PLANT SCIENCE TODAY
Vol x(x): xx-xx
https://doi.org/10.14719/pst.9941

eISSN 2348-1900

RESEARCH ARTICLE

Response of seasoned pressmud, growth regulators, bio stimulants on yield, uptake and post harvest nutrient status in neutral and coastal saline soil

Durairaj Venkatakrishnan[1*], Anindita Majumder[1], Kasilingam Dhanasekaran[1], Sambandam Manimaran[2] & Gopalan Sathyanarayanan[3]

[1]Department of Soil Science and Agricultural Chemistry, Annamalai University, Annamalai Nagar 608 002, Tamil Nadu, India
[2]Department of Agronomy, Annamalai University Annamalai Nagar 608 002, Tamil Nadu, India
[3]Tamil Nadu Rice Research Institute, Aduthurai 612 101, Tamil Nadu, India

*Correspondence email - v.mahemasree@gmail.com

Received: 09 June 2025; Accepted: 17 October 2025; Available online: Version 1.0: 12 November 2025

Cite this article: Durairaj V, Anindita M, Kasilingam D, Sambandam M, Gopalan S. Response of seasoned pressmud, growth regulators, bio stimulants on yield, uptake and post harvest nutrient status in neutral and coastal saline soil. Plant Science Today (Early Access). https://doi.org/10.14719/pst.9941

Abstract

Brinjal is also known as egg plant or Aubergine belongs to family Solanaceae. In India, Tamil Nadu is blessed with diverse agro-climatic condition varied soil types inclusive of neutral and coastal saline soil, which enable brinjal cultivation. Field experiments were conducted at Vallampadugai (*Typic Ustifluvents*) Therkupichavaram (*Typic Udipsamments*) from Chidambaram taluk, Tamil Nadu, India in the brinjal crop (var. Annamalai). The design adopted RBD design with 3 replications. The treatments imposed in T_1 - control NPK (100 % RDF), T_2 - 75 % RDF + seasoned pressmud @ 12.5 t ha^{-1} + soil application of $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1}, T_3 - T_2 humic acid @ 3 %, T_4 - T_2 + foliar spray of seaweed extract @ 3 %, T_5 - T_2 + panchagavya @ 3 %, T_6 - T_2 + gibberellic acid @ 50 ppm and T_7 - T_2 + foliar spray NAA @ 50 ppm. All the foliar application were done on 30 and 60 DAT. The treatment (T_4) 75 % RDF + seasoned pressmud @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} + foliar spray seaweed extract @ 3 % on 30 and 60 DAT registered the highest fruit yield (28.06 t ha^{-1} in neutral soil, 24.3 t ha^{-1} in coastal saline soil), fruit N uptake (90.13 kg ha^{-1} in neutral soil, 71.91 kg ha^{-1} in coastal saline soil), P uptake (14.79 kg ha^{-1} in neutral soil, 17.477 kg ha^{-1} in coastal saline soil, K uptake (87.3 kg ha^{-1} in neutral soil, 69.99 kg ha^{-1} in coastal saline soil), Zn uptake (6.02 g ha^{-1} in neutral soil, 4.806 g ha^{-1} in coastal saline soil), B uptake (12.75 g ha^{-1} in neutral soil, 11.945 g ha^{-1} in coastal saline soil) and maximum post harvest NPK, Zn and B content in soil were noticed.

Keywords: borax; brinjal; fruit yield; seasoned pressmud; seaweed extract; $ZnSO_4$

Introduction

Brinjal (*Solanum melongena* L.) also known as egg plant or Aubergine belongs to family Solanaceae. Brinjal is an important indigenous vegetable crop of India. In India brinjal is cultivated as one of the leading major vegetable crops covering an area of 6.79 lakh hectares with a total production of 129.33 lakh tones (1). Tamil Nadu has a share of 2.7 % in area (20 million hectares) with the share of 2.2 % production (275 million metric tones) and with a productivity of 11.12 t ha^{-1} (1). Tamil Nadu is blessed with diverse agroclimatic condition, varied soil types inclusive of neutral soil and coastal saline soil, which enable the cultivation of brinjal. The ideal soil pH is close to neutral and is considered to fall within a range from pH 6.5 to 7.5. If the soil is dominated by NaCl and Na_2SO_4, the soil is said to be coastal saline soil (pH less than 8.5). In coastal areas, salinization can be associated with the over exploitation of ground water caused by the demands of growing urbanization, industry and agriculture. Soil salinity affects the chemical parameters in soil and it is one of the major reasons for decline in the organic matter and nitrogen level.

Coastal saline soils are spread over 19 % area of salt affected soil in the country to the extent of 1250 million hectare in India, Tamil Nadu share is 1.1 % of total area to be extent of 14 million ha (2). Development of salinity not only deteriorates the quality and quantity of produce but also limits the choice of cultivable crops. Among vegetables, egg plants are highly salt tolerant and can grow in all types of soil. It is warm-season vegetable that is native to tropical and sub-tropical regions. Although brinjal is highly salt tolerant, it is still important to properly manage the soil salinity levels to ensure nutrient management (3). The cultivation of egg plants faces numerous challenges, including the need to maintain soil fertility and optimize nutrient availability. Farmers use employs imbalance fertilization to harvest good yield. The continuous use of chemical fertilizer disturbs soil health and quality which cannot support plant growth in long run (4). Farmers must manage soil fertility and nutrients in an integrated manner in order to satisfy the demand of expanding population for food in the twenty first century: Integrated nutrient management (INM) a system approach is an ideal one for the coastal region where it ensures not only balanced fertilization, but also better fertilizer use efficiency which finally culminates in higher yield and quality of produce (5).

Pressmud is used to maintain soil fertility and enhance crop production because it contains appreciable amount of essential plant nutrients *viz.,* organic carbon, nitrogen, phosphorus, potassium along with traces of micronutrients *viz.,* Fe, Mn, Zn and Cu (6). Plants require mineral elements essential for the normal life process of plants and are needed in all small amounts are called trace elements or minor elements such as boron and zinc (7). Zinc deficient soils can be treated with zinc containing fertilizers several different zinc compounds are used as fertilizer, but zinc sulphate is by far the most widely used material (8).

Boron is relatively immobile in plants and thus its availability is essential at all stages of growth especially during fruit development. Among boron fertilizer sources, borax is the most used boron fertilizer to prevent deficiency in crops. Apart from regular application of conventional organic manures there are other organic substance *viz.,* biostimulants (seaweed extract, humic acid and plant growth regulator) which promote growth and yield of crops besides help in maintenance of soil fertility (9). Foliar applications of plant bio-regulators and micronutrients have immense important role in recovery of nutritional, physiological disorder and productivity of vegetables.

Seaweed extracts are the biostimulant extracted from seaweed. It also enhanced the adsorption of macronutrients including N, P, K and micronutrients such as Fe, Mn and Zn. Seaweed is an excellent source of bioactive components (10). Naphthalene acetic acid is a synthetic acid but is like naturally occurring indole acetic acid in its action on plants. Thus, it is a synthetic plant hormone in the auxin family. Rapid cell elongation and cell division in the meristem and thought to be a direct outcome of NAA's positive impact, which is ascribed to an enhanced rate of photosynthetic activity, quicker transport and efficiency of using photosynthetic products (11). Gibberellic acid (GA_3) is an endogenous growth regulator in plants plays an important role in plant cell growth and elongation. Use of this plant growth regulator is becoming increasingly common on all crops (12).

Panchagavya considered to be a highly effective liquid organic manure with multiple functions that can be effectively supplement to chemical fertilizers. Complementary use of organic and biological sources of plant nutrient along with chemical fertilizers is a great importance for the maintenance of crop productivity (13). The objective of the research.

i) To evaluate nutrient management practices for yield maximization of brinjal and

ii) To study the impact of inputs on brinjal nutrition, uptake and post harvest nutrient status.

Materials and Methods

Investigation pertaining to soil and nutrient management for maximising brinjal productivity and quality were undertaken in two different soils *viz.*, neutral and coastal saline soils. The detailed information about field experiments and methodology followed for soil, plant analysis and quality parameters are presented.

Location of experiment

The field experiment was conducted at the farmers holding at two different locations. The first field experiment was conducted in neutral soil belonging to Padugai series located at Vallampadugai, Tamil Nadu (11°20'18 N latitude and 79°42'19 E longitude). The second field experiment was conducted at coastal saline soil belonging to Valuthalakudi series located at Pichavaram, Tamil Nadu (11°38'37 N latitude and 79°72'48 E longitude).

Rationale

In terms of plant nutrition perspective in terms of macro and micronutrients may augment growth and yield of crops, there are natural or synthetic substances called biostimulants when applied to plant or soil along with nutrients can cause changes in vital and structural processes to influence plant growth through improved tolerance to abiotic stresses and increase fruit yield and quality. Similarly, plant growth regulators when applied to plants improve yield and quality by altering the life processes. In this context, two field experiments were conducted in neutral and coastal saline soil.

Treatment	Designation	Specification
T_1	Control	100 % RDF
T_2	75 % RDF + seasoned pressmud + borax	Seasoned pressmud applied basally @ 12.5 t ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1} @ 10 kg ha^{-1} borax was applied before transplantation
T_3	75 % RDF + seasoned pressmud + borax + $ZnSO_4$ + humic acid	Seasoned pressmud applied basally @ 12.5 t ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1} borax @ 10 kg ha^{-1} applied before transplanting include foliar spray of humic acid @ 3 % on 30 (vegetative stage) and 60 DAS (flowering stage) after transplanting. Ideal timing for foliar spray in early morning
T_4	75 % RDF + seasoned pressmud + $ZnSO_4$ + seaweed extract	Seasoned pressmud applied basally @ 12.5 t ha^{-1} $ZnSO_4$ @ 25 kg ha^{-1}, borax @ 10 kg ha^{-1} applied before transplanting include foliar spray of seaweed extract @ 3 % on 30 (vegetative) and 60 (flowering) days after transplanting. Ideal timing for foliar spray in early morning
T_5	75 % RDF + seasoned pressmud + $ZnSO_4$ + borax + panchagavya	Seasoned pressmud applied basally @ 12.5 t ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1}, borax @ 10 kg ha^{-1} applied before transplanting include foliar spray of panchagavya @ 3 % on 30 (vegetative) and 60 (flowering) days after transplanting. Ideal timing for foliar spray in early morning
T_6	75 % RDF + seasoned pressmud + $ZnSO_4$ + borax + gibberellic acid	Seasoned pressmud applied basally @ 12.5 t ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1}, borax @ 10 kg ha^{-1} applied before transplanting include foliar spray of gibberellic acid @ 50 ppm on 30 (vegetative) and 60 (flowering) days after transplanting. Ideal timing for foliar spray in early morning
T_7	75 % RDF + seasoned pressmud + $ZnSO_4$ + borax + NAA	Seasoned pressmud applied basally @ 12.5 t ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1}, borax @ 10 kg ha^{-1} applied before transplanting include foliar spray of NAA @ 50 ppm on 30 (vegetative) and 60 (flowering) days after transplanting. Ideal timing for foliar spray in early morning

The details of physico-chemical properties of initial experiment soil samples and their results are presented in Table 1.

Dry matter production

Five plants were taken at each stage from the sample rows (Field). They were dried and kept in hot air oven at 65 °C for 72 hrs. The oven dry weight was recorded as kg ha^{-1}.

Fruit yield

The weight of fruits harvested from in each plot (Field experiment) at different picking were added and total yield expressed in yield as (t ha^{-1}).

Stover yield (g pot^{-1})

The brinjal plant yield was obtained by harvesting crops from individual plot and weighed and reported as t ha^{-1}.

Nutrient uptake

The brinjal plant and fruit samples collected at harvest were dried in hot air oven @ 60 ± 2 °C for 48 hrs. The oven dried samples were ground to pass through 40 mesh-siever in a macro-Wiley mill. Nitrogen was estimated by modified kjeldahl method (14). P concentration by vanado molybdo phosphoric yellow colour method and K concentration by Flame photometer method (14). Analysis of nutrient uptake by brinjal was carried out to ascertain the amount of nutrient taken up by the crop. The uptake of nutrients was calculated as follows.

$$\text{NPK uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content(\%)} \times \text{Dry matter yield (kg ha}^{-1}\text{)}}{100}$$

The Fe, Mn, Zn and Cu concentration of brinjal (Stover and fruit) were determined as described (15) using atomic absorption spectrophotometry (AAS). The boron concentration was estimated (16, 17). The micronutrient uptake by brinjal was worked out using the following equation.

$$\text{Micronutrient uptake (g ha}^{-1}\text{)} = \frac{\text{Nutrient content(ppm)} \times \text{Dry matter yield (kg ha}^{-1}\text{)}}{1000}$$

Table 1. Physico-chemical properties of experimental soils

S. No.	Parameters	Neutral soil	Coastal saline soil
A.	**Physical properties**		
1	Mechanical analysis		
	Sand (%)	6.5 %	76
	Silt (%)	28	19
	Clay (%)	6	4
	Textural class	Sandy loam	Sandy
	Taxonomical class	*Typic Ustifluvents*	*Typic Udipsamments*
	Series	Padugai	Valutholakudi
2.	Bulk density (mg m^{-3})	1.55	1.6
3.	Particle density (mg m^{-3})	2.22	2.61
B.	**Chemical properties**		
4	pH	7.2	7.8
5	Electrical conductivity (dSm^{-1})	0.75	4.02
6	Organic carbon (g kg^{-1})	4.7 (Medium)	0.99 (Low)
7	CEC (Cmol(p^+ kg^{-1})	16.8	2.4
8	$KmNO_4$-N (kg ha^{-1})	159.6 (Low)	103.6 (Low)
9	Olsen-P (kg ha^{-1})	50 (High)	23 (High)
10	NH_4OAC-K (kg ha^{-1})	135.5 (Medium)	197 (Medium)
11	DTPA-Fe (mg kg^{-1})	25.13 (Sufficient)	19.13 (Sufficient)
12	DTPA-Mn (mg kg^{-1})	12.56 (Sufficient)	9.56 (Sufficient)
13	DTPA-Zn (mg kg^{-1})	0.28 (Deficient)	0.22 (Deficient)
14	DTPA-Cu (mg kg^{-1})	1.53 (Sufficient)	0.55 (Sufficient)
15	Hot water soluble B (mg kg^{-1})	0.47 (Deficient)	0.32 (Deficient)

The post harvest soil samples were collected and analysed for pH and EC (14), soil organic carbon (SOC) (18) and available N (19), available P (20), available K were analysed by neutral normal ammonium acetate method (14), available micronutrients by DTPA extractable method (15) and available B by hot water-soluble B (16, 17).

The mean data of each parameters were statistically analysed by the technique of analysis of variance the significant difference was tested by F test and differences between mean by using C.D. at 5 % level as described using Agri Software (version 3.01). Data from soil analysis were utilized to develop linear regression equation with fruit yield, Zn content and B content (21). Similarly, data from fruit samples analysis were done to evolve multiple linear regression equation with fruit yield, Zn and B uptake. Different combinations of above mentioned soil application of $ZnSO_4$, borax, seasoned pressmud, foliar spray of biostimulants, growth regulators were merged to be evaluated based on the values of coefficient by determination (R^2) obtained while performing multiple linear regression analysis.

Dehydrogenase activity (DHA)

Dehydrogenase activity (TPF mg g^{-1} 24 h^{-1}) was determined by triphenyltetrazolium chloride (TTC) reduction rate to tryphenyl formazan (TPF) in soils after the incubation at 30 °C for 24 hrs (22).

Urease activity

Urease activity was determined by ammonia released after the incubation of samples with urea solution for 2 hrs at 37 °C and their activity, was expressed as Mg NHG-Ng 12 h^{-1}.

Results and Discussion

Yield and growth responses

The addition of Seasoned pressmud, $ZnSO_4$, borax, plant growth regulators and biostimulants caused a significant effect on fruit yield, stover yield and dry matter production (Table 2). This was followed by the treatments T_6, T_5, T_7, T_3, T_2 in fruit yield, stover yield and dry matter production. Treatment T_4 which included 75 % RDF combined with seasoned pressmud $ZnSO_4$, borax and foliar seaweed extract recorded the highest fruit yield (28.06 t ha^{-1} in neutral soil 24.3 t ha^{-1} in coastal soil) indicating the synergistic effect of integrated nutrient management on brinjal productivity. The highest stover yield (18.79 t ha^{-1} in neutral soil, 16.63 t ha^{-1} in coastal saline soil) fruit, dry matter production (3480.26 kg ha^{-1} in neutral soil, 2748.72 kg ha^{-1} in coastal saline soil), stover dry matter production (1930.1 kg ha^{-1} in neutral soil, 1766.09 kg ha^{-1} in coastal saline soil) were recorded in treatment T_4.

Yield and growth responses

Application of seasoned pressmud improved the soil physical condition and promote microbial and soil organic matter which in turn produces organic acids which inhibits IAA, oxidase enzymes resulting which have direct influence on growth performance (23). Application of $ZnSO_4$ treatment was found to increase photosynthetic activity and the rate of respiration which results in improved growth factors (24). Borax fertilization leads to increase in plant growth and physiological characters with best treatment might be due to the greater absorption, translocation effect of boron at appropriate plant growth (25). Spraying of foliar spray of seaweed extract and application of seasoned presmud could supply the required crop nutrients and

Table 2. Effect of seasoned pressmud, $ZnSO_4$, borax, growth regulators and biostimulants on fruit yield (t ha^{-1}), stover yield (t ha^{-1}) and dry matter yield (kg ha^{-1})

Treatment	Neutral soil				Coastal saline soil			
	Fruit yield (t ha^{-1})	Stover yield (t ha^{-1})	DMP Fruit	DMP Harvest	Fruit yield (t ha^{-1})	Stover yield (t ha^{-1})	DMP Fruit	DMP stover
T_1	18.99	11.72	2310.03	1080.26	15.82	10.196	1916.09	980
T_2	19.03	11.82	2320.06	1090.30	15.87	12.275	2044.04	1080.39
T_3	20.28	16.06	2480.26	1300.06	16.74	13.119	2040.09	1160.39
T_4	28.06	18.79	3480.26	1930.10	24.30	16.631	2748.74	1766.09
T_5	21.82	16.39	2650.16	1510.03	18.08	14.909	2167.19	1419.59
T_6	24.90	17.67	2980.26	1660.2	19.61	16.301	2581.43	1560
T_7	21.06	15.82	2610	1470.0	17.98	14.249	2056.49	1207.49
Mean	22.02	15.46	2725.16	1455.15	18.39	14.128	2241.54	1329.14
S.Ed.	0.029	0.02	3.25	2.37	0.029	0.017	2.46	2.17
CD (P=0.05)	0.059	0.05	6.98	5.09	0.063	0.038	5.29	4.66

growth (26). Spraying of panchagavya enhances that growth attributes might be due to the presence of various growth enzymes which favours rapid cell division and cell multiplication contributing to the overall growth and development (27). Foliar spray of NAA causes elongation and rapid cell division increased growth parameters (28). Foliar application of gibberellic acid stimulates growth and cell expansion through increasing the plasticity of cells by improving growth attributes (29). Foliar feeding of humic acid enhances the activity of microorganism in rhizosphere improves membrane permeability, protein synthesis and to the effective at promoting plant development (30). Higher productivity of vegetable crops because of integrated use of major nutrients and boron could be explained on the grounds that addition of NPK in balanced and adequate amounts increased nutrient uptake which leads to higher yield of brinjal fruit (31). Combination of boron and zinc application might help the balanced absorption of nutrients increasing the rate of photosynthesis as a result fruit yield plant^{-1} was highest (32). Regarding stover yield the increased in stover yield due to zinc application may be attributed to the fact that zinc is main limiting plant nutrient in zinc deficient soil. Applied zinc is reported to enhance the absorption of native as well as added major nutrients and thereby improving overall growth and development and ultimately stover yield (33). The improvement in stover yield with increase in boron application might be due to good balance between photosynthetic and respiration. The final yield depends on translocation of photosynthates from the source to sink, boron is supposed to play a significant role (34).

Effect of growth regulators and biostimulants

Seaweed fertilizer that has been used as additional nutrients and as biostimulants to increase plant growth because they contain plant growth regulators. Growth regulators contained in seaweed play a role in physiology of plants such as growth, division and cell differentials and protein synthesis. Plants can absorb nutrients, including growth regulators from all surfaces of plant cells. The absorption of nutrients that take place on organs so that the plants can form more shoots and leaves. Subsequently these substances are converted into protein, nucleic acids, polysaccharides and other complex molecules which in turn form organs and tissues so that stover yield increases (35). It also increased the activity of soil enzymes responsible for the conversion of unavailable forms of nutrients into available forms. It facilitates more availability of essential nutrients to plants which supported the vegetative growth and finally increased the fruit yield (36).

Increased fruit length could be credited to the nutrients and hormone in the seaweed extract which improved photosynthetic process. The manufactured carbohydrates and other photosynthates will be translocated to fruit to growth requirements and development. Auxin and cytokinin hormones in particular influence the plants' fruit size development (37). The increase in fruit weight can also be attributed to the increase in fruit size of those plants sprayed with seaweed.

As mentioned, seaweed contains essential elements (potassium and magnesium) and hormones that enhance fruit setting and its development. Aside from increasing the fruit size potassium role also improves the quality of fruits including their weight potassium regulates essential functions in a plant like maintaining turgor pressure in cells and carbon assimilation which enhances and keep the weight of fruit intact. In addition, cytokinin and auxins cell expansion function enlarge fruit sizes that may contribute to weight of fruit (38). Like other fruit parameters egg plant sprayed with seaweed extract @ 3 % had the highest fruit circumference. This signifies the positive effect of seaweed extract as biostimulants for solanaceous crops.

Phytohormones in seaweed extract such as auxin and cytokinin enhance the egg plants fruit size and circumference due to its cell division and expansion function (39). Seaweed extracts encourage flowering by initiating plant growth. Yield increases in seaweed treated plants are thought to be associated with the hormonal substances present in the extracts especially cytokinin (40).

Subsequently in panchagavya @ 3 % on 30 and 60 DAT, the number of fruits per plant is (19.30), the fruit weight per plant (37.70 g), fruit yield (21.82 t ha^{-1}) and stover yield (17.67 t ha^{-1}) in the field experiment - I (neutral soil). Similarly for field experiment - II (coastal saline soil) the no. of fruits per plant (16.90), fruit weight per plant (35.68 g), fruit yield (18.08 t ha^{-1}) and stover yield (14.909 t ha^{-1}). With reference to plant growth regulators the highest yield attributes were recorded in foliar spray of panchagavya. The number of fruits plant^{-1} might be due to presence of auxin and kinetic in panchagavya which upon applying as foliar spray favoured the plants to produce were no. of fruits plant^{-1} (41). The maximum length of fruit might be due to growth hormones and macronutrients that have affected treated plants along with increase photosynthesis causing the cell elongation and division (42). Higher girth of fruit may be due to NPK along with combination with cytokinin increases efficiency of chlorophyll pigment, photosynthates and increases aberration in the economic part which results in higher girth (43). The beneficial effect of panchagvya increased biological efficiency of crop plants had a positive effect on reproductive growth which ultimately led to realization of higher yield of crops (44). Similarly in NAA @ 50 ppm on 30 and 60 DAT the number of fruits per plant (18.72), fruit weight per plant (37.50 g), fruit yield (21.06 t ha^{-1}), stover yield (15.82 tha^{-1}) in the field experiment-I. For the field experiment-II the number of fruits per plant (16.88), fruit weight plant^{-1} (35.25 g), fruit yield (17.82 t ha^{-1}), stover yield (14.249 t ha^{-1}). Increase in yield was observed in plants sprayed with NAA might be due to stimulating effect of auxins on various vegetative growth characters including dry weight which might have helped in having highest yield similar increase in fruit yield due to application of growth substances (45). Afterwards in gibberellic acid @ 50 ppm on 30 and 60 DAT the number of fruits per plant (18.02), fruit weight per plant (36.29 g), fruit yield (19.61 t ha^{-1}), stover yield (16.301 t ha^{-1}) in the field experiment - II. Followed by gibberellic acid @ 50 ppm, the number of fruits per plant (20.79), the fruit weight per plant (39.93 g), fruit yield (24.90 t ha^{-1}), stover yield (17.67 t ha^{-1}) in the field experiment-I. The best growth regulator was recorded in foliar spray of gibberellic acid @ 50 ppm. The yield in brinjal was found to be strongly influenced by the spray of gibberellic acid and thus indicating the importance of these compounds in increasing the yield potential through their effect on yield parameters of brinjal. The increase in fruit yield could be attributed to experiments of yield attributes (46).

With regard to stover yield the increased in stover yield due to zinc application may be attributed to the fact that zinc is main limiting plant nutrient in zinc deficient soil. Applied zinc is reported to enhance the absorption of native as well as added major nutrients and thereby improving overall growth and development and ultimately stover yield (33). The improvement in stover yield with increase in boron application might be due to good balance between photosynthetic and respiration. The final yield depends on translocation of photosynthates from the source to sink, boron is supposed to play a significant role (34).

The seaweed fertilizer that has been used as additional nutrients and as biostimulants to increase plant growth because they contain plant growth regulators. Growth regulators contained in seaweed play a role in physiology of plants such as growth, division and cell differentials and protein synthesis. Plants can absorb nutrients, including growth regulators from all surfaces of plant cells.

Nutrient uptake and content

Integrated nutrient application notably enhanced NPK, Zn and B accumulation in plant tissues and fruits, with maximum concentration observed under T_4 treatment (Table 3). This suggests improved nutrient availability and translocation under combined organic and inorganic amendments. The maximum fruit N content (2.59 %), P content (0.425 %), K content (2.5086 %), Zn content (1.729 mg kg^{-1}), B content (5.106 mg kg^{-1}), plant N content (3.0979 %), P content (0.411 %), K content (2.8069 %), Zn content (2.069 mg kg^{-1}), B content (2.597 %), Zn content (1.749 mg kg^{-1}), B content (4.347 mg kg^{-1}), plant N content (2.945 %), P content (0.332 %), K content (2.606 %), Zn content (1.957 mg kg^{-1}) and B content (5.347 mg kg^{-1}) were registered in treatment T_4.

In the field experiment - I conducted at Vallampadugai observed the highest nitrogen stover content (3.0979 %), nitrogen fruit content (2.590 %), phosphorus stover content (0.411 %), phosphorus fruit content (0.425 %), potassium stover content (2.8069 %), potassium fruit content (2.5086 %), zinc

Table 3. Effect of seasoned pressmud, zinc sulphate, borax, growth regulators and biostimulants on NPK, Zn, B content

Treatment	Neutral soil										Coastal saline soil									
	Fruit					Plant					Fruit					Plant				
	N (%)	P (%)	K (%)	Zn (mg kg^{-1})	B (mg kg^{-1})	N (%)	P (%)	K (%)	Zn (mg kg^{-1})	B (mg kg^{-1})	N (%)	P (%)	K (%)	Zn (mg kg^{-1})	B (mg kg^{-1})	N (%)	P (%)	K (%)	Zn (mg kg^{-1})	B (mg kg^{-1})
T_1	2.551	0.382	2.4486	1.708	5.085	3.0468	0.369	2.7179	1.850	6.585	2.407	0.406	2.337	1.729	4.326	2.936	0.323	2.597	1.936	5.326
T_2	2.552	0.383	2.4496	1.711	5.088	3.0479	0.371	2.7189	1.889	6.588	2.437	0.436	2.367	1.731	4.329	2.939	0.326	2.601	1.939	5.329
T_3	2.553	0.390	2.5166	1.714	5.091	3.0569	0.372	2.8179	1.919	5.691	2.467	0.466	2.407	1.734	4.332	2.942	0.329	2.603	1.942	5.332
T_4	2.590	0.425	2.5086	1.729	5.106	3.0979	0.411	2.8069	2.069	6.606	2.617	0.636	2.597	1.749	4.347	2.945	0.332	2.606	1.957	5.347
T_5	2.570	0.411	2.4646	1.720	5.097	3.0769	0.385	2.7469	1.979	6.594	2.527	0.536	2.457	1.740	4.338	2.948	0.335	2.603	1.948	5.338
T_6	2.661	0.423	2.4869	1.726	5.103	3.0969	0.406	2.7500	2.039	6.603	2.587	0.606	2.517	1.746	4.344	2.951	0.338	2.612	1.954	5.344
T_7	2.554	0.408	2.4526	1.717	5.094	3.0669	0.382	2.7314	1.949	6.594	2.497	0.506	2.430	1.737	4.335	2.95	0.344	2.618	1.945	5.335
Mean	2.576	0.405	2.4747	1.718	5.096	3.0771	0.386	2.7569	1.967	6.595	2.512	0.519	2.443	1.738	4.336	2.838	0.333	2.607	1.946	5.336
S.Ed.	0.005	0.004	0.0004	0.003	0.001	0.0003	0.004	0.007	0.003	0.001	0.001	0.002	0.002	0.003	0.001	0.003	0.005	0.006	0.002	0.003
CD (P=0.05)	0.010	0.009	0.0008	0.007	0.003	0.0006	0.008	0.0015	0.007	0.002	0.002	0.005	0.004	0.007	0.003	0.006	0.011	0.013	0.004	0.007

stover content (2.069 mg kg^{-1}), zinc fruit content (1.729 mg kg^{-1}), boron stover content (6.606 mg kg^{-1}), boron fruit content (5.109 mg kg^{-1}) in treatment (T_4).

In the second field experiment resulted at Therku Pichavaram noticed the maximum nitrogen stover content (2.945 %), nitrogen fruit content (2.617 %), phosphorus stover content (0.332 %), phosphorus fruit content (0.636 %), potassium stover content (2.606 %), potassium fruit content (2.457 %), zinc stover content (1.957 mg kg^{-1}), zinc fruit content (1.749 mg kg^{-1}), boron stover content (5.347 mg kg^{-1}), boron fruit content (4.347 mg kg^{-1}) were recorded in treatment T_4 of coastal saline soil.

The soil application of $ZnSO_4$ along with organic manure increased the zinc content in plant tissue. $ZnSO_4$ is readily soluble in water and hence there is an increased absorption of zinc which resulted in increased concentration of zinc in plant (47). At harvest nutrient concentration was reduced which might be due to the utilization of nutrient for various metabolic and catalytic activities during the crop growth (48). The NPK content increased due to application of levels of zinc and boron on with RDF. There was significant increase in N and P concentration in increasing levels. The effect of zinc on N concentration may be dilution effect while the effect of B on N concentration may be synergistic relationship between these nutrients (49).

Boron application increased K concentration irrespective of Zn supply. This may be due to synergistic interaction between B and K (50). Irrespective of zinc supply, B concentration was markedly increased with increasing B application (51).

With related to seaweed extract application the increase in NPK content in brinjal resulted from the application of seaweed extract may be attributed as natural regulators or an organic stimulator which improve plant vigour. The seaweed extract contains many ingredients, i.e., auxins, cytokininn, mineral elements and vitamins. It was found that the presence of bioactive substances in seaweed extract improved stomata uptake efficiency in the treated plants compared with untreated plants (52).

The increase in leaf content of micronutrients following spraying with seaweed extract may be due to the direct absorption of it from the leaves through the stomata when adding foliar spray. It was positively reflected in the increase in the concentration of nutrients inside the plant. Amino acids have a physiological role in changing the osmotic potential inside the plant tissues as it reduces the water stress. It increases the cells' ability to absorb water and nutrients and increases the leaf contents of then nutrients. These results agree with when spraying seaweed extract (53).

With regard to foliar spray of panchagavya the increase in NPK content may be due to fermented solutions of panchagavya containing various salts rich in NPK and micronutrients in plant available form helps in the formation of chlorophyll in the leaves. The maximum zinc and iron content in fruit with use of panchagavya spray might be due to optimum dose of bioregulator panchakavya which provide more micronutrients as well as growth regulators like auxin and gibberellic acid which helped in providing higher biomass and in better recovery of Fe and Zn in plant (54).

Subsequently with foliage application of gibberellic acid the increase in NPK content of leaves of nutrients when spraying gibberellin mixture may be due to its role increasing vegetative growth through increased cell division which leads to an increase in the number and growth of new branches and an increase in the leaf area and the circumference of stem and branches and it also increase the accumulation of chlorophyll which increase the efficiency of the carbonic metabolism process and increase the content of leaves of nutrient (55). The improve micronutrient content may be role of gibbberellic acid in the division which may lead to increased absorption of some nutrients including the significant effect of the leaf Fe, Mn and Zn content (56).

Due to foliage application of humic acid, the increase in NPK content related to nitrogen content in brinjal plant was believed to the responsible for more chlorophyll content and palisade cells per unit area of leaf tissue which ultimately increased the photosynthesis. The foliar spray of humic acid is easily absorbed by plants. The stimulating activity of humic acid might have increased the demand for inorganic P for ATP synthesis revealed accumulation of P in leaves. The foliar application of humic acid readily changed into compounds available to plants by mineralization (57).

The concentration of all the micronutrients (Fe, Mn, Zn, Cu and B) was significantly higher in the treatments which receiving foliar spray humic acid along with recommended dose of NPK. The higher concentration of nutrient observed may be due to enhanced nutrient supply because of plant ability to absorb nutrients. Addition of humic acid increased the concentration which might be due to the chelating property of the humic acid which complexed with micronutrient and increased the absorption and translocation of nutrients within the crop. The increased content of micronutrients by humic acid evidenced (58).

With respect to NAA foliar spray the increase in concentration of N, P, Fe, Mn, Zn and Cu at foliar nutrition to overcome fixation of nutrients in soils measure against hidden deficiencies. Macronutrients are N, P and K are use of the chief importance in enhancing quality and productivity of brinjal (59).

In the field experiment I (Table 4) conducted at Vallampadugai (Typic Ustifluvents) (neutral soil) the maximal N stover uptake (59.806 kg ha^{-1}), N fruit uptake (90.13 kg ha^{-1}), P stover uptake (7.95 kg ha^{-1}), P fruit uptake (14.79 kg ha^{-1}), K stover uptake (54.193 kg ha^{-1}), K fruit uptake (87.3 kg ha^{-1}), Zn stover uptake (4.014 kg ha^{-1}), Zn fruit uptake (6.02 kg ha^{-1}), boron stover uptake (17.77 g ha^{-1}), boron fruit uptake (12.75 g ha^{-1}) in the treatment T_4 (75 % RDF + seasoned pressmud @ 12.5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} + foliar seaweed extract @ 3 % on 30 and 60 DAT). Similar trend were observed in the field experiment - II (Coastal saline soil) registered N stover uptake (52.01 kg ha^{-1}), N fruit uptake (71.91 kg ha^{-1}), P stover uptake (5.863 kg ha^{-1}), P fruit uptake (17.47 kg ha^{-1}), K stover uptake (46.02 kg ha^{-1}), K fruit uptake (69.99 kg ha^{-1}), Zn stover uptake (2.226 g ha^{-1}), Zn fruit uptake (4.806 g ha^{-1}), boron stover uptake (16.72 g ha^{-1}) and boron fruit uptake (11.945 g ha^{-1}) observed in treatment (T_4).

Due to foliar application of seaweed extract increased significantly NPK uptake. The presence of marine bioactive substances in seaweed extract improves stomata uptake efficiency in treated plants compared to non-treated plants. In addition, concentrations of seaweed extract can increase not size, thus increasing the volume of soil sampled by a plant which indeed helps in the uptake of nutrients by plant. Increasing evidence exists that nutrient uptake and movement within plants is under normal control interestingly seaweed saps used in present study contained hormone were used as foliar

Table 4. Effect of seasoned pressmud, zinc sulphate, borax, growth regulators and biostimulants on NPK, Zn, B uptake

Treatment	Neutral soil									
	Fruit					Stover				
	N (%)	P (%)	K (%)	Zn (mg kg^{-1})	B (mg kg^{-1})	N(%)	P(%)	K (%)	Zn (mg kg^{-1})	B (mg kg^{-1})
T_1	58.92	8.824	56.54	3.947	7.112	32.906	3.995	29.359	2.019	11.74
T_2	59.20	8.885	56.72	3.971	7.182	33.226	4.054	29.639	2.071	11.80
T_3	63.32	9.673	62.41	4.253	8.569	39.746	4.848	36.639	2.509	12.62
T_4	90.13	14.79	87.30	6.020	12.750	59.806	7.950	54.193	4.014	17.77
T_5	68.10	10.89	65.31	4.560	9.962	43.446	5.827	45.615	3.004	13.50
T_6	79.30	12.60	74.11	5.146	10.960	51.416	6.755	44.127	3.403	15.20
T_7	66.55	10.64	64.01	4.483	9.690	45.086	5.628	40.174	2.880	13.29
Mean	69.37	10.90	66.62	4.687	9.598	44.834	5.668	46.616	2.891	13.88
S.Ed.	0.084	0.02	0.07	0.006	0.016	0.214	0.011	0.488	0.005	0.019
CD (P=0.05)	0.181	0.04	0.16	0.014	NS	0.460	0.023	1.047	0.012	0.041

Treatment	Coastal saline soil									
	Fruit					Stover				
	N (%)	P (%)	K (%)	Zn (mg kg^{-1})	B (mg kg^{-1})	N (%)	P (%)	K (%)	Zn (mg kg^{-1})	B (mg kg^{-1})
T_1	46.12	7.77	44.77	3.312	8.288	28.77	3.165	25.45	1.214	5.21
T_2	49.81	8.91	48.38	3.538	8.848	31.75	3.521	28.19	1.341	5.757
T_3	50.32	9.50	49.70	3.537	8.837	34.13	3.817	30.21	1.319	6.187
T_4	71.91	17.47	69.99	4.806	11.945	52.01	5.863	46.02	2.226	9.442
T_5	69.92	11.61	53.24	3.771	9.400	41.84	4.753	37.02	1.766	7.774
T_6	66.77	15.64	64.96	4.506	11.211	46.03	5.272	40.74	1.960	8.296
T_7	51.23	10.40	49.96	3.581	8.912	35.06	4.152	31.59	1.506	8.336
Mean	58.42	11.84	54.98	3.864	9.634	39.08	4.439	34.67	1.645	6.435
S.Ed.	0.07	0.02	0.08	0.006	0.016	0.48	0.011	0.48	0.005	0.041
CD (P=0.05)	0.16	0.04	0.18	0.014	0.035	1.04	0.033	1.04	0.011	0.080

applications that might be responsible for increasing nutrient uptake by brinjal (60).

Due to foliar application of panchagavya the increase in uptake of nutrients with foliar spray of panchagavya was to increase microbial efficiency of crop plants and create greater source and sink in the plant system.

The increased NPK uptakes were due to consequence of better nutritional environmental need. Although cumulative effect of organic and inorganic source of nutrients and foliar spraying of panchagavya increased N accumulation. Its consequences colonization of bacteria and bacterial activity in roots and availability of N to the plants due to fixation of these bacteria might have fixation of these bacteria might have advanced mineral uptake especially nitrogen (61). This might have contributed to greater absorption of nutrients. The increase in uptake of nutrients may be attributed to higher total dry matter production (62).

The increase in micronutrient uptake might be due to regulation of stomata was favourably influenced by bioactive substances produced by beneficial microorganisms present in panchagavya which also enhanced the uptake of nutrient (63).

Due to foliar spray the spray of gibberellic acid during the active growth phase of the crop trigger indigenous utilization cultivation of resources and results is a better source sink relationship. Hence the cause of increased nutrient uptake may be the increased assimilation of all nutrients effectively during the vegetative phase under maximum uptake potential (64). Moreover, the translocation of nutrients to sink during formation and subsequent development of fruit can also be reasonably individual to be responsible for nutrient depleting at latter stages of growth (65).

Due to foliar application of humic acid promote the conversion of mineral nutrients into available forms for plants. Our findings claim that nutrient absorption by plants is significantly higher if we increase the humic acid level along with NPK application. In T_4 (75 % RDF + seasoned pressmud @ 12.5 t ha^{-1} + Soil application of zinc sulphate 25 kg ha^{-1} + borax @ 10 kg ha^{-1} + foliar spray seaweed extract 3 % on 30 and 60 DAT) treatment in which higher dose of humic acid exists; facilitate the plants leaves for maximum nutrient accumulation (NPK contents). It is observed that HA plays a vital role in nutrient accumulation to roots and hence phosphorus absorption rate may be increased by HA application at critical growth stages (66).

Potassium increases water use efficiency and transforms sugars into starch in the grain filling processes. It's important for a plant's ability to withstand extreme cold and hot temperatures, drought and pests. The addition of 'K' contents in plant higher by increasing the HA and NPK application. Seaweed extract and humic acid significantly enhanced the enzyme activity *viz.,* peroxidase (POD), catalase (CAT), superoxide dismutase (SOD) in the plant thereby increased macro and micronutrients uptake (67).

Soil health and enzyme activity

With respect to third trial experiment (Table 5) (Field trial - I) and 4th trial (Field trial - II). The highest organic carbon (4.019 g kg^{-1}), soil available N (151.139 kg ha^{-1}), soil available P (44.549 kg ha^{-1}), soil available K (131.049 kg ha^{-1}), DTPA Zn (0.290 mg kg^{-1}) (R^2 = 0.8382) and hot water soluble boron (0.489 mg kg^{-1}) in neutral soil

Table 5. Effect of seasoned pressmud, $ZnSO_4$, borax, biostimulants, growth regulators on soil organic carbon, post harvest soil available NPK

Treatment	Neutral soil				Coastal saline soil			
	Soil organic carbon (g kg^{-1})	$KmnO_4$-N	Olsen-P	NH_4OAC-K	SOC (g kg^{-1})	$KMnO_4$-N (kg ha^{-1})	Olsen-P (kg ha^{-1})	NH4OAC-K (kg ha^{-1})
T_1	3.939	150.719	44.129	130.639	0.817	100.54	21.41	191.01
T_2	3.949	150.779	44.189	130.700	0.821	137.41	23.39	205.88
T_3	3.959	150.839	44.249	130.759	0.824	138.41	23.47	206.41
T_4	4.019	151.139	44.549	131.049	0.838	145.19	23.88	211.39
T_5	3.979	150.959	44.369	130.839	0.829	140.27	23.61	208.41
T_6	4.009	151.049	44.509	131.000	0.835	143.19	23.81	210.81
T_7	3.969	150.879	44.309	130.819	0.826	139.23	23.59	207.41
Mean	3.978	150.920	44.339	130.849	0.827	135.79	23.37	206.29
S.Ed.	0.0004	0.002	0.006	0.056	0.002	0.33	0.005	0.05
CD (P=0.05)	0.0008	0.005	0.013	0.113	0.005	0.72	0.012	0.11

(Vallampadugai) were recorded in T_4. The highest organic carbon (0.998 g kg^{-1}), soil available N (145.19 kg ha^{-1}), soil available P (23.88 kg ha^{-1}), soil available K (211.39 kg ha^{-1}), DTPA Zn (0.250 mg kg^{-1}) (R^2 = 0.3687), hot water soluble boron (0.341 mg kg^{-1}) in coastal saline soil (Therku Pichavaram) in treatment T_4(Seasoned pressmud @ 12.5 t ha^{-1} + $ZnSO_4$ application @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} + gibberellic acid 3 % on 30 and 60 DAT) (Table 6). Application of pressmud as an organic manure shown increase in organic carbon after first application, as level of initial carbon in soil is very low and it has the potential to store more carbon (68).

The amount of available N content in soil gradually increased over the initial amount. It might be due to the direct addition of nitrogen from the decomposition of pressmud leads to mineralization of organically bound nitrogen. This result was in agreement with the findings of (69). The increase in P and K in soil might be explained by the release of P from the applied pressmud after mineralization and K due to releasing from organics and potash bearing minerals that already exist in both soils. The higher value of available phosphorus was recorded in pressmud treated plots, which might be because pressmud is a rich source of phosphorus. Increasing soil available P with pressmud application (70).

Organics were superior in improving available P it might be due solubilizing effect of organic acids and organic phosphorus and organic anions retard the fixation by P in by complexing with organic ligands and chelation of P fixing cation like Ca, Mg, Fe, Zn, Mn and Cu. Phosphorus complex with humic acid fulvic acids increase the availability of phosphorus to the plants (71).

The soil available potassium increased due to pressmud having significant amount of potassium, it was related due to microbial decomposition during the study and enhanced available potassium in soil (72). With the increase of soil micronutrient content in treatment (T_4) might be due to application of pressmud having large amount of organic matter and abundant quantity of micronutrients such as iron, manganese, zinc, copper and boron.

Table 6. Effect of seasoned pressmud, $ZnSO_4$, borax, biostimulants, growth regulators on DTPA Zn and hot water-soluble B

Treatment	Neutral soil		Coastal saline soil	
	DTPA-Zn	Hot water-soluble B	DTPA-Zn	Hot water-soluble B
T_1	0.260	0.471	0.200	0.320
T_2	0.266	0.474	0.236	0.323
T_3	0.270	0.477	0.238	0.326
T_4	0.290	0.489	0.250	0.341
T_5	0.276	0.480	0.244	0.332
T_6	0.286	0.489	0.248	0.338
T_7	0.272	0.480	0.241	0.329
Mean	0.272	0.481	0.238	0.330
S.Ed.	0.002	0.002	0.002	0.001
CD (P=0.05)	0.004	0.005	0.004	0.002

Therefore, pressmud will more likely improve the micronutrient distribution and enhance beneficial microbial activities with soil system (73). Concentration of zinc increase as level of $ZnSO_4$ with pressmud. This is because $ZnSO_4$ is the direct source of Zn and pressmud works as pool of most micronutrients (74).

Nutrient management practices had significant influences on soil enzyme activities soils treated seasoned pressmud showed higher activity of urease (90.27 and 86.4 mgNH_4-N g^{-1}2 h^{-1}), dehydrogenase 68.42 and 64.4 TPF mg-01- 24 h^{-1}) (Table 7) in both the soils of treatment T_4. These enzymes help release plant nutrients. Soil organic matter is an important factor for soil quality improvement. It influences soil physico-chemical properties of normal and coastal saline soils. Soil organic matter regulates the soil enzymatic activities and energy nutrients for soil (75).

It also increased the activity of soil enzymes responsible for the conversion of unavailable forms of nutrients to available form. It facilitates more availability of essential nutrients to plants which supported the vegetative growth and finally increased the fruit yield (36).

Regression analysis and nutrient correlation

The positive response existed between fruit yield and $ZnSO_4$ application increased zinc content in post harvest soil (R^2 = 0.8382 for neutral soil and R^2 = 0.368 for coastal saline soil) (Fig. 1 and 2). Optimum yield was obtained by receiving 10 kg borax ha^{-1}. This might be due to the fact that boron plays role in many biochemical processes in plants like carbohydrate metabolism and transplant of sugar through membrane, tissue development and formation of cell walls and helps in cell division (28, 29) (Fig. 3 and 4).

Foliar spray of seaweed extract for @ 3 % facilitates fruit number in brinjal phytohormone, gibberellin and particular essential elements such as potassium and magnesium which are major by present in most seaweed extract influenced the fruit number of most plants (76). This resulted in increased boron content in post harvest residue to borax application associated

Table 7. Effect of seasoned pressmud, $ZnSO_4$, borax, growth regulators and biostimulants on urease and dehydrogenase

Treatment	Normal soil		Coastal saline soil	
	Urease	Dehydrogenase	Urease	Dehydrogenase
T_1	60.41	54.24	54.41	50.24
T_2	87.22	61.85	83.24	57.83
T_3	74.24	58.16	70.25	54.12
T_4	90.23	68.42	86.48	64.45
T_5	89.71	64.73	85.79	60.52
T_6	88.24	63.81	84.32	59.73
T_7	87.95	62.42	83.21	58.24
Mean	82.57	61.94	61.91	57.84
S.Ed.	0.09	0.16	0.64	0.03
CD (P=0.05)	0.19	0.35	1.39	0.08

NEUTRAL SOIL

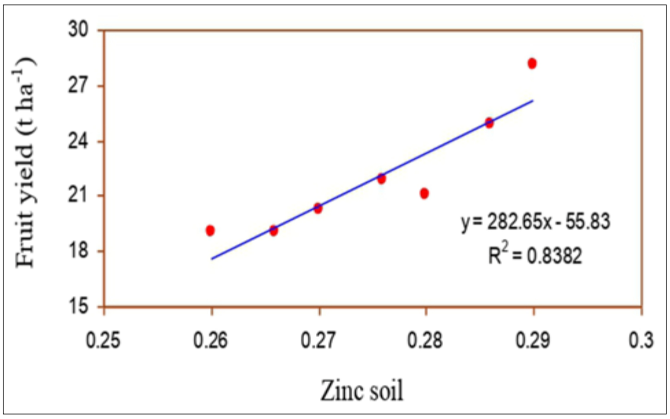

Fig. 1. Linear relationship between soil zinc content and fruit yield.

COASTAL SALINE SOIL

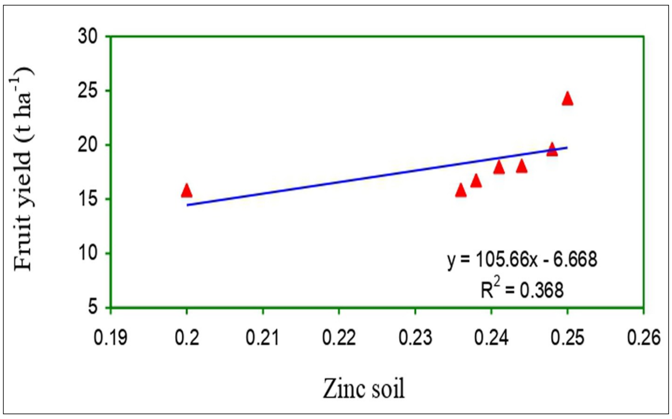

Fig. 2. Linear relationship between soil zinc content and fruit yield.

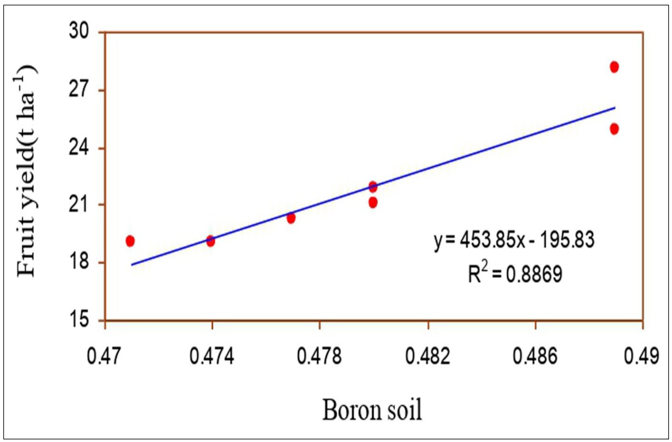

Fig. 3. Linear relationship between soil boron content and fruit yield.

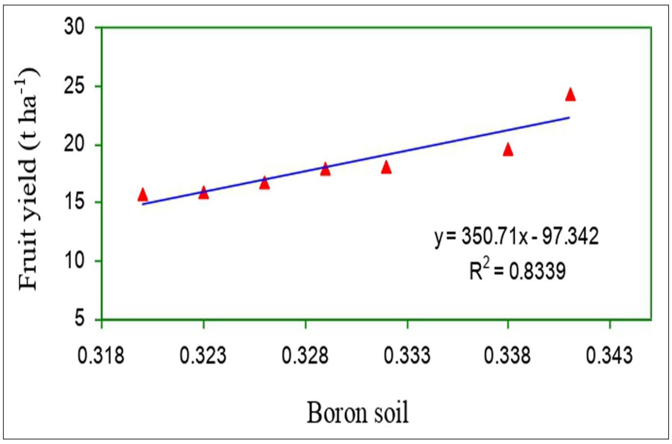

Fig. 4. Linear relationship between soil boron content and fruit yield.

with fruit yield (R_2= 0.8869 in neutral soil and R^2 = 0.8339 in coastal saline soil).

The beneficial influence of zinc application in the yield of brinjal may be attributed to its role in various enzymatics reactions, growth process, hormone production and protein synthesis and also the translocation of photosynthates to reproductive plants, thereby leading to higher yield of crop (77). Optimum yield was obtained by treatment receiving 10 kg borax ha^{-1}. This might be due to the fact that boron plays role in many biochemical processes in plants like carbohydrate metabolism and transplant of sugar through membrane, tissue development and formation of cell walls and helps in cell division (78).

The application of pressmud taken part in chlorophyll. Chlorophyll synthesis is mainly affected by light, temperature and carbohydrate. In the present study addition of pressmud increased the growth as well as production of plants because these materials increased the growth of roots, reinforced the plant stems and enhanced the photosynthetic rates thus increasing the amount as well as uptake of micronutrient (79). Biostimulants even those minerals cannot supply all the essential nutrients in the quantities required by plants. In addition to proper mineral fertilization, biostimulants can enhance the effectiveness of fertilizer as well as nutrient utilization from soil (80). This is evidenced in increased zinc uptake due to $ZnSO_4$ application resulted with fruit yield (R^2 = 0.9931 in neutral soil and R^2 = 0.8622 in coastal saline soil) (Fig. 5 and 6). The increase in fruit yield (R^2 = 0.9305) in neutral soil, R^2 =

NEUTRAL SOIL

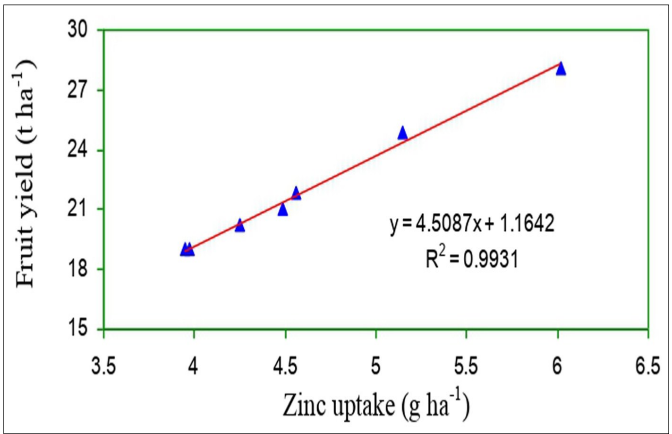

Fig. 5. Linear relationship between zinc uptake and fruit yield.

COASTAL SALINE SOIL

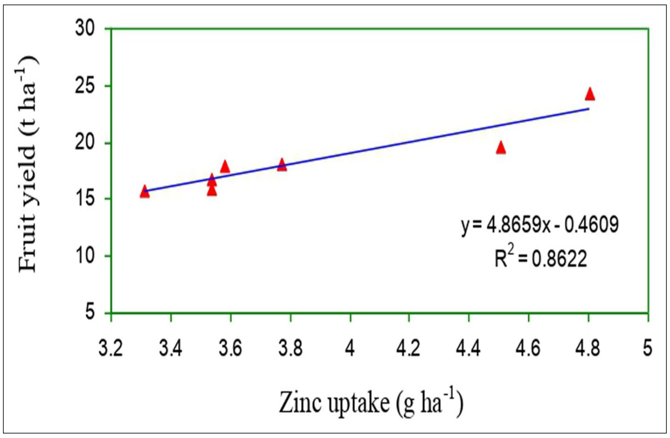

Fig. 6. Linear relationship between zinc uptake and fruit yield.

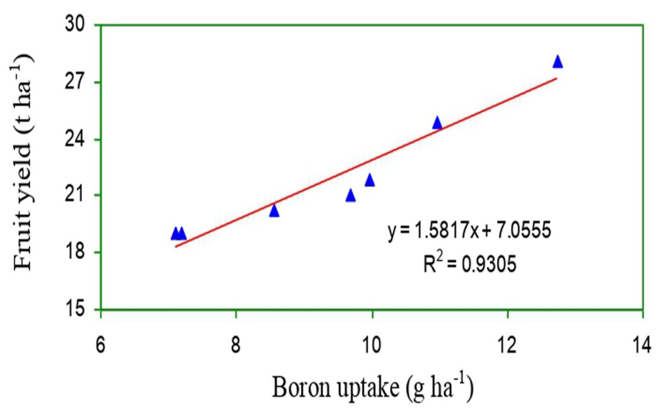

Fig. 7. Linear relationship between boron uptake and fruit yield.

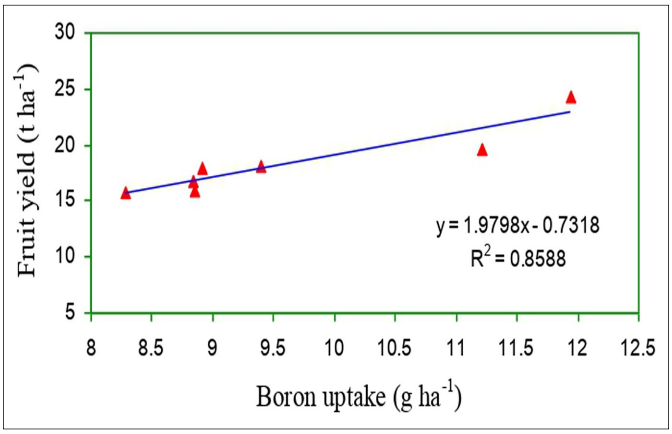

Fig. 8. Linear relationship between boron uptake and fruit yield.

0.8588 in coastal saline soil (Fig. 7 and 8) due to application of seasoned pressmud, borax and foliar spray of biostimulants.

Conclusion

Application of 75 % RDF + seasoned pressmud @ 12.5 t ha^{-1} + soil application of $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1} + seaweed extract @ 3 % on 30 (vegetative) and 60 (flowering) DAT found to be the best soil and nutrient management for yield and quality of brinjal in neutral and coastal saline soil.

Acknowledgements

The authors would like to thank the Department of Soil Science and Agricultural Chemistry, Annamalai University,Annamalainagar 608 002, Tamilnadu and Mr. Thennavan, Vallampadugai and Mr. Sekar, Therkupichavaram, Cuddalore district who provided land for conducting trial.

Authors' contributions

All authors contributed for analyzing samples and traced land for trial. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

References

1. https://www.prtau.edu.in>Agrimkt> February 2024.
2. Kumar P, Sharma PK. Salinity and food security in India. Front Sustain Food Syst. 2020;4:1-15. https://doi.org/10.3389/fsufs.2020.533781
3. Firdaus J. Best salt tolerant vegetables flowers and fruit tree for beach agriculture. Agric Garden English Version. 2022;1-23. https://doi.org/10.1007/978-981-13-5832-6_24
4. Pandey SK, Chandra KK. Impact of integrated nutrient management on tomato yield under farmers' conditions. J Environ Biol. 2013;34:1047-51. https://doi.org/10.5958/2230-732X.2016.00075.9
5. Manohar SVS, Paliwal R, Matwa J, Leua HN. Integrated nutrient management in tomato. Asian J Hortic. 2013;8(2):414-17.
6. Sunil Kumar B, Meena RS, Jinger D, Jatav HS, Banjara T. Use of pressmud compost for improving crop productivity and soil health. Int J Chem Stud. 2017;5(2):384-89.
7. Singh DP, Maurya, Kumari M, Singh RP, Singh DB, Kumar P. Response of integrated nutrient management (INM) on growth and yield attributes in tomato (*Solanum lycopersicum* L.). Ann Agric Res New Ser. 2023;44(1):120-26.
8. Rautaray SK, Sucharita S. Zinc fertilizer application. Indian Farming. 2023;73(5):7-10.
9. Rani P, Tripura U. Effect of integrated nutrient management on growth and yield of tomato: A review. Pharma Innov Int J. 2021;10(5):1695-701.
10. Margal PB, Thakare RS, Kumble BM, Patil VS, Patel KB, Titrimare NS. Effect of seaweed extracts on crop growth and soil: A review. J Exp Agric Int. 2023;45(9):9-19. https://doi.org/10.9734/jeai/2023/v45i92170
11. Muller M, Munne-Bosch S. Hormonal impact on photosynthesis and photoprotection in plants. Plant Physiol. 2021;185:1500-22. https://doi.org/10.1093/plphys/kiaa119
12. Thuc LV, Sakagani JK, Uuoc KN, Orgill SE, Huu TN, Thi N, et al. Effect of spraying gibberellic acid doses on growth, yield and oil content in blackgram. Asian J Crop Sci. 2021;13:1-8. https://doi.org/10.3923/ajcs.2021.1.8
13. Upadhyay PK, Sen A, Prasad SK, Singh Y, Srivastava JP, Singh SP, et al. Effect of panchagavya and recommended dose of fertilizers on growth, nutrient content and productivity of transplanted rice under middle Gangetic plains of India. Indian J Agric Sci. 2018;88(6):931-36. https://doi.org/10.56093/ijas.v88i6.80650
14. Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India Pvt. Ltd.; 1973. p. 498.
15. Lindsay WL, Norvell WA. Development of DTPA test for zinc, iron, manganese and copper. Soil Sci Soc Am Proc. 1978;42:421-28. https://doi.org/10.2136/sssaj1978.03615995004200030009x
16. Wolf B. Improvements in the azomethine-H method for the determination of boron. Commun Soil Sci Plant Anal. 1974;5:39-44. https://doi.org/10.1080/00103627409366478
17. Gupta UC. Some factors affecting the determination of hot water-soluble boron from podzol using azomethine-H. Can J Soil Sci. 1979;59:241-47. https://doi.org/10.4141/cjss79-027
18. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 1934;37:29-38.
19. Subbiah BV, Asija GL. A rapid procedure for determination of available nitrogen in soils. Curr Sci. 1956;31:259-60.
20. Watanabe FS, Olsen SR. Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from the soil. Soil Sci Soc Am J. 1965;29:677-78. https://doi.org/10.2136/sssaj1965.03615995002900060025x
21. Sharma A. Agricultural statistics for field and laboratory experimental. New Delhi: Kalyani Publishers; 2016.
22. Kumar R, Biswas TK. Soil enzymic activities as affected by long-term

application of organic and inorganic fertilizers in tropical rice and wheat cropping system. J Indian Soc Soil Sci. 2016;64:258-65. https://doi.org/10.1016/j.ejsobi.2008.02.004

23. Arumugam S, Anburani A. Effect of certain organics and pressmud on growth and yield characters of tomato. Asian J Hortic. 2008;3 (2):273-76.

24. Nagar V, Kumar S, Khan R, Bagri UK, Bunker RR. Effect of foliar spray of zinc sulphate on growth and yield of tomato. Pharma Innov J. 2022;11(3):933-37.

25. Karuppaiah P. Effect of zinc and boron on growth, yield and quality of tuberose (*Polianthes tuberosa* L.) cv. Prajwal. Hortic Int J. 2019;3 (1):7-11. https://doi.org/10.15406/hij.2019.03.00104

26. Swarnam TP, Velmurugan A, Lakshmi NV, Kavitha G. Foliar application of seaweed extract on yield and quality of okra grown in a tropical acid soil. Trends Biosci. 2020;13(6):1-6.

27. Suchith Kumar C, Singh G. Effect of panchagavya on growth and yield: A review. Int J Curr Microbiol Appl Sci. 2020;9(12):617-24. https://doi.org/10.20546/ijcmas.2020.912.073

28. Hilli JS, Vyakarnahal BS, Biradar DP, Hunje R. Effect of growth regulators and stages of spray on growth, fruit set and seed yield of ridge gourd. Karnataka J Agric Sci. 2010;23:239-42.

29. Dhenglel RP, Bhosale AM. Effect of NAA and GA along with urea on certain quality attributes of cabbage (*Brassica oleracea* var. *capitata*). Asian J Hortic. 2007;70(2):30-32.

30. Hemati A, Alikhani HA, Ajdanian L, Babaei M, Asgari Lajayer B, van Hullebusch ED. Effect of different enriched vermicomposts, humic acid extract and indole-3-acetic acid amendments on the growth of *Brassica napus*. Plants. 2022;11(2):227. https://doi.org/10.3390/plants11020227

31. Kumar A, Khare A. Nutrient management in cabbage for higher production in Bundelkhand region of Uttar Pradesh. Ann Plant Soil Res. 2015;17(1):33-36.

32. Kumar M, Sen NL. Interaction effect of zinc and boron on okra (*Abelmoschus esculentus* (L.) Moench) cv. Prabhani Kranti. Agric Sci Digest. 2004;24(4):307-08.

33. Singh S, Singh V. Effect of rate and source of zinc on yield, quality and uptake of nutrients in Indian mustard (*Brassica juncea*) and soil fertility. Indian J Agric Sci. 2017;87(2):1701-05. https://doi.org/10.56093/ijas.v87i12.76517

34. Kumararaja P, Premi OP, Kandpal BK. Application of boron enhances Indian mustard (*Brassica juncea*) productivity and quality under boron-deficient calcareous soil in semi-arid environment. Ecol Environ Conserv. 2015;21:249-54.

35. Erulan V, Soundarapandian P, Thirumaran G, Ananthan G. Studies on the effect of *Sargassum polycystum* (C. Agardh, 1824) extract on the growth and biochemical composition of *Cajanus cajan* (L.) Millsp. Am Eur J Agric Environ Sci. 2009;6(4):392-99.

36. Pannu RPS, Chopra S, Kaur N. Effect of combined application of FYM, pressmud and fertilizers on the yield and growth characteristics of summer mash (*Vigna mungo*). Agric Sci Digest. 2007;27(3):216-8.

37. Khazaal ZH, Rashed ZS. Effects of cultivars and spraying with seaweed extract (Tecamin algae) on the growth and yield of eggplant (*Solanum melongena* L.). Euphrates J Agri Sci. 2018;10(2):1-6. https://doi.org/10.13140/RG.2.2.17632.64007

38. Aremu AO, Fawole OA, Makunga NP, Masondo NA, Moyo M, Buthelezi NMD, et al. Applications of cytokinins in horticultural fruit crops: Trends and future prospects. Biomolecules. 2014;10(9):1-68. https://doi.org/10.3390/biom10091222

39. Arun D, Gayathri PK, Chandran M, Yuvaraj D. Studies on effect of seaweed extracts on crop plants and microbes. Int J ChemTech Res. 2014;6(9):4235-40.

40. Sanodiya LK, Kevat P, Tiwari M. Seaweed extract: Usable for plants growth and yield. Vigyan Varta Int E-Mag Sci Enthusiasts. 2022;3 (3):80-4.

41. Gore NS, Sreenivasa MN. Influence of liquid organic manures on growth, nutrient content and yield of tomato (*Lycopersicon esculentum* Mill.) in sterilized soil. Kar J Agric Sci. 2011;24(2):153-7. https://www.cabidigitallibrary.org/doi/full/10.5555/20113149285

42. Shree S, Regar CL, Ahmad F, Singh VK, Kumari R, Kumari A. Effect of organic and inorganic fertilizers on growth, yield and quality attributes of hybrid bitter gourd (*Momordica charantia* L.). Int J Curr Microbiol App Sci. 2018;7(4):2256-66. https://doi.org/10.20546/ijcmas.2018.704.258

43. Shafeek MR, Helmy YI, Ahmed AA, Ghoname AA. Effect of foliar application of growth regulators (GA3 and Ethereal) on growth, sex expression and yield of summer squash plants (*Cucurbita pepo* L.) under plastic house condition. Int J ChemTech Res. 2016;9(6):70-6.

44. Balakumbhan R, Rajamani K. Effect of biostimulants on growth and yield of senna (*Cassia angustifolia* var. KKM 1). J Horti Sci Orn Plants. 2010;2(1):16-8.

45. Kaveri K, Singh R, Indu T. Effect of foliar spray of nitrogen and NAA on growth and yield traits of cowpea (*Vigna unguiculata* L.). Int J Plant Soil Sci. 2022;34(8):56-61. https://doi.org/10.9734/ijpss/2022/v34i1831053

46. Vijayaraghavan H. Effect of seed treatment with plant growth regulators on bhendi (*Abelmoschus esculentus* L.) grown under sodic soil conditions. Madras Agrl J. 1999;86(4-6):247-9. https://doi.org/10.29321/MAJ.10.A00592

47. Verma M, Choudhary MR, Mahawar AK, Singh SP, Meena NK. Response of thiourea and zinc on quality characteristics and economics of cauliflower (*Brassica oleracea* var. botrytis L.). Chem Sci Rev Lett. 2017;6(22):1285-9.

48. Chethana KH, Subbarayappa CT, Naveen DV. Effect of soil and foliar application of zinc on zinc content and uptake by cauliflower (*Brassica oleracea* var. botrytis L.). J Pharmacog Phytochem. 2019;8 (4):3159-63.

49. Adiloglu A, Adiloglu S. The effect of boron (B) application on the growth and nutrient contents of maize in zinc (Zn) deficient soil. Bulg J Agrl Sci. 2006;12:387-92.

50. Hosseini SM, Maftoun M, Karimian N, Ronaghi A, Emam Y. Effect of zinc × boron interaction on plant growth and tissue nutrient concentration of corn. J Plant Nutr. 2007;30(5):773-81. https://doi.org/10.1080/01904160701289974

51. Sinha P, Jain R, Chatterjee C. Interaction effect of boron and zinc on growth and metabolism of mustard. Commun Soil Sci Plant Anal. 2000;31(1-2):41-9. https://doi.org/10.1080/00103620009370419

52. Mancuso S, Azzarello E, Mugnai S, Briand X. Marine bioactive substances (IPA extract) improve foliar ion uptake and water stress tolerance in potted *Vitis vinifera* plants. Adv Hort Sci. 2006;20(2):156-61. https://www.jstor.org/stable/42882475

53. Spinelli F, Fiori G, Noferini M, Sprocatti M, Costa G. Perspectives on the use of a seaweed extract to moderate the negative effects of alternate bearing in apple trees. J Horti Sci Biotechnol. 2009;17 (7):131-7. https://doi.org/10.1080/14620316.2009.11512610

54. Kumawat R, Mahajan SS, Mertia RS. Growth and development of groundnut (*Arachis hypogaea*) under foliar application of panchgavya and leaf extracts of endemic plants. Ind J Agr. 2009;54 (3):324-31. https://doi.org/10.59797/ija.v54i3.4798

55. Al-Bayati HJM, Ibraheem FFR, Allela W, AL-Taey DKA. Role of organic and chemical fertilizer on growth and yield of two cultivars of pea (*Pisum sativum* L.). Plant Archives. 2019;19:1249-53. https://doi.org/10.13140/RG.2.2.30469.60648

56. Shahin MFM, Fawzi MIF, Kandil EA. Influence of foliar application of some nutrients (Fertifol Misr) and gibberellic acid on fruit set, yield, fruit quality and leaf composition of “Anna” apple trees grown in sandy soil. J Am Sci. 2012;6(12):202-8.

57. Ananthi K, Vanangamudi M. Foliar spray of humic acid with growth

regulators in nutrient content and yield of greengram (*Vigna radiata* (L.) Wilczek). Leg Res. 2014;37(4):359-62. https://doi.org/10.5958/0976-0571.2014.00644.4

58. Khaled H, Fawy HA. Effect of different levels of humic acids on the nutrient content, plant growth and soil properties under conditions of salinity. Soil Water Res. 2011;6(1):21-9. https://doi.org/10.17221/4/2010-SWR
59. Al-Juthery HWA, Hardan HM, Al-Swedi FGA, Obaid MH, Al-Shami QMN. Effect of foliar nutrition of nano-fertilizers and amino acids on growth and yield of wheat. IOP Conf Ser Earth Environ Sci. 2019;388:012046. https://doi.org/10.1088/1755-1315/388/1/012046
60. Prasad K, Das AK, Oza MD, Brahmbhatt H, Siddhanta AK, Meena R, et al. Detection and quantification of some plant growth regulators in a seaweed-based foliar spray employing a mass spectrometric technique sans chromatographic separation. J Agric Food Chem. 2010;58(8):4594. https://doi.org/10.1021/jf904500e
61. Sangameshwari P, Kumarimanimuthuveeral D. Effect of INM on soil fertility status of cotton (*Gossypium hirsutum* L.). Int J Creative Res Thoughts. 2022;10(2):863-73.
62. Choudhary GL, Sharma SK, Choudhary S, Singh KP, Kaushik MK, Bazaya BR. Effect of panchagavya on quality, nutrient content and nutrient uptake of organic blackgram (*Vigna mungo* (L.) Hepper). J Pharmacog Phytochem. 2017;6(5):1572-5.
63. Sivakumar V, Ponnusami V. Influence of spacing and organics on plant nutrient uptake of black nightshade (*Solanum nigrum*). Int J Agrl Ext Rural Develop. 2013;1(1):5-7. https://doi.org/10.5897/JHF.9000068
64. Mousa GT, El-Sallami IH, Ali EF. Response of *Nigella sativa* L. to foliar application of gibberellic acid, benzyladenine, iron and zinc. Assiut J Agr Sci. 2001;32:141-56. https://aun.edu.eg/agriculture/ar/node/30300
65. Khan NA, Ansari HR, Samiullah R. Effect of gibberellic acid spray during ontogeny of mustard on growth, nutrient uptake and yield characteristics. J Agron Crop Sci. 1998;181:61-3. https://doi.org/10.1111/j.1439-037X.1998.tb00399.x
66. Nikbakht A, Mohsen K, Mesbah B, Ping XY, Ancheng L, Nemat Allah E. Effect of humic acid on growth, nutrient uptake and post harvest life of *Gerbera*. J Plant Nutr. 2008;31:2155-67. https://doi.org/10.1080/01904160802462819
67. Yidiztekin M, Tuna AL, Kaya C. Physiological effects of the brown seaweed (*Ascophyllum nodosum*) and humic substances on plant growth, enzyme activities of certain pepper plants grown under salt stress. Acta Biol Hungarica. 2018;69(3):325-35. https://doi.org/10.1556/018.68.2018.3.8
68. Padalkar RC, Raut PD. Assessment of soil carbon level after application of pressmud and mulching regarding soil carbon sequestration. Nat Environ Poll Technol. 2016;15(2):601-4.
69. Baishya LK, Rathore SS, Singh D, Sarkar D, Deka BC. Effect of integrated nutrient management on rice productivity, profitability and soil fertility. Annal Plant Soil Res. 2015;17(1):86-90.
70. Lakshmi CSR, Sreelatha T, Usha Rani T, Rao SRK, Naidu NV. Effect of organic manures on soil fertility and productivity of sugarcane in North coastal zone of Andhra Pradesh. Ind J Agrl Res. 2011;45(4):307-13.
71. Singh G, Kumar D, Sharma P. Effect of organics, biofertilizers and crop residue application on soil microbial activity in rice-wheat and rice-wheat-mungbean cropping systems in the Indo-Gangetic plains. Cogent Geosci. 2015;1(1):1085296. https://doi.org/10.1080/23312041.2015.1085296
72. Dotaniya ML, Datta SC, Biswas DR, Dotaniya CK, Meena BL, Rajendiran S, et al. Use of sugarcane industrial by-products for improving sugarcane productivity and soil health. Int J Recycl Org Waste Agri. 2016;7:327-34. https://doi.org/10.1007/s40093-016-0132-8
73. Kumar S, Meena RS, Jinger D, Jatav HS, Banjara T. Use of pressmud compost for improving crop productivity and soil health. Int J Chem Stud. 2017;5(2):384-9. https://doi.org/10.22271/chemi
74. Sharma M, Sharma YK, Dotaniya ML, Pradepkumar. Effect of different levels of FYM, pressmud and zinc sulphate application on soil properties. J Plant Develop Sci. 2014;6(3):455-9.
75. Sudhakaran M, Kokila M, Ravanachandar A. Influence of enzyme activities and nutrient cycles in semi-arid agricultural soils. J Indian Soc Soil Sci. 2023;71:150-8.
76. Jamili KM, Catubis KML, Pascual PRL, Cabillo RA. Enhanced growth and yield of eggplant (*Solanum melongena* L.) applied with seaweed extract. J Agrl Sci. 2022;55(3):175-84.
77. Saharan BS, Sharma Y, Babel AL, Kameriya PR. Effect of sulphur and zinc on yield and uptake of mustard. J Indian Soc Soil Sci. 2013;61(1):59-62.
78. Bakhtiar M, Farooq M, Ahmed S, Ilyas N, Khan I, Saboor A, et al. Influence of sulfur and boron on the growth and yield of broccoli. Int J Environ Agri Res. 2018;4(4):9-16.
79. Jamil Khan M, Qasim Khan M, Sharif Zia M. Sugar industry press mud as alternate organic fertiliser source. Int J Environ Waste Manag. 2012;9:41-55. https://doi.org/10.1504/IJEWM.2012.044159
80. Zhang X, Ervin EH, Schmidt RE. Plant growth regulators can enhance the recovery of Kentucky bluegrass sod from heat injury. Crop Sci. 2003;43:952-6. https://doi.org/10.2135/cropsci2003.9520

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.