of Humic acid @ 4ml/l	1.86	2.36	2.33
T_{10} - RDF+ Foliar application of Amino acid @ 3ml/l	1.84	2.35	2.33
T_{11} - RDF+ Foliar application of Arka microbial consortium @ 10ml/l	1.82	2.35	2.34
S.Em. ±	-	-	-
CD@ 5%	NS	NS	NS

TABLE 6

Soil properties of brinjal (*Solanum melongena* L.) cultivated plot as influenced by bio-stimulants during *Rabi,* 2023

Treatments	Ph	EC (dsm^{-1})	OC (%)
T_1 - Control	5.40	0.13	0.60
T_2 - RDF + Soil application of Seaweed extract @ 5m/l	5.48	0.17	0.61
T_3 - RDF+ Soil application of Chitosan @ 20ml/l	5.44	0.16	0.63
T_4 - RDF+ Soil application of Humic acid @ 4ml/l	5.45	0.16	0.63
T_5 - RDF+ Soil application of Amino acid @ 3ml/l	5.41	0.17	0.61
T_6 - RDF+ Soil application of Arka microbial consortium @10ml/l	5.46	0.18	0.61
T_7 - RDF+ Foliar application of Seaweed extract @ 5ml/l	5.52	0.16	0.61
T_8 - RDF+ Foliar application of Chitosan @ 20ml/l	5.55	0.17	0.61
T_9 - RDF+ Foliar application of Humic acid @ 4ml/l	5.48	0.16	0.62
T_{10} - RDF+ Foliar application of Amino acid @ 3ml/l	5.51	0.17	0.61
T_{11} - RDF+ Foliar application of Arka microbial consortium @ 10ml/l	5.48	0.16	0.62
S.Em. ±	-	-	-
CD@ 5%	NS	NS	NS

also enhance antioxidant enzyme activities in roots, reducing oxidative stress and supports sustained root growth. Liaqat *et al.* (2019) observed comparable increases in root length in eggplant.

Nutrient Content

The bio-stimulant treatmentshad no significant influence on nitrogen, phosphorous and potassium contents in brinjal plants and fruits (Table 4 and 5).

The application of bio-stimulants also did not have significant effect on soil pH, EC and OC in the brinjal plot (Table 6).

Soil nutrient availability at the post-harvest sampling stage revealed that, plants treated with RDF + foliar application of seaweed extract @ 5ml/L hadlesser available nitrogen (235.64 kg ha^{-1}), phosphorous (38.02 kg ha^{-1}), potassium (78.10 kg ha^{-1}) and was *on par* with RDF + Foliar application of chitosan @ 20ml/L (235.87 kg ha^{-1}, 38.35 kg ha^{-1} and 79.01 kg ha^{-1}). While, maximum available nutrients, N : 311.05 kg ha^{-1}, P : 40.24 kg ha^{-1} and K : 92.86 kg ha^{-1}) was noted in control (Table 7).

The decline in available soil NPK under T_7 and T_8 closely coincided with their maximum nutrient uptake and biomass production demonstrating that bio stimulants enhanced nutrient use efficiency by transferring a greater fraction of soil nutrients into plant biomass rather than leaving them as residual nutrients in the soil. Thus, the higher available nutrient status in the control represents unutilized nutrient reserves associated with poor crop performance, whereas lower post harvest availability under effective bio stimulant treatments reflects more intensive nutrient extraction and utilization by brinjal. These findings are similar with Megha & Shailesh (2022) and Kumar *et al*. (2018) in brinjal.

Nutrient Uptake

Among various treatments, uptake of nitrogen (323.02 kg ha^{-1}), phosphorous (31.47 kg ha^{-1}), and potassium (144.12 kg ha^{-1}) was maximum in the treatment, RDF + foliar application of seaweed extract @ 5ml/L and

TABLE 7

Influence of bio-stimulants on available Soil nutrients in brinjal (*Solanum melongena* L.) cultivated plot during *Rabi*, 2023

Treatments	Available Nutrients (kg ha^{-1})		
	Nitrogen	Phosphorous	Potassium
T_1 - Control	311.05 [a]	40.24 [a]	92.86 [a]
T_2 - RDF + Soil application of Seaweed extract @ 5m/l	276.49 [bc]	39.48 [c]	86.03 [de]
T_3 - RDF + Soil application of Chitosan @ 20ml/l	280.65 [bc]	38.99 [d]	85.35 [e]
T_4 - RDF + Soil application of Humic acid @ 4ml/l	284.11 [bc]	39.05 [d]	88.27 [c]
T_5 - RDF + Soil application of Amino acid @ 3ml/l	290.48 [b]	40.40 [a]	89.13 [bc]
T_6 - RDF + Soil application of Arka microbial consortium @10ml/l	280.98 [bc]	39.35 [c]	89.27 [b]
T_7 - RDF + Foliar application of Seaweed extract @ 5ml/l	235.64 [d]	38.02 [g]	78.10 [g]
T_8 - RDF+ Foliar application of Chitosan @ 20ml/l	235.87 [d]	38.35 [f]	79.09 [g]
T_9 - RDF+ Foliar application of Humic acid @ 4ml/l	263.88 [c]	38.76 [e]	84.08 [f]
T_{10} - RDF+ Foliar application of Amino acid @ 3ml/l	274.60 [bc]	39.40 [c]	86.37 [d]
T_{11} - RDF+ Foliar application of Arka microbial consortium @ 10ml/l	266.92 [c]	39.89 [b]	85.21 [e]
S.Em. ±	6.63	0.07	0.31
CD@ 5%	19.5	70.21	0.92

TABLE 8

Effect of bio-stimulants on uptake of nutrients by brinjal (*Solanum melongena* L.) during *Rabi,* 2023

Treatments	Uptake of Nutrients (kg ha^{-1})		
	Nitrogen	Phosphorous	Potassium
T_1 - Control	247.62 d	19.15 g	107.22 d
T_2 - RDF + Soil application of Seaweed extract @ 5m/l	282.18 c	23.39 e	124.28 c
T_3 - RDF+ Soil application of Chitosan @ 20ml/l	278.02 cd	26.06 cd	125.98 c
T_4 - RDF+ Soil application of Humic acid @ 4ml/l	277.69 cd	25.74 d	118.69 cd
T_5 - RDF+ Soil application of Amino acid @ 3ml/l	268.19 cd	18.25 g	116.54 cd
T_6 - RDF+ Soil application of Arka microbial consortium @10ml/l	274.56 cd	24.09 e	116.18 cd
T_7 - RDF+ Foliar application of Seaweed extract @ 5ml/l	323.02 a	31.47 a	144.12 a
T_8 - RDF+ Foliar application of Chitosan @ 20ml/l	322.80 ab	29.64 b	141.64 ab
T_9 - RDF+ Foliar application of Humic acid @ 4ml/l	294.79 ac	27.35 e	129.16 bc
T_{10} - RDF+ Foliar application of Amino acid @ 3ml/l	284.07 c	23.80 e	123.44 c
T_{11} - RDF+ Foliar application of Arka microbial consortium @ 10ml/l	291.75 c	21.05 f	126.33 c
S.Em. ±	9.33	0.46	2.36
CD@ 5%	27.53	1.36	6.97

was *at par* with RDF+ Foliar application of chitosan @ 20ml/L (322.80 kg ha^{-1}, 29.64 kg ha^{-1} and 141.64 kg ha^{-1} N, P and K, respectively). While, minimum uptake of N, P and K, was noted in control, 247.62 kg ha^{-1}, 19.15 kg ha^{-1} and 107.22 kg ha^{-1}, respectively (Table 8).

The superior nutrient uptake under foliar seaweed and chitosan applications can be attributed to improved root system development. which directly increases root surface area available for nutrient absorption.and physiological activity. Increase membrane permeability and stimulate the activity of nutrient transporter proteins, thereby facilitating greater absorption and translocation of N, P and K to the shoots. In addition, their bio stimulating effects on photosynthesis and nitrogen metabolism promote higher assimilation of absorbed nutrients into structural and metabolic compounds, which is reflected in the higher biomass obtained. These findings are similar with Megha & Shailesh (2022) and Kumar *et al*. (2018) in brinjal.The present investigation revealed that RDF + Foliar application of seaweed extract @ 5 ml/L resulted higher biomass production and nutrient uptake.

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