Influence of Different Levels of Seaweed Extract and Humic Acid Granules on Growth and Productivity of Bengal Gram (*Cicer arietinum* L.) in *Alfisols*

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Abstract

A field experiment was conducted at ZARS, UAS, GKVK, Bengaluru during *rabi,* 2021. Two species of seaweed extract granules (A-SWEG: *Ascophyllum* sp. and S-SWEG: *Sargassum* sp.) and humic acid granules (HAG) were applied to the soil at three levels (40, 60 and 80 kg ha^{-1}) in two equal doses as basal and at 30 DAS to assess their effect on growth and productivity of bengal gram. The experiment was laid out in RCBD with twelve treatments replicated thrice. Soil application of 100% NPK + S-SWE Granules @ 80 kg ha^{-1} recorded significantly higher growth attributes *i.e.,* plant height, number of branches, shoot and root length, shoot and root weight, leaf chlorophyll content and nodules per plant over control (100% NPK + FYM @ 7.5 t ha^{-1}) and found on par with soil application of 100% NPK + HAG @ 80 kg ha^{-1}. The lowest growth was observed in absolute control treatment. Similarly, with increase in the rate of seaweed extract and humic acid granules, increased the yield and yield attributes *viz*., pod weight per plant, seed weight per plant, 100 seed weight and grain yield per hectare. Higher grain yield was recorded with soil application of 100% NPK (25:50:50 kg ha^{-1}) + S-SWEG @ 80 kg ha^{-1} (18.65 q ha^{-1}) followed on par with soil application of 100% NPK + HAG @ 80 kg ha^{-1} (18.40 q ha^{-1}) and both were significant over control (16.10 q ha^{-1}) and soil application of 100% NPK + A-SWEG @ 80 kg ha^{-1} (14.15 q ha^{-1}). Absolute control recorded significantly lower grain yield (5.73 q ha^{-1}). Highest B: C ratio of 2.21 was recorded with application of 100% NPK + S-SWEG @ 80 kg ha^{-1} (T_9), whereas the lowest B: C ratio (1.17) was observed in absolute control treatment. Hence, treatment involving 100% NPK + S-SWEG @ 80 kg ha^{-1} was found to be superior in improving bengal gram productivity over all other treatments.

Keywords : Productivity of bengal gram, Humic acid, Seaweed extract

Pulses occupy a unique position in every known system of farming all over the world. Among pulses chickpea (*Cicer arietinum* L.), popularly known as Gram or Bengal gram is mainly grown in *rabi* season. It is the member of family *Leguminaceae* and sub family *Papilionaceae.* It is originated in the area of present-day south-eastern Turkey and adjacent Syria. It is a significant source of human food and animal feed. Chickpea is a rich source of highly digestible dietary protein (17-21 %), carbohydrates (61.5%) and fat (4.5%). It is also rich in Ca, Fe, niacin, Vitamin-B and Vitamin-C. It's leaves contain malic acid which is very useful for stomach ailments and blood purification (Ahmad, 2017).

Conventional agricultural production systems, coupled with lower productivity of the crops, need to be improved to accomplish sustainable production. It has been realized that any advance in an agricultural system resulting in higher crop production should reduce environmental impacts and enhance the sustainability of the system as a whole. In this context, the use of bio-stimulants in improving the effectiveness of conventional mineral fertilizers may be a good choice. Among many viable options, the use of seaweed extracts and humic acid may be a possible option.

Sea weeds are macrophytic algae. They form an integral part of marine coastal ecosystems. They include the macroscopic, multicellular marine algae that commonly inhabit the coastal regions of the world's oceans where suitable substrata exist. They grow in salt water or marine environment. They are primitive type of plants lacking true roots, stems and leaves (Krishnamurthy, 1965). Seaweeds commonly grow on coral reefs or in rocky landscape at greater depths if sunlight can penetrate through the water. The uses of seaweeds have been cited as early as 2500 years ago in Chinese literature (Tseng, 2004).

Seaweed application as farmyard manure, liquid extracts obtained from seaweeds have recently gained importance as foliar sprays (Thivy, 1961), soil application and for soaking of seeds before sowing as it contains growth promoting hormones such as auxins (IAA and IBA), cytokinin (Durand *et al.,* 2003), trace elements (Fe, Cu, Zn, Co, Mo, Mn, Ni), vitamins and amino acids which helps in increasing root development, mineral absorption (Jeannin *et al.,* 1991), enhance plant chlorophyll content, triggers early flowering, fruit set, ripening of fruits and shelf-life of the produce in number of crop plants (Zodape, 2001).

Humic substances are composed of humic and fulvic acids play a significant role in soil fertility and plant nutrition, they are frequently referred as black gold of agriculture. Humic acid (HA) is derived primarily through the biochemical decomposition of plant and animal wastes as well as microbial synthesis activity and it accounts for 65-70 per cent of soil organic matter (Gulser *et. al.,* 2010). Plants grown on soil with sufficient humic acid experience less stress, grow healthier and yield greater. Humic acid acts as root stimulators and increase root growth and development, improve stress tolerance in plant and also act as soil conditioner and promote aggregate stability, aeration and improve water holding and nutrient supplying capacity of soil (Pettit, 2004). In addition, humic substances promote the conversion of a number of mineral elements into forms available to plants. The HS presence in soil may exert several effects on plant functions and some of these may result, directly or indirectly, in a modulation of ion uptake (Nardi *et al.,* 2002). The HS also improves plant development by improving cell membrane permeability, respiration, photosynthesis, oxygen and phosphorus absorption and providing root cell growth (Pizzeghello *et. al*., 2013).

Information on optimal application rates, timing and methods needs to be developed for specific crops, geographic allocations and environments (Craigie, 2010). With this backdrop, experiment entitled 'Influence of different levels of seaweed extract and humic acid granules on growth and productivity of bengal gram (*Cicer arietinum* L.) in *Alfisols*' was conducted.

Material and Methods

A field experiment was conducted during *rabi* season of 2021 to study on the soil application of seaweed extracts and humic acid granules on growth and yield of Bengal gram (*Cicer arietinum* L.) at M-Block, Agroforestry, UAS, GKVK, Bengaluru. It is located in the Eastern dry zone of Karnataka. The experiment was laid out in Randomized Complete Block Design (RCBD) with twelve treatments and three replications (Table 1). Two species (*Ascophyllum* sp. and *Sargassum* sp.) of seaweed extract (SWE) and humic acid granules were applied to soil at three levels (40, 60 and 80 kg ha^{-1}) in two equal splits as basal and at 30 DAS as mentioned in Table 2. Detailed chemical properties of seaweed and humic acid granules used in the study were given in Table 3. The observations

TABLE 1
Details of experiment

Location	M-Block, Agroforestry
Season	*Rabi* 2021
Crop	Bengal gram (Desi channa)
Variety	JG 11
Recommended dose of fertilizer (RDF)	25:50:50 (N, P_2O_5, K_2O kg ha^{-1})
FYM	7.5 t ha^{-1}
Seed rate	62.5 kg ha^{-1}
Design	Randomized Complete Block Design
Number of treatments	12
Number of replications	3
Gross plot size	4.5 m x 2.8 m (12.6 m^2)
Net plot size	3.3 m x 2.6 m (5.58 m^2)
Spacing	30 cm x 10 cm
Date of sowing	03/01/2022
Date of harvest	07/04/2022

TABLE 2
Treatment details of the field experiment

Treatment	Treatment details
T_1	Absolute Control
T_2	100% NPK (25: 50: 50 kg ha^{-1})
T_3	100% NPK + FYM @ 7.5 t ha^{-1} (Control)
T_4	T_2 + A-SWEG @ 40 kg ha^{-1}
T_5	T_2 + A-SWEG @ 60 kg ha^{-1}
T_6	T_2 + A-SWEG @ 80 kg ha^{-1}
T_7	T_2 + S-SWEG @ 40 kg ha^{-1}
T_8	T_2 + S-SWEG @ 60 kg ha^{-1}
T_9	T_2 + S-SWEG @ 80 kg ha^{-1}
T_{10}	T_2 + HAG @ 40 kg ha^{-1}
T_{11}	T_2 + HAG @ 60 kg ha^{-1}
T_{12}	T_2 + HAG @ 80 kg ha^{-1}

Note : A-SWEG : *Ascophyllum* sp. Seaweed Extract Granules; S-SWEG : *Sargassum* sp. Seaweed Extract Granules; HAG : Humic Acid Granules; SWEG and HAG applied in two equal doses as basal and at 30 DAS

Plate 1 : General view of chickpea experimental plot as influenced by application of seaweed extract

TABLE 3

Chemical properties of Seaweed extract, humic acid granules and farm yard manure used in field experiment

Parameters	Seaweed extractgranules		Humic acid granules	FYM
	Sargassum sp.	*Aschophyllum* sp.		
pH	10.05	9.89	4.01	7.09 (1:10)
EC (dS m^{-1})	-	-	0.52	1.19 (1:10)
Total organic carbon(%)	14.63	11.12	14.39	15.30
Nitrogen (%)	0.87	0.71	0.84	0.53
Phosphorous (%)	1.05	0.96	0.14	0.37
Potassium (%)	1.45	1.38	0.06	0.65
Calcium (%)	0.11	0.09	0.91	1.31
Magnesium (%)	0.01	0.01	0.42	0.67
Total S(%)			0.27	0.29
Iron (ppm)	556	484	1043	898
Manganese (ppm)	281	242	209	156.08
Zinc (ppm)	140	113	90	62.64
Copper (ppm)	69	48	42	28.99
E_4/E_6 ratio			4.61	
C:N ratio				30.21

viz., plant height, number of branches, shoot length, root length, fresh shoot weight, fresh root weight, dry shoot weight, dry root weight, SPAD reading and number of nodules in each plot at an interval of 30, 60 days after sowing (DAS) and at harvest were taken from five plants randomly. The yield and yield attributes *viz.,* number of flowers per plant, number of pods per plant, pod weight per plant (g), seed weight per plant (g), 100 seed weight (g), haulm yield per hectare and grain yield per hectare (q) were recorded from 10 plants from each plot and statistical analysis was done as given by Gomez and Gomez (1984).

Initial Soil Properties of the Experimental Site

A composite soil sample was collected from the experimental plot at 0-15 cm depth before treatment imposition and analysed for its physico-chemical properties following standard procedures. The soil was sandy clay loam in texture with red colour. It belongs to the *Isohyperthermic* family of the sub group *typic kandicpaleustalfs*. The pH of the soil was 6.01 (slightly acidic). The soil was low in available nitrogen (232.2 kg ha^{-1}), high in available phosphorus (58.78 kg ha^{-1}) and medium in available potassium (174.01 kg ha^{-1}). The available sulphur and DTPA extractable micronutrients content of the soil were above their respective critical levels. Details of initial soil characteristics of the experimental site are given in Table 4.

TABLE 4

Initial physico-chemical properties of the soil from the experimental site

Particular	Values	Method followed
A. *Mechanical properties*		
Sand (%)	54.23	International Pipette method (Piper, 1966)
Silt (%)	21.66	
Clay (%)	24.11	
Textural classes	Sandy Clay Loam	
Bulk density (Mg m^3)	1.36	Keen rackzowski method (Baruah and Barthakur, 1997)
MWHC (%)	40.48	
B. *Chemical properties*		
Soil pH (1:2.5)	6.01	Potentiometry (Jackson, 1973)
Electrical Conductivity (dS m^{-1}) at 25°C (1:2.5)	0.043	Conductometry (Jackson, 1973)
Organic Carbon (per cent)	0.39	Wet oxidation (Walkley and Black, 1934)

Continued....

TABLE 4 Continued....

Particular	Values	Method followed
Available N (kg ha^{-1})	232.2	Alkaline permanganate method (Subbaiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	58.78	Bray's extraction method (Bray and Kurtz, 1945)
Available K_20 (kg ha^{-1})	174.01	Flame photometry (Jackson,1973)
Exchangeable Ca[c mol (p^+) kg^{-1}]	3.70	Complexometric titration method (Jackson, 1973)
Exchangeable Mg [c mol (p^+) kg^{-1}]	1.65	
Available S (kg ha^{-1})	17.90	Turbidometry extraction method (Black 1965)
DTPA extractable Fe (mg kg^{-1})	15.20	Atomic Absorption Spectrophotometry
DTPA extractable Mn (mg kg^{-1})	15.80	(Lindsay and Norwell, 1978)
DTPA extractable Zn (mg kg^{-1})	0.78	
DTPA extractable Cu (mg kg^{-1})	0.70	
Available B (mg kg^{-1})	0.39	Hot water-soluble extraction method (John *et al.,* 1975)
C. *Biological properties*		
Dehydrogenase activity (g TPF $g^{-1}hr^{-1}$)	39.25	TTC reduction technique (Casida, 1964)
Acid Phosphatase activity (g PNP g^{-1} hr^{-1})	30.46	Eivazi and Tabatabai (1977)
Urease activity (g NH_4^+-N $g^{-1}hr^{-1}$)	27.43	Eivazi and Tabatabai (1977)
Biomass carbon (g g^{-1} soil)	130.37	Extraction method (Brookes *et al*., 1982)
Biomass nitrogen (g g^{-1}soil)	15.21	Extraction method (Brookes *et al*., 1982)

RESULTS AND DISCUSSION

Effect of Seaweed Extract and Humic Acid Granules on Growth Attributes of Bengal Gram

Plant Height

Significantly higher plant height (26.03, 44.73 and 47 cm at 30, 60 DAS and at harvest, respectively) was recorded in treatment T_9 : 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} which was on par with T_{12} : 100% NPK + HAG @ 80 kg ha^{-1} (25.80, 44.27 cm and 46.67 cm at 30, 60 DAS and at harvest, respectively). The lowest values were observed in the treatment with absolute control *i.e.,* 20.83, 33.93 and 35.70 cm at 30, 60 DAS and at harvest, respectively (Table 5).

Plant height increased significantly due to the application of seaweed extract granules. This increase in plant height in the SWE applied treatments might be due to presence of plant hormones, plant growth regulators like auxin, gibberellins, cytokinin, macro and microelements present in the seaweed extract (SWE) which would have contributed for the strong physiological response of the crop (Rathod *et al.,* 2019). Pramanick *et al.* (2014) also reported the same results in the rice that with the foliar application of SWE are effective in enhancing the growth attributes. The increased plant height might be due to improved cell wall plasticity, apical dominance, meristematic growth and translocation of photo synthetase in maize (Dilavarnaik *et al.,* 2017). Rajasekhar Reddy *et al.* (2018) found that spraying chickpea plants with seaweed extract resulted in a significant increase in plant height, as well as other growth parameters such as number of branches and number of leaves.

TABLE 5

Effect of seaweed extract and humic acid granules on plant height and number of branches in bengal gram at 30 DAS, 60 DAS and at harvest

Treatments	Plant height (cm)			Number of branches		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T_1: Absolute Control	20.83	33.93	35.70	3	10	10
T_2: 100% NPK (25: 50: 50 kg ha^{-1})	23.56	38.80	39.50	4	14	17
T_3: 100% NPK + FYM @ 7.5 t ha^{-1}(Control)	24.83	42.13	42.70	4	18	20
T_4: T_2 + A-SWEG @ 40 kg ha^{-1}	24.53	38.93	40.00	4	15	17
T_5: T_2 + A-SWEG @ 60 kg ha^{-1}	24.57	39.53	40.37	4	16	18
T_6: T_2 + A-SWEG @ 80 kg ha^{-1}	24.77	40.60	42.53	4	16	20
T_7: T_2 + S-SWEG @ 40 kg ha^{-1}	25.00	42.27	42.90	4	20	22
T_8: T_2 + S-SWEG @ 60 kg ha^{-1}	25.57	43.93	46.17	5	23	23
T_9: T_2 + S-SWEG @ 80 kg ha^{-1}	26.03	44.73	47.00	5	25	25
T_{10}: T_2 + HAG @ 40 kg ha^{-1}	25.29	39.87	43.57	5	20	22
T_{11}: T_2 + HAG @ 60 kg ha^{-1}	25.40	43.60	45.00	5	21	23
T_{12}: T_2 + HAG @ 80 kg ha^{-1}	25.80	44.27	46.67	5	23	25
S.Em. ±	0.82	1.33	1.29	0.23	0.81	0.70
C.D. (0.05)	2.40	3.91	3.78	0.66	2.38	2.04

Note : A-SWEG : *Ascophyllum* sp. Seaweed Extract Granules; S-SWEG : *Sargassum* sp. Seaweed Extract Granules; HAG : Humic Acid Granules; SWEG and HAG applied in two equal doses as basal and at 30 DAS

Number of Branches

Application of seaweed and humic acid granules influenced number of branches of bengal gram during all growth stages starting from 30 DAS (Table 5). At 30 DAS, application of S-SWE granules @ 80 kg ha^{-1} along with RDF (T_9) recorded significantly higher number of branches (5) over treatments control T_3 : 100 per cent NPK + FYM @ 7.5 t ha^{-1} (4) and T_6 : T_2 + A-SWEG @ 80 kg ha^{-1} (4). The same treatment recoded significantly higher number of branches both at 60 DAS and at harvest (25) over control T_3 : 100 per cent NPK + FYM @ 7.5 t ha^{-1} (18 and 20 at 60 DAS and at harvest, respectively) and followed on par with T_{12} : T_2 + HAG @ 80 kg ha^{-1} (23 and 25 at 60 DAS and at harvest, respectively). Significantly lower numbers of branches per plant were recorded in absolute control treatment (T_1) during all growth stages of bengal gram (3, 10 and 10 at 30 DAS, 60 DAS and at harvest, respectively).

Significantly higher number of branches per plant were recorded with the application of S-SWEG @ 80 kg ha^{-1} along with RDF. This increase in the number of branches per plant can be attributed to presence of Phytohormones in seaweed extract, such as auxins, cytokinins and gibberellins, can promote cell division and elongation, leading to increased plant growth and branching. Presence of polysaccharides such as alginates and fucoidance in seaweed extract can also stimulate microbial activity and nutrient availability. Ali *et al.* (2013) found that soil application of a brown seaweed extract (*Ascophyllum nodosum*) at a rate of 10 L ha^{-1} significantly increased the number of branches per plant in chickpeas. Another study by Abdel-Latef *et al.* (2015) found that soil application of a red seaweed extract (*Gracilaria* *corticata*) at a rate of 15 L ha^{-1} significantly increased the number of branches per plant in chickpeas.

Root and Shoot length

Application of seaweed and humic acid granules influenced significantly on root and shoot length bengal gram during all growth stages (Table 6).

Root length of bengal gram at 30 DAS, 60 DAS and at harvest, T_9 : 100 per cent RDF + S-SWEG @ 80 kg ha^{-1} treatment (15.25, 17.08 and 17.70 cm at 30 DAS, 60 DAS and at harvest, respectively) was significantly higher over T_3 : 100 per cent NPK + FYM @ 7.5 t ha^{-1} (12.25, 15.38 and 15.60 cm at 30 DAS, 60 DAS and at harvest, respectively). Data recorded in T_9 was showing on par results with treatment receiving soil application of HAG @ 80 kg ha^{-1} along with RDF *i.e.,* 14.08, 16.25 and 16.59 cm at 30 DAS, 60 DAS and at harvest, respectively (Table 6). T_1 (absolute control) recorded least root length (11.33, 12.25 and 13.51 cm at 30 DAS, 60 DAS at harvest, respectively).

At 30 DAS, 60 DAS and at harvest there was significant increase in shoot length upon application of S-SWEG @ 80 kg ha^{-1} along with RDF (28.67, 41 and 48.28 cm, respectively) over absolute control (24.57, 34.67 and 39.14 cm at 30 DAS, 60 DAS and at harvest, respectively) and T_3 : 100 per cent NPK + FYM @ 7.5 t ha^{-1} *i.e.,* 26.25, 38 and 43.95 cm at 30 DAS, 60 DAS and at harvest, respectively (Table 6). Significantly lower values were observed in absolute control plot (T_1 : 24.57, 34.67 and 39.14 cm at 30 DAS, 60 DAS and at harvest, respectively).

Root and Shoot Weight (fresh)

Among the treatments, significantly higher root weight was observed in T_9 : 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} (1.16 and 3.39 g plant^{-1} at 30 DAS and 60

TABLE 6

Effect of seaweed extract and humic acid granules on shoot and root length of bengal gram at 30 DAS, 60 DAS and at harvest

Treatments	Shoot length (cm)			Root length (cm)		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T_1: Absolute Control	24.57	34.67	39.14	11.33	12.25	13.51
T_2: 100% NPK (25: 50: 50 kg ha^{-1})	25.00	35.67	41.39	11.58	13.33	14.22
T_3: 100% NPK + FYM @ 7.5 t ha^{-1}(Control)	26.25	38.00	43.95	12.25	15.38	15.60
T_4: T_2 + A-SWEG @ 40 kg ha^{-1}	25.17	37.08	42.21	11.75	14.08	14.84
T_5: T_2 + A-SWEG @ 60 kg ha^{-1}	26.08	37.33	42.32	11.83	14.50	15.43
T_6: T_2 + A-SWEG @ 80 kg ha^{-1}	26.17	37.58	43.14	12.08	14.58	15.44
T_7: T_2 + S-SWEG @ 40 kg ha^{-1}	26.33	38.33	44.69	12.41	15.42	15.87
T_8: T_2 + S-SWEG @ 60 kg ha^{-1}	26.83	40.00	46.80	13.67	15.75	16.27
T_9: T_2 + S-SWEG @ 80 kg ha^{-1}	28.67	41.00	48.28	15.25	17.08	17.70
T_{10}: T_2 + HAG @ 40 kg ha^{-1}	26.58	38.50	45.96	12.42	15.58	16.04
T_{11}: T_2 + HAG @ 60 kg ha^{-1}	26.75	39.50	46.15	12.50	15.75	16.23
T_{12}: T_2 + HAG @ 80 kg ha^{-1}	28.67	40.33	47.32	14.08	16.25	16.59
S.Em. ±	0.82	1.19	1.46	0.32	0.40	0.43
C.D. (0.05)	2.40	3.49	4.29	1.81	1.67	1.83

Note : A-SWEG : *Ascophyllum* sp. Seaweed Extract Granules; S-SWEG : *Sargassum* sp. Seaweed Extract Granules; HAG : Humic Acid Granules; SWEG and HAG applied in two equal doses as basal and at 30 DAS

DAS, respectively) which was on par with the treatment T_{12} : 100 per cent NPK + HAG @ 80 kg ha^{-1} (1.13 and 3.20 g $plant^{-1}$ at 30 DAS and 60 DAS, respectively). Treatment with no application of either NPK or FYM recorded lower fresh root weight (0.71 and 1.53 g $plant^{-1}$ at 30 DAS and at harvest, respectively) (Table 7).

Significantly higher shoot weight was observed in T_9 : 100 per cent NPK+ S-SWEG @ 80 kg ha^{-1} (8.73 and 57.21 g $plant^{-1}$ at 30 DAS and 60 DAS, respectively) followed on par with treatment T_{12} : 100 per cent NPK + HAG @ 80 kg ha^{-1} (7.86 and 53.40 g $plant^{-1}$ at 30 DAS and 60 DAS, respectively). Both T_9 and T_{12} were significant over control treatment T_3 : 100 per cent NPK + FYM @ 7.5 t ha^{-1} (6.41 and 42.58 g $plant^{-1}$ at 30 DAS and 60 DAS, respectively). Absolute control recorded significantly lower values of fresh shoot weight (5.31 and 23.65 g $plant^{-1}$ at 30 DAS and 60 DAS, respectively) (Table 7).

Root and Shoot Weight (Dry)

Among the treatments, significantly higher root weight (dry) was observed in T_9 : 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} (0.378, 1.37 and 1.577 g $plant^{-1}$ at 30, 60 DAS and at harvest, respectively) which was on par with the results obtained from the treatment T_{12} : 100 per cent NPK + HAG @ 80 kg ha^{-1} (0.351, 1.308 and 1.463 g $plant^{-1}$ at 30, 60 DAS and at harvest, respectively). Both T_9 and T_{12} were significant over control treatment which was supplied with 100 per cent NPK along with FYM @ 7.5 t ha^{-1} (0.294, 1.003 and 1.080 g $plant^{-1}$ at 30, 60 DAS and at harvest, respectively). Whereas, lower values for dry root weight were recorded in untreated plot (0.225, 0.913 and 0.918 g $plant^{-1}$, respectively) at all stages of bengal gram (Table 8).

TABLE 7

Effect of seaweed extract and humic acid granules on fresh shoot and root weight of bengal gram at 30 and 60 DAS

Treatments	Fresh shoot weight ($g\ plant^{-1}$)		Fresh root weight ($g\ plant^{-1}$)	
	30 DAS	60 DAS	30 DAS	60 DAS
T_1 : Absolute Control	5.31	23.65	0.71	1.53
T_2 : 100% NPK (25: 50: 50 kg ha^{-1})	5.54	29.64	0.81	2.34
T_3 : 100% NPK + FYM @ 7.5 t ha^{-1} (Control)	6.41	42.58	0.90	2.46
T_4 : T_2 + A-SWEG @ 40 kg ha^{-1}	5.98	33.67	0.82	2.42
T_5 : T_2 + A-SWEG @ 60 kg ha^{-1}	6.01	36.07	0.83	2.42
T_6 : T_2 + A-SWEG @ 80 kg ha^{-1}	6.20	40.63	0.88	2.43
T_7 : T_2 + S-SWEG @ 40 kg ha^{-1}	6.81	43.22	0.93	2.67
T_8 : T_2 + S-SWEG @ 60 kg ha^{-1}	7.18	47.97	1.04	3.18
T_9 : T_2 + S-SWEG @ 80 kg ha^{-1}	8.73	57.21	1.16	3.39
T_{10} : T_2 + HAG @ 40 kg ha^{-1}	6.85	43.27	0.97	2.94
T_{11} : T_2 + HAG @ 60 kg ha^{-1}	7.08	46.15	1.02	3.10
T_{12} : T_2 + HAG @ 80 kg ha^{-1}	7.86	53.40	1.13	3.20
S.Em. ±	0.33	1.70	0.05	0.14
C.D. (0.05)	0.97	4.98	0.15	0.42

Note : A-SWEG : *Ascophyllum* sp. Seaweed Extract Granules; S-SWEG : *Sargassum* sp. Seaweed Extract Granules; HAG : Humic Acid Granules; SWEG and HAG applied in two equal doses as basal and at 30 DAS

Among the treatments, significantly higher shoot weight (dry) was observed in T_9 : 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} (2.0, 7.13 and 8.76 g plant^{-1} at 30, 60 DAS and at harvest, respectively) which was on par with the results obtained from the treatment T_{12} : 100 per cent NPK + HAG @ 80 kg ha^{-1} (1.92, 6.95 and 8.31 g plant^{-1} at 30, 60 DAS and at harvest, respectively). Both T_9 and T_{12} were significant over control treatment which was supplied with 100 per cent NPK along with FYM @ 7.5 t ha^{-1} (1.43, 5.58 and 7.40 g plant^{-1} at 30, 60 DAS and at harvest, respectively). Lower values for dry shoot weight were recorded in untreated plot (1.17, 6.72 and 7.60 g plant^{-1}, respectively) at all stages of bengal gram (Table 8).

The root and shoot characteristics are the important parameter for plant growth. The SWE has positively influenced the shoot characteristics *viz.,* shoot weight and shoot length of bengal gram crop. Increased shoot length and shoot weight might be due to presence of growth-promoting hormones (cytokinins, auxins and gibberellins) in the extract. These hormones can stimulate the cell division and elongation that is necessary for shoot growth. In addition to the growth-promoting hormones, seaweed extract also contains a variety of other nutrients that are essential for plant growth, such as nitrogen, phosphorus and potassium. These nutrients can help to improve the overall health and vigor of the plants, which can lead to increased shoot length and shoot weight.

Seaweed extracts contain phytohormones, such as auxins and cytokinins, which can promote root growth and development. Improved root growth can lead to increased water and nutrient uptake, which can also contribute to increased shoot growth (shoot length and shoot weight) El-Bassiouny *et al*. (2015).

TABLE 8

Effect of seaweed extract and humic acid granules on dry shoot and root weight of bengal gram at 30 DAS, 60 DAS and at harvest

Treatments	Shoot weight (dry) (g plant^{-1})			Root weight (dry) (g plant^{-1})		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T_1: Absolute Control	1.17	1.94	2.87	0.225	0.613	0.675
T_2: 100% NPK (25: 50: 50 kg ha^{-1})	1.24	4.12	6.26	0.233	0.715	0.742
T_3: 100% NPK + FYM @ 7.5 t ha^{-1} (Control)	1.43	5.58	7.40	0.294	0.813	0.835
T_4: T_2 + A-SWEG @ 40 kg ha^{-1}	1.39	4.45	6.40	0.277	0.731	0.761
T_5: T_2 + A-SWEG @ 60 kg ha^{-1}	1.39	4.87	6.86	0.282	0.756	0.784
T_6: T_2 + A-SWEG @ 80 kg ha^{-1}	1.40	5.23	7.14	0.288	0.784	0.809
T_7: T_2 + S-SWEG @ 40 kg ha^{-1}	1.48	5.89	7.52	0.303	0.829	0.867
T_8: T_2 + S-SWEG @ 60 kg ha^{-1}	1.60	6.62	8.04	0.328	0.875	0.958
T_9: T_2 + S-SWEG @ 80 kg ha^{-1}	2.00	7.13	8.76	0.378	0.925	1.135
T_{10}: T_2 + HAG @ 40 kg ha^{-1}	1.53	6.08	7.70	0.322	0.836	0.892
T_{11}: T_2 + HAG @ 60 kg ha^{-1}	1.56	6.41	7.92	0.328	0.859	0.925
T_{12}: T_2 + HAG @ 80 kg ha^{-1}	1.92	6.95	8.31	0.351	0.892	1.089
S.Em. ±	0.08	0.21	0.26	0.019	0.03	0.03
C.D. (0.05)	0.23	0.61	0.78	0.056	0.09	0.10

Note : A-SWEG : *Ascophyllum* sp. Seaweed Extract Granules; S-SWEG : *Sargassum* sp. Seaweed Extract Granules; HAG : Humic Acid Granules; SWEG and HAG applied in two equal doses as basal and at 30 DAS

The SWE has positively influenced the root characteristics *viz.,* root weight and root length of bengal gram crop. This might be due to the stimulated action of seaweed application leading to increased root length and weight which could be ascribed to alginate oligosaccharides of an auxin related gene promoting the root cells division and produced more lateral root growth formation, elongation and biomass. The results are in line up with Rayorath *et al.* (2008) in barley crop that, the components of seaweed improved the root activity and crop productivity in agricultural systems. Ashour and Rady (2018) found that soil application of seaweed extract at a rate of 2.5 L ha^{-1} significantly increased root weight and root length in chickpea plants grown under water stress conditions.

Leaf Chlorophyll Content

Treatment receiving soil application of S-SWEG @ 80 kg ha^{-1} along with RDF shows significantly higher leaf chlorophyll content (45.74 and 68.61 at 30 DAS and 60 DAS, respectively) which was on par with treatment T_{12} : 100 per cent NPK + Humic acid granules @ 80 kg ha^{-1} (45.18 and 67.13 at 30 and 60 DAS, respectively). Whereas at harvest, these treatments showed non-significant difference in chlorophyll content with the application of seaweed extract and humic acid granules (Table 9). Absolute control recorded lower chlorophyll content at all growth stages of bengal gram (35.35, 36.68 and 14.57 at 30 DAS, 60 DAS and at harvest, respectively). Among the various treatments, there was a slight variation in leaf chlorophyll content during harvest, likely due to the crop approaching its senescence stage. As the plants matured, their leaves naturally began to lose chlorophyll content over time. It might be due to the low concentration of betaines in SWE has incrementally increased the SPAD reading at flowering stage and later it declined due to the

TABLE 9

Effect of seaweed extract and humic acid granules on leaf chlorophyll content and number of nodules in bengal gram at 30 DAS, 60 DAS and at harvest

Treatments	Leaf chlorophyll content (SPAD reading)			Number of nodules $plant^{-1}$		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T_1: Absolute Control	35.35	36.68	14.57	13	16	4
T_2: 100% NPK (25: 50: 50 kg ha^{-1})	37.99	50.26	14.83	16	18	4
T_3: 100% NPK + FYM @ 7.5 t ha^{-1} (Control)	43.14	53.99	17.23	23	21	5
T_4: T_2 + A-SWEG @ 40 kg ha^{-1}	38.66	50.39	15.57	17	18	5
T_5: T_2 + A-SWEG @ 60 kg ha^{-1}	39.71	53.45	16.83	20	19	5
T_6: T_2 + A-SWEG @ 80 kg ha^{-1}	40.42	53.91	16.85	23	21	5
T_7: T_2 + S-SWEG @ 40 kg ha^{-1}	43.52	54.25	17.77	24	21	5
T_8: T_2 + S-SWEG @ 60 kg ha^{-1}	44.68	63.07	18.13	27	24	5
T_9: T_2 + S-SWEG @ 80 kg ha^{-1}	45.74	68.61	18.65	33	27	6
T_{10}: T_2 + HAG @ 40 kg ha^{-1}	44.04	54.99	17.89	25	21	5
T_{11}: T_2 + HAG @ 60 kg ha^{-1}	44.08	59.98	18.09	26	24	5
T_{12}: T_2 + HAG @ 80 kg ha^{-1}	45.18	67.13	18.56	31	27	5
S.Em. ±	2.17	2.82	0.71	1.10	1.02	0.23
C.D. (0.05)	6.36	8.28	NS	3.24	2.98	0.68

Note : A-SWEG : *Ascophyllum* sp. Seaweed Extract Granules; S-SWEG : *Sargassum* sp. Seaweed Extract Granules; HAG : Humic Acid Granules; SWEG and HAG applied in two equal doses as basal and at 30 DAS

development of fibrous material in plant tissues. Zodape *et al.* (2011) reported that plant growth boosting chemicals such as betaines and inorganic salts in the SWE might have increased chloroplast size granular development and chlorophyll concentration in the leaf surface. Similar findings were quoted by Whapham *et al.* (1993) that SWE enhanced the SPAD by forming more betaines and size of chloroplast in tomato crop.

No of Nodules Plant^{-1}

Seaweed and Humic granules showed significant impact on nodulation. Result revealed that at 30 DAS, 60 DAS and at harvest, treatment T_9 : 100 per cent NPK + S-SWEG @ 80 kg ha^{-1}) (33, 27 and 6 at 30, 60 DAS and at harvest, respectively) recorded significantly higher numbers of nodules over control T_3 : 100 per cent NPK + FYM @ 7.5 t ha^{-1} (23, 21 and 5 at 30 DAS, 60 DAS and at harvest, respectively). Lower number of nodules was recorded in the untreated plot (13, 16 and 4 at 30 DAS, 60 DAS and at harvest, respectively) at all stages of bengal gram (Table 9).

Seaweed extract increases the number of root nodules in chickpea is by promoting the growth and activity of rhizobia. Rhizobia are bacteria that live in symbiosis with legumes, such as chickpea and fix atmospheric nitrogen into a form that can be used by the plants. Seaweed extract contains various nutrients and bioactive compounds that are essential for the growth and activity of rhizobia. For example, seaweed extract contains auxins, which are plant hormones that promote root growth and development. Seaweed extract also contains cytokinins, which are plant hormones that promote cell division and differentiation and also by improving soil health Abdel-Motagally and El-Gamal (2016). Seaweed extract contains various compounds that can improve soil structure, aeration and drainage. Seaweed extract also contains humic substances, which can increase the availability of nutrients to plants. Improved soil health can create a more favorable environment for the growth and activity of rhizobia, which can lead to an increase in the number of root nodules in chickpea (Elsharkawy *et al.,* 2014).

Effect of Seaweed Extract and Humic Acid granules on Yield and Yield Attributes of Bengal Gram

Number of Flowers Plant^{-1}

Significantly higher number of flowers plant^{-1} was observed in T_9 : 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} (103) which was on par with the results obtained from the treatment T_{12} : 100 per cent NPK + HAG @ 80 kg ha^{-1} (100). Both T_9 and T_{12} were significant over control treatment which was supplied with 100 per cent NPK along with FYM @ 7.5 t ha^{-1} (86). Whereas, lower values for number of flowers plant^{-1} was recorded in untreated plot (40).

Number of Pods Plant^{-1}

The data pertaining to number of pods plant^{-1} as influenced by soil application of seaweed and humic acid granules is presented in Table 10. Among the treatments, significantly higher number of pods plant^{-1} was observed in T_9 : 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} (64) which was on par with the treatment T_{12} : 100 per cent NPK + HAG @ 80 kg ha^{-1} (59). Both T_9 and T_{12} were significant over control treatment which was supplied with 100 per cent NPK along with FYM @ 7.5 t ha^{-1} (48). Whereas, lower values for number of pods plant^{-1} was recorded in untreated plot T_1 (28).

Pod Weight

Significantly higher values of pod weight (g plant^{-1}) were recorded due to the application of seaweed and humic acid granules (Table 10). Among the treatments, significantly higher pod weight plant^{-1} was observed in T_9 : 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} (9.43 g plant^{-1}) followed on par with the results obtained from the treatment T_{12} : 100 per cent NPK + HAG @ 80 kg ha^{-1} (8.88 g plant^{-1}). Both T_9 and T_{12} were significant over control treatment which was supplied with 100 per cent NPK along with FYM @ 7.5 t ha^{-1} (7.41 g plant^{-1}). Whereas, lower values for number of pod weight plant^{-1} were recorded in untreated plot T_1 (4.33 g plant^{-1}).

Seed weight

Significantly higher values of seed weight (g plant^{-1}) were recorded due to the application of seaweed and humic acid granules (Table 10). Among the treatments, significantly higher seed weight was observed in T_9 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} (5.60 g plant^{-1}) followed on par with the results obtained from the treatment T_{12} : 100 per cent NPK + HAG @ 80 kg ha^{-1} (5.52 g plant^{-1}). Both T_9 and T_{12} were significant over treatment which was supplied with 100 per cent NPK along with FYM @ 7.5 t ha^{-1} (4.83 g plant^{-1}). Whereas, lower values for seed weight plant^{-1} were recorded in untreated plot (1.72 g plant^{-1}).

100 Seed Weight (g)

Significantly higher values of 100 seed weight was recorded due to the application of seaweed and humic acid granules (Table 10). Among the treatments, significantly higher 100 seed weight was observed in T_9 : 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} (16.01 g) followed on par with the results obtained from the treatment T_{12} : 100 per cent NPK + HAG @ 80 kg ha^{-1} (15.99 g) and control treatment which was supplied with 100 per cent NPK along with FYM @ 7.5 t ha^{-1} (15.02 g). Whereas, lower values for 100 seed weight was recorded in absolute control T_1 (13.70 g).

Haulm and Grain Yield (q ha^{-1})

The data on haulm and grain yield of bengal gram as influenced by soil application of seaweed and humic acid granules was presented in Table 10 and Fig. 1. Among the treatments, significantly higher haulm and yields were observed in T_9 : 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} (58.72 and q ha^{-1}) followed on

TABLE 10

Effect of seaweed extract and humic acid granules on yield and yield attributes of bengal gram

Treatments	Number of flowers Plant^{-1}	Number of pods Plant^{-1}	Pod weight Plant^{-1}	Seed weight Plant^{-1}	100 Seed weight	Haulm yield (q ha^{-1})	Grain yield (q ha^{-1})	Harvest index
			g					
T_1: Absolute Control	40	28	4.33	1.72	13.70	9.59	5.73	0.37
T_2: 100% NPK (25: 50: 50 kg ha^{-1})	80	37	6.34	4.25	14.46	20.88	13.92	0.40
T_3: 100% NPK + FYM @ 7.5 t ha^{-1} (Control)	86	48	7.41	4.83	15.02	24.67	16.10	0.39
T_4: T_2 + A-SWEG @ 40 kg ha^{-1}	84	41	6.43	4.38	14.49	21.36	14.15	0.40
T_5: T_2 + A-SWEG @ 60 kg ha^{-1}	85	41	6.78	4.53	14.84	22.89	15.10	0.40
T_6: T_2 + A-SWEG @ 80 kg ha^{-1}	85	43	6.78	4.68	14.88	23.81	15.61	0.40
T_7: T_2 + S-SWEG @ 40 kg ha^{-1}	92	49	7.59	4.98	15.13	25.08	16.60	0.40
T_8: T_2 + S-SWEG @ 60 kg ha^{-1}	96	57	8.25	5.33	15.83	26.82	17.78	0.40
T_9: T_2 + S-SWEG @ 80 kg ha^{-1}	103	64	9.43	5.60	16.01	29.23	18.65	0.39
T_{10}: T_2 + HAG @ 40 kg ha^{-1}	94	51	7.61	5.06	15.34	25.67	16.86	0.40
T_{11}: T_2 + HAG @ 60 kg ha^{-1}	95	53	8.18	5.26	15.65	26.42	17.53	0.40
T_{12}: T_2 + HAG @ 80 kg ha^{-1}	100	59	8.88	5.52	15.99	27.72	18.40	0.40
S.Em. ±	3.90	1.97	0.30	0.17	0.44	0.88	0.62	0.014
C.D. (0.05)	11.44	5.76	0.89	0.50	1.29	2.59	1.82	NS

Note : A-SWEG : *Ascophyllum* sp. Seaweed Extract Granules; S-SWEG : *Sargassum* sp. Seaweed Extract Granules; HAG : Humic Acid Granules; SWEG and HAG applied in two equal doses as basal and at 30 DAS

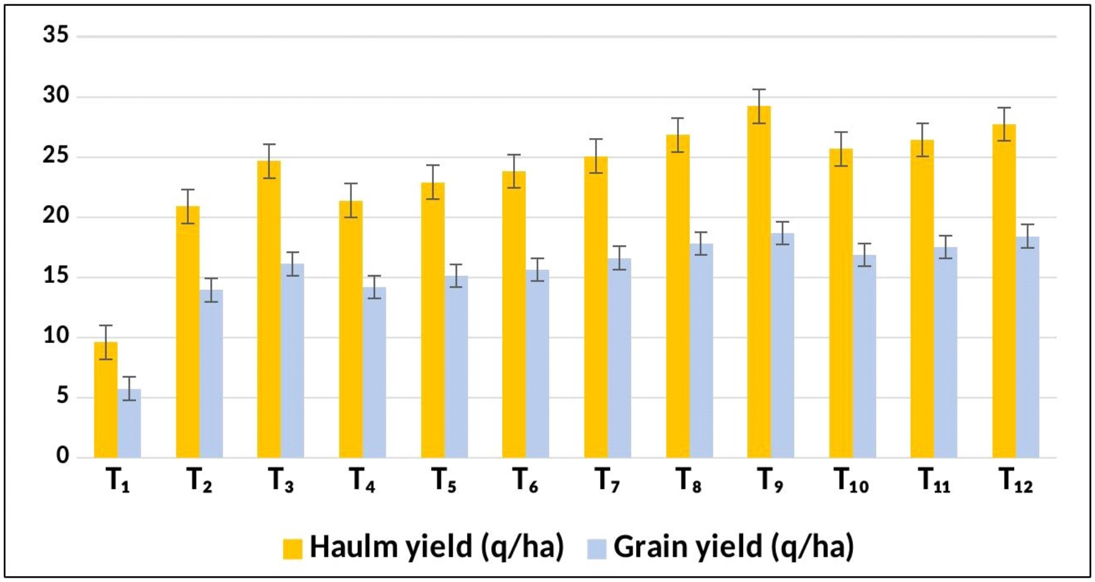

Fig. 1 : Effect of seaweed extract and humic acid granules on haulm yield and grain yield of bengal gram

par with the results obtained from the treatment T_{12} : 100 per cent NPK + HAG @ 80 kg ha^{-1} (52.69 and 18.40q ha^{-1}). Both T_9 and T_{12} were significantly higher over control treatment which was supplied with 100 per cent NPK along with FYM @ 7.5 t ha^{-1} (31.32 and 16.10q ha^{-1}). Absolute control (T_1) recorded significantly lower haulm and grain yield (25.33 and 5.73q ha^{-1}).

The yield attributes are important parameters for agricultural technology. The use of SWE increased all the yield attributes *viz.,* Number of flowers plant^{-1}, Number of pods plant^{-1}, Pod weight (g plant^{-1}), Seed weight (g plant^{-1}), 100 seed weight (g) of bengal gram. This might be due to the various nutrient concentrations in the SWE. This was in conformity with the findings of Singh *et al.* (2021) in rice crop where the foliar application of 2.5 per cent K sap with 100 per cent RDF improved the yield attributes *viz.,* number of productive tillers, test weight and number of grains per panicle.

The increased grain and haulm yield by the SWE application also might be due to increased plant height, no. of branches, chlorophyll, root weight and root length by the presence of versatile plant nutrients in SWE in the present study itself (Banakar *et al.,* 2018). Iswarya *et al*. (2019) also reported more nutrient uptake, nutrient use efficiency by SWE application by triggering the plant growth and vigour in-turn reflecting the higher yield of greengram. The results attributed are phyto- hormones, amino acids, vitamins, antibiotic substances present in the SWE enhanced the root volume, biomass accretion, dispersal of photosynthates from vegetative parts to flowering and then promote the growth of plant. The results matched with Pramanick *et al.* (2017) in potato, the K sap at 7.5 per cent along with 100 per cent RDF improved the yield over the 5 per cent sap with 100 per cent RDF.

Harvest Index

There was no significant variation in harvest index upon application of different rates of seaweed extract and humic acid granules. However, the data on harvest index of bengal gram varied from 0.37 - 0.40 (Table 10).

Soil application of seaweed extract granules has a positive effect on growth and productivity of bengal gram. Soil application of 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} recorded significantly higher growth and productivity of bengal gram over control (100%

TABLE 11

Effect of seaweed extract and humic acid granules on economics of bengal gram

Treatments	Cost of cultivation	Gross returns	Net returns	B:C ratio
	Rs. ha^{-1}			
T_1: Absolute Control	24399	28650	4251	1.17
T_2: 100% NPK (25: 50: 50 kg ha^{-1})	38064	70750	32686	1.86
T_3: 100% NPK + FYM @ 7.5 t ha^{-1} (Control)	43689	80500	36811	1.84
T_4: T_2 + A-SWEG @ 40 kg ha^{-1}	40444	69615	29171	1.72
T_5: T_2 + A-SWEG @ 60 kg ha^{-1}	41324	75500	34176	1.83
T_6: T_2 + A-SWEG @ 80 kg ha^{-1}	42204	78050	35846	1.85
T_7: T_2 + S-SWEG @ 40 kg ha^{-1}	40444	83000	42556	2.05
T_8: T_2 + S-SWEG @ 60 kg ha^{-1}	41764	88900	47136	2.13
T_9: T_2 + S-SWEG @ 80 kg ha^{-1}	42204	93250	51046	2.21
T_{10}: T_2 + HAG @ 40 kg ha^{-1}	41484	84300	42816	2.03
T_{11}: T_2 + HAG @ 60 kg ha^{-1}	42884	87650	44766	2.04
T_{12}: T_2 + HAG @ 80 kg ha^{-1}	44284	92000	47716	2.08

Note : A-SWEG : *Ascophyllum* sp. Seaweed Extract Granules; S-SWEG : *Sargassum* sp. Seaweed Extract Granules; HAG : Humic Acid Granules; SWEG and HAG applied in two equal doses as basal and at 30 DAS

NPK + FYM @ 7.5 t ha^{-1}. Absolute control recorded significantly lower growth and yield of bengal gram crop.

Economics

The treatment wise economic returns were worked out with the help of operating cost of individual treatment and the cost of production. The data so obtained have been given in the Table 11. Variation on gross returns and net returns has been founded by application of seaweed extract and humic acid granules. The economic feasibility and usefulness of a treatment can be effectively adjusted in terms of B : C ratio and net returns. Application of 100 per cent NPK + HAG @ 80 kg ha^{-1} (T_{12}) fetched more cost of cultivation Rs.44,284 ha^{-1} and application of 100 per cent NPK + S-SWEG @ 80 kg ha^{-1} (T_9) fetched more gross returns Rs.93,250 ha^{-1} and net returns Rs.51046 ha^{-1}. However, less cost of cultivation Rs.24,399 ha^{-1}, gross returns Rs.28,650 ha^{-1} and net returns Rs.4,251 ha^{-1} fetched in absolute control treatment (T_1). This might be due to the higher grain yield was obtained by the application of different organic granules and the significant difference in grain yield of bengal gram crop and cost of organic granules incurred at different treatments (Zhang *et al.,* 2020).

Highest B:C ratio of 2.21 was recorded with application of 100 per cent NPK (25: 50: 50 kg ha^{-1}) + S-SWEG @ 80 kg ha^{-1} (T_9) followed by treatment T_8 : 100 per cent NPK + S-SWEG @ 60 kg ha^{-1} (2.13) and T_{12} : 100 per cent NPK + HAG @ 80 kg ha^{-1} (2.08), whereas the lowest B:C ratio of 1.17 was observed in absolute control treatment (T_1). This might be due to variation in cost of cultivation and net returns. Increased yield can be attributed to higher levels of biomass accumulation and effective translocation of nutrients to reproductive parts, which led to higher monetary returns and B:C ratio that was higher (Roy *et al.,* 2018). Sharma (2020) reported that application of seaweed extract granules resulted in maximum returns and benefit-cost ratio compared to conventional fertilizer application alone. The differences in the B:C ratio was attributed to yield differences and varying costs when different inputs were added. Application of seaweed extract granules along with conventional fertilizer gave more profitable income.

References

Abdel-Latef, A. A. H., El-Gizawy, A. M. and Behairy, A. A., 2015, Effect of seaweed extract (*Gracilaria corticata*) on growth, yield and chemical composition of chickpea (*Cicer arietinum* L.) plants grown under salt stress conditions. *Sci. Hortic.,***193** : 65 - 72.

Abdel-Motagally, F. M. and El-Gamal, A. A., 2016, Effect of seaweed extract on growth, yield and nutrients content of chickpea (*Cicer arietinum* L.) under sandy soil conditions. *Int. J. Plant Soil Sci.,* **12** (5) : 1 - 10.

Ahmad, I., 2017, Growth, physiological and yield attributes of chickpea as influenced by Thermal Power Plant Wastewater, coal fly ash and different levels of phosphorus. *Int. J. Appl. Environ. Sci.,* **12** (1) : 179 - 200.

Ali, M. F., El-Mahrouk, M. E. and El-Gizawy, A. M., 2013, Effect of seaweed extract (*Ascophyllum nodosum*) on growth and yield of chickpea (*Cicer arietinum* L.) under saline soil conditions. *Egypt. J. Agric. Res.,* **61** (11) : 317 - 330.

Ashour, M. E. and Rady, M. M., 2018, Effect of sea weed extract application on growth and yield of chickpea (*Cicer arietinum* L.) under water stress conditions. *J. Plant Prod.,* **9** (1) : 13 - 22.

Banakar, S. N., Rangaswamy, K. T. and Prasanna Kumar. M. K., 2018, Effect of seaweed bioformulations in relieving biotic and abiotic stress in rice. *Mysore J. Agric. Sci.,* **52** (3) : 581 - 587.

Baruah, T. C. and Barthakur, H. P., 1997*, A text book of soil analysis*, Vikas Publishing Housing, Pvt. Ltd., New Delhi, pp. : 35 - 67.

Black, C. A., 1965, Methods of soil analysis part-1 physical and mineralogical properties. Agronomy Monograph No.9. *American Soc. Agron*. Madison, Wisconsin, USA, **7** : 18 - 25.

Bray, R. H. and Kurtz, L. T., 1945, Determination of total, organic and available forms of phosphorus in soils. *Soil Sci*., **59** (1) : 39 - 46.

Brookes, P. C., Powlson, D. S. and Jenkinson, D. S., 1982, Measurement of microbial biomass phosphorous in soil. *Soil Biol. Biochem*., **14** : 319 - 329.

Casida, L. E., Klein, D. A. and Santoto, T., 1964, Soil dehydrogenase activity. *Soil Sci.*, **98** : 371 - 376.

Craigie, J., 2010, Sea weed extracts timuliin plant science and agriculture. *J. Appl. Phycol*., **23** : 371 - 393.

Dilavarnaik, S., Basavaraja, P. K., Yogendra, N. D. and Ghosh, A., 2017, Influence of seaweed saps on germination, growth and yield of hybrid maize under Cauvery Command of Karnataka, India. *Int. J. Curr. Microbiol. App. Sci.*, **6** (9) : 1047 - 1056.

Eivazi, F. and Tabatabai, M. A., 1977, Phosphatases in soils. *Soil Biol. Biochem*., **9** : 167 - 177.

El-Bassiouny, H. M., Abd El-Gawad, H. M. A. and Gobarah, M. E., 2015, Effect of seaweed extract application on growth, yield and yield components of chickpea (*Cicer arietinum* L.) under saline conditions. *Plant Prod. Sci.,* **18** (1) : 96 - 103.

Elsharkawy, M. M., Abdel-Motagally, F. M. and El-Gamal, A. A., 2014, Effect of seaweed extract on nodulation, growth and yield of chickpea (*Cicer arietinum* L.) under different irrigation intervals and nitrogen fertilization levels. *J. Plant Prod.,* **5** (1) : 191 - 206.

Gomez, K. A. and Gomez, A. A., 1984, *Statistical procedures for Agric. Res. II Ed.* John Wiley & Sons*,* New York.

Gulser, F., Ferit, S. and Sibel, B., 2010, Effects of calcium nitrate and humic acid on pepper seedling growth under saline condition. *J. Envir. Bio*., **31** (5) : 873 - 876.

Hansra, B. S., 1993, Transfer of agricultural technology on irrigateda griculture, *Fert. News,* **38** : 31 - 33.

ISWARYA, S., LATHA, K. R. AND SRINIVASAN, K., 2019, Evaluation of seaweed extract on growth determinants, yield and biochemical parameters of greengram (*Vigna radiata*). *J. pharmacogn. phytochem*., **8** (3) : 1861 - 1864.

JACKSON, M. L., 1973, Soil chemical analysis. Prentice Hall of India, New Delhi, **1** : 485 - 486.

JEANNIN, I., LESCURE J. C. AND MOROT-GAUDRY J. F., 1991, The effects of aqueous seaweed sprays on the growth of maize. *Bot. Mar.,* **34** : 469 - 471.

JOHN, H., LINDSAY, B. U. AND SAWADA, Y., 1975, Assessment of plant-available boron in some New Zealand soils. *J. Agric. Res*., **26** (2) : 191 - 195.

KRISHNAMURTHY, V., 1965, Marine algal cultivation. In proc. seminar on sea salt and plants, Bhavnager, India, 327 - 333.

LINDSAY, W. L. AND NORWELL, W. A., 1978, Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Amer. J*., **42** : 421 - 428.

METTING, B., ZIMMERMAN, W. J., CROUCH, I. J. AND VANSTADEN, J., 1990, Agronomic uses of seaweed and microalgae. *In: Akatsuka I(ed) introduction to applied phycology.* SPB Academic publishing, The hague, Netherlands, pp. : 269 - 627.

NARDI, S. D., PIZZEGHELLO, A., MUSCOLO AND VIANELLO, A., 2002, Physiological effects of humic substances on higher plants. *Soil Biol. Biochem*., **34** : 1527 - 1536.

PETTIT, R. E., 2004, Organic matter, humus, humate, humic acid, fulvic acid and humin: their importance in soil fertility and plant health. Retrived from *www. humate*.info/mainpage.htm.

PIPER, C., 1966, *soil and plant analysis*., Hans Publication, Bombay.

PIZZEGHELLO, D., FRANCIOSO, O., ERTANI, A, NUSCOLIO, A. AND NARDI, S., 2013, Isopentnyladenisine and cytokinin-like activity of different humic substances. *Journal for Environmental and Economic Geochemistry*, **129** : 70 - 75.

PRAMANICK, B., BRAHMACHARI, K., GHOSH, A. AND ZODAPE, S. T., 2014, Effect of seaweed saps on growth and yield improvement of transplanted rice in old alluvial soil of West Bengal. *Bangladesh J. Bot.*, **43** (1) : 53 - 58.

PRAMANICK, B., BRAHMACHARI, K., MAHAPATRA, B. S., GHOSH, A., GHOSH, D. AND KAR, S., 2017, Growth, yield and quality improvement of potato tubers through the application of seaweed sap derived from the marine alga *Kappaphycus alvarezii. J. Appl. Phycol.,* **29** : 3253 - 3260. https://doi.org/10.1007/s10811-017-1189-0

RAJASEKHAR REDDY, K., KUMAR, K. M. AND GIRIBABU, V., 2018, Effect of seaweed extracts on growth, yield parameters in chickpea (*Cicer arietinum* L). *Int. J. Curr. Microbiol. Appl. Sci.,***7** (1) : 1931 - 1936.

RATHOD, S. S., MAMATA, B., CHAMEGOWDA, S. T., BHAIRAPPANAVAR AND TAMBAT, B., 2019, Effect of different methods of application of zinc and boron on yield and nutrient uptake of chickpea (*Cicer arietinum* L.). *Mysore J. Agric. Sci.,* **53** (3) : 76 - 80.

RAYORATH, P., KHAN, W., RAVISHANKAR, P., SHAWNA, L. M., ROUMIANA, S., SIMON, D. H., ALAN, T. C. AND BALAKRISHAN, P., 2008, Extract of the brown seaweed *Ascophyllum nodosum* induce gibberellic acid (GA3) - independent amylase activity in barley. *J. plant growth regul.,* **27** : 370 - 379. https://doi.org/10.1007/s00344-008-9063-6

ROY, A. K., ALI, N., LAKRA, R. K., ALAM, P., MAHAPATRA, P. AND NARAYAN, R., 2018, Effect of integrated nutrient management practices on nutrient uptake, yield of finger millet (*Eleusine coracana* L. Gaertn.) and post harvest nutrient availability under rainfed condition of Jharkhand. *Int. J. Curr. Microbiol. App. Sci*., **7** (8) : 339 - 347.

SHARMA, R. K., 2020, Role of seaweed extract in sustainable agriculture: A review. *J. Appl. Phycol.,* **32** (2) : 1325 - 1345.

SUBBAIAH, A. Y. AND ASIJA, G. K., 1956, A rapid procedure for the estimation ofavailable nitrogen in soils. *Curr. Sc*i., **25** : 270 - 280.

TSENG, C. K., 2004, The past, present and future of phycology in China. *Hydrobiologia,* **512** : 11 - 20.

WALKLEY, A. J. AND BLACK, I. A., 1934, An examination of wet acid method fordetermining soil organic matter and proposed modification of chromic acid titrationmethod. *J. Soil Sci*., **37** : 29 - 38.

WHAPHAM, C. A., BLUNDEN, G., JENKINS, T. AND HANKINS, S. D., 1993, Significance of betaines in the increased chlorophyll content of tomato plants treated with seaweed extract. *J. Appl. Phycol.,* **5** : 231 - 234. https:/ / doi.org/10.1007/BF00004023.

ZHANG, W., ZHANG, X., LIU, Y. AND WANG, M., 2020, Seaweed extract and farm manure combined application improve soil water retention and crop yield in a sandy soil. *Scientific Agriculture*, **77** (10) : 1197 - 1206.

ZODAPE, S. T., 2001, Seaweed as a bio-fertilizer. *J. Sci. Ind. Res.,* **60** (56) : 378 - 382.

ZODAPE, S. T., GUPTA, A., BHANDARI, S. C., RAWAT, U. S., CHAUDHARY, D. R., Eswaran, K. AND CHIKARA, J., 2011, Foliar application of seaweed sap as biostimulants of enhancement of yield and quality of tomato. *J. Sci. Indus. Res.,* **70** : 215 - 219.