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Response of green gram (*Vigna radiata* L.) to various biostimulants

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Abstract
An experiment was conducted at the Research Farm, Maharishi Markandeshwar (Deemed to be University), Mullana during the summer 2023 to evaluate "Response of Green gram (*Vigna radiata* L.) to various biostimulants". This experiment was conducted in a randomized block design (RBD) with three replications. The experiment comprised 10 biostimulant treatments including seaweed extract, humic acid, biochar, hairamine used individually and in combinations. The results indicated that (T_7) 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) exhibited the highest values for plant height (41.67 cm, 51.73 cm), number of branches (7.56, 10.59), number of leaves (21.83, 29.50), and dry weight (11.49 g, 21.96 g) at 45 DAS and at harvest, respectively. (T_7) 100% RDF + Seaweed extract (0.2%) +Hairamine (0.4%) also recorded the highest values of number of pods (21.65), number of seeds pod^{-1} (9.45), and 100-seed weight (4.99 g). The highest seed yield (10.47 q ha^{-1}), stover yield (27.47 q ha^{-1}), biological yield (37.93 q ha^{-1}), and harvest index (27.63%) were also achieved under the (T_7) 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) treatment. T_7 100% RDF +Seaweed extract (0.2%) +Hairamine (0.4%) showed significant higher values for most plant characters as compared to control and was at par with 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8), 100% RDF + Biochar (0.2%) + Hairamine (0.4%) (T_9) and 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) in most of the cases. Thus, 100% RDF + 0.2% Seaweed extract + 0.4% Hairamine can be recommended to farmers to include in the agronomic package of green gram to increase their production and profitability.

Keywords: Green gram, biostimulants, seaweed extract, humic acid, biochar, hairamine

Introduction
Green gram (*Vigna radiata* L.) is an annual crop originated in India. Green gram has a short growth period and can be grown in three different seasons namely kharif, rabi, and summer. India produces more than 70% of the green grams used worldwide. In India, green gram cultivation occupied over 33.45 lakh hectares in 2022-23. Rajasthan, Karnataka, Maharashtra, Odisha, Madhya Pradesh, and Telangana are among the states in India where green gram is extensively grown and are among the top producers of this crop (Green gram Outlook December, 2022, Agricultural Market Intelligence Centre, PJTSAU). Haryana produces 0.024 million tons of green gram each year from 0.029 million ha of land, with 8.24 q ha^{-1} productivity. (Anonymous, 2019) [1]. Growth, productivity and production of a crop are determined by the variety, agronomic management along with prevailing environmental conditions. Agronomic management includes irrigation, nutrient supply through fertilizers, manures and adjuvants like biostimulants. Biostimulants are substances other than fertilizers that have beneficial effects on plant growth and development. In this research, four biostimulants namely seaweed extract, humic acid, biochar and hairamine were assessed to evaluate their individual and combined effects on growth and yield of green gram. Seaweed extract is a valuable marine source. Various seaweed preparations like Seaweed Liquid Fertilizer (SLF), Liquid Seaweed Fertilizer (LSF), Liquid Fertilizer (LF) and algal manure have been studied by various scientists. The use of seaweed extracts has been found to have various benefits for crops, such as increased yield, better nutrient uptake, improved resistance to frost and stress, enhanced seed germination, and reduced occurrence of fungal and insect attacks.

Iswarya *et al.* (2019) [6] found that treating the seeds with a 0.1% solution of seaweed extract and then applying a foliar spray of 0.25% seaweed extract twice on 25 and 35 DAS exhibited 12.48 q ha^{-1} of seed yield in green gram. Humic acid increases enzyme activity in plants along with increasing the nutrient availability to plants. Humic acid comprises 51% to 57% C, 0.2% to 1% P, 4% to 6% N and other trace minerals in small quantities. Humic acid plays many important roles in improving soil properties by increasing biochemical and physical activities by increasing the water holding capacity, optimizing soil structure, soil texture and microbiota of the soil (Nardi *et al.*, 2017; Fuentes *et al.*, 2018; Shah *et al.*, 2018) [12, 2, 17] and decrease the uptake of harmful heavy metals by their precipitation (Wu *et al.*, 2017) [20]. 1.0 kg humic acid ha^{-1} is reported to increase in yields of maize, wheat, groundnut, cotton, and sugar beet while improving the physical and chemical conditions of soil (Khattak *et al.*, 2006; Sharif *et al.*, 2003) [8, 18]. Biochar is a product that is rich in carbon, produced from organic material under a limited oxygen supply (O_2) at temperatures lower than 700 °C (Tilman, 1999) [19]. Biochar is a highly porous material which can be used for applications focused on enhancement of crop, remediation and improvement of soil. It also enhances carbon dioxide sequestration. Hussain *et al.* (2017) [5] revealed that biochar @ of 25-ton ha^{-1} resulted in an increased seed yield of green gram. Hairamine is a protein hydrosolate. Protein hydosolate is a mixture of polypeptides, oligopeptides and free amino acids, which are hydolysed using partial hydrolysis. It is prepared by dissolving human hair and animal hair in hydrochloric acid. Hairamine is known to boost the overall health of plants. It promotes the uptake of macro and micronutrients. It also helps plants to tolerate stress conditions. Kumar *et al.* (2021) [10] used hairamine in cotton and Kumar *et al.* (2023) [11] used hairamine in winter cereals which has shown positive responses. In light of the information mentioned above, the study titled "Response of Green gram to various biostimulants" was carried out during summer season of year 2023 to evaluate the complementary effect of RDF and biostimulants on plant growth, yield and its attributes in green gram.

Materials and Methods

The present study was carried out in 2023 at the Research Farm of Maharishi Markandeshwar (Deemed to be University), Mullana. The site of the experiment is situated at 30°17'0" N latitude, 77°3'0" E Longitude and at a height of 264 m over the average level of sea. The green gram (var. SML-668) was grown with the standard package of practices in the summer season to analyse the effect of biostimulants treatments. Ten treatments *viz.* Control (T_1, No fertilizer), 100% RDF (20 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1}, 20 kg K_2O ha^{-1}, 25 kg $ZnSO_4$ ha^{-1}) (T_2), 100% RDF + Seaweed extract (0.5%) (T_3), 100% RDF + Humic Acid (0.5%) (T_4), 100% RDF + Biochar (0.5%) (T_5), 100% RDF + Hairamine (0.8%) (T_6), 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7), 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8), 100% RDF + Biochar (0.2%) + Hairamine (0.4%) (T_9), 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) were assessed three times in randomized block design with three replications with gross and net plot sizes of 4.5 m^2 and 3.04 m^2, respectively using a seed rate of 20 kg ha^{-1} with a spacing of 30 cm x 10 cm. Biostimulants were applied 25 days after sowing (DAS) in single biostimulant treatment while the treatments having the combination of two stimulants had sprayed after 25 DAS for the first biostimulant while 26 DAS for the second biostimulant. The data was recorded on five randomly selected plants for parameters of plant growth and yield.

Table 1: Effect of various biostimulants on plant height (cm) and number of branches at 30 and 45 DAS and at harvest

Treatments		Plant height (cm)			Number of branches $plant^{-1}$		
		30 Das	45 Das	At Harvest	30 Das	45 Das	At Harvest
T_1	Control	19.85	32.67	40.06	4.00	5.18	7.35
T_2	100% RDF	20.06	38.89	45.07	4.16	5.90	8.64
T_3	100% RDF + Seaweed extract (0.5%)	20.16	39.87	48.02	4.24	6.77	9.45
T_4	100% RDF + Humic Acid (0.5%)	20.10	39.76	47.70	4.20	6.60	9.37
T_5	100% RDF + Biochar (0.5%)	20.07	39.08	45.83	4.17	6.56	9.21
T_6	100% RDF + Hairamine (0.8%)	20.17	40.03	48.49	4.28	6.82	9.52
T_7	100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%)	20.25	41.67	51.73	4.40	7.56	10.59
T_8	100% RDF + Humic Acid (0.2%) + Hairamine (0.4%)	20.20	41.35	51.14	4.39	7.40	10.30
T_9	100% RDF + Biochar (0.2%) + Hairamine (0.4%)	20.18	40.32	49.10	4.33	7.15	10.09
T_{10}	100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%)	20.19	40.97	50.57	4.37	7.23	10.28
S.EM.±		0.11	0.28	0.55	0.14	0.18	0.23
C.D. @5%		NS	0.84	1.63	NS	0.55	0.70

The means of different observations were analysed as per the design of the experiment (RBD) described by Panse and Sukhatme (1985) using OPSTAT software developed by CCS, HAU, Hisar (Haryana).

Result

Growth Parameters

The results regarding various growth parameters are depicted in Table 1 and Table 2.

Plant Height (cm)

Data (Table 1) indicated that the plant height showed an increase over the control at 30 DAS, with non-significant differences among various biostimulant treatments. At 45 DAS, the treatment 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7) recorded significantly higher plant height (41.67 cm), which was statistically at par to 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8) and 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) with values 41.35 cm and 40.97 cm, respectively. The control (T_1) recorded the shortest plant height (32.67 cm). At harvest, the treatment 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7) also noted significantly higher plant height (41.67 cm), which was statistically similar to treatment 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8) and treatment 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) recording

values 51.14 cm and 50.57 cm, respectively. Under the control treatment (T_1), the plant height was observed to be the lowest (40.06 cm).

Number of Branches plant^{-1}

The results (Table 1) showed that the number of branches plant^{-1} at 30 DAS exhibited non-significant differences among various biostimulant treatments. At

45 DAS, 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7) resulted in the highest value of number of branches (7.56) which was statistically similar to 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8), 100% RDF + Biochar (0.2%) + Hairamine (0.4%) (T_9), 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) with the values 7.40, 7.15 and 7.23, respectively. The control (T_1) had the lowest number of branches (5.18). At harvest, the number of branches was significantly higher (10.59) in the treatment 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7) which was statistically similar to 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8), 100% RDF + Biochar (0.2%) + Hairamine (0.4%) (T_9) and 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) noting values 10.30, 10.09 and 10.28, respectively. The control group (T_1) had significantly lower value of 7.35 for number of branches plant^{-1} when compared to other treatments.

Number of leaves plant^{-1}

The data (Table 2) revealed non-significant differences for number of leaves plant^{-1} among various biostimulant treatments at 30 DAS. However, higher values compared to control were recorded in all the treatments.

Table 2: Effect of various biostimulants on number of leaves plant^{-1} and dry weight (g plant^{-1}) at 30 and 45 DAS and at harvest

Treatments		Number of leaves plant^{-1}			Dry weight (g plant^{-1})		
		30 Das	45 Das	At Harvest	30 Das	45 Das	At Harvest
T_1	Control	12.56	15.53	19.66	3.89	7.04	14.25
T_2	100% RDF	13.05	17.54	22.81	4.09	8.27	17.20
T_3	100% RDF + Seaweed extract (0.5%)	13.33	19.48	25.93	4.24	9.53	19.33
T_4	100% RDF + Humic Acid (0.5%)	13.19	19.27	25.51	4.21	9.47	19.20
T_5	100% RDF + Biochar (0.5%)	13.08	18.45	23.81	4.18	9.30	18.18
T_6	100% RDF + Hairamine (0.8%)	13.43	19.80	26.32	4.25	9.68	19.42
T_7	100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%)	13.94	21.83	29.50	4.41	11.49	21.96
T_8	100% RDF + Humic Acid (0.2%) + Hairamine (0.4%)	13.80	21.43	28.88	4.32	11.03	21.63
T_9	100% RDF + Biochar (0.2%) + Hairamine (0.4%)	13.67	20.17	26.91	4.26	10.47	20.74
T_{10}	100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%)	13.78	20.83	27.93	4.28	10.87	21.24
S.EM.±		0.44	0.33	0.39	0.11	0.32	0.54
C.D. @5%		NS	0.98	1.16	NS	0.95	1.61

The various biostimulants treatments showed a significant effect on number of leaves plant^{-1} at 45 DAS. Among various biostimulant treatments, the highest number of leaves plant^{-1} (21.83) was registered with the application of 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7), which was statistically equivalent to 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8) at 45 DAS with the value 21.43. On the opposite, the treatment T_1 (Control) recorded the lowest number of leaves plant^{-1} (15.53). The treatment T_7 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) recorded significantly higher number of leaves plant^{-1} (29.50) at harvest, which were statistically at par with 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8) recording 28.88 leaves plant^{-1}. However, the lowest number of leaves plant^{-1} (19.66) was registered under control (T_1).

Dry Weight (g plant^{-1})

An appraisal of data (Table 2) indicated non-significant differences for the dry weight (g plant^{-1}) among different treatments at 30 DAS. Highest dry weight (g plant^{-1}) (11.49 g) was observed under the treatment 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7), which remained statistically similar to 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8) and 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) having values 11.03 and 10.87 g, respectively at 45 DAS and T_1 (Control) had the lowest dry weight (7.04 g plant^{-1}). At harvest, the treatment 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7) recorded highest dry weight (21.96 g plant^{-1}), which remained statistically similar to 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8), 100% RDF + Biochar (0.2%) + Hairamine (0.4%) (T_9) and 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) possessing dry weight of 21.63, 20.74 and 21.24 g plant^{-1}, respectively and control (T_1) had the lowest dry weight (14.25 g plant^{-1}).

Yield Attributes

Number of Pods plant^{-1}

A close study of Table 3 showed that the highest number of pods plant^{-1} (21.65) was exhibited by the treatment 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7), which was statistically at par with to 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8) and 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) exhibiting 21.32 and 21.03 pods plant^{-1}, respectively. On the opposite, the treatment T_1 (Control) had significantly lower number of pods plant^{-1} (16.60) when compared to other treatments.

Number of seeds pod^{-1}

The data (Table 3) indicated that significantly higher (9.45) number of seeds pod^{-1} were observed under the treatment comprising 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7), which remained statistically at par with 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8), 100% RDF + Biochar (0.2%) + Hairamine (0.4%) (T_9) and 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) having 9.27, 9.17 and 9.24 seeds per pod^{-1}, respectively and the least values were recorded under control (T_1) (7.37).

Table 3: Effect of various biostimulants on yield parameters and yield

Treatments		Yield parameters			Yield			
		Number of pods plant^{-1}	Number of seeds pod^{-1}	Test wt. (g)	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
T_1	Control	16.60	7.37	4.43	6.10	18.40	24.50	24.91
T_2	100% RDF	18.87	8.43	4.78	8.13	22.33	30.47	26.73
T_3	100% RDF + Seaweed extract (0.5%)	20.10	9.03	4.85	9.38	24.81	34.19	27.45
T_4	100% RDF + Humic Acid (0.5%)	20.03	8.98	4.84	9.24	24.70	33.94	27.27
T_5	100% RDF + Biochar (0.5%)	19.21	8.50	4.80	8.37	22.82	31.19	26.86
T_6	100% RDF + Hairamine (0.8%)	20.30	9.11	4.86	9.40	24.90	34.30	27.46
T_7	100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%)	21.65	9.45	4.99	10.47	27.47	37.93	27.63
T_8	100% RDF + Humic Acid (0.2%) + Hairamine (0.4%)	21.32	9.27	4.96	10.31	27.16	37.46	27.62
T_9	100% RDF + Biochar (0.2%) + Hairamine (0.4%)	20.73	9.17	4.90	9.98	26.25	36.23	27.58
T_{10}	100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%)	21.03	9.24	4.93	10.28	26.89	37.17	27.60
S.EM.±		0.28	0.11	0.02	0.28	0.54	0.76	0.41
C.D. @5%		0.83	0.33	0.06	0.85	1.62	2.28	1.23

Test Weight (g plant^{-1})

A close study of Table 3 revealed that different treatments had a significant influence on test weight. The highest test weight (4.99 g) was noted under the 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7), which was statistically equivalent to 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8) and 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) with the values 4.96g and 4.93 g, respectively. Under the control treatment (T_1), the test weight was recorded as lowest (4.43 g).

Seed yield (q ha^{-1})

The data regarding the effect of various biostimulants on seed yield is furnished in Table 3. Different treatments exercised their positive influence on seed yield. Significantly higher seed yield (10.47 q ha^{-1}) was under 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7), which remained statistically similar to 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8), 100% RDF + Biochar (0.2%) + Hairamine (0.4%) (T_9) and 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}), with seed yield of 10.31, 9.98 and 10.28 q ha^{-1}, respectively. However, the control (T_1) had the lowest seed yield (6.10 q ha^{-1}).

Stover Yield (q ha^{-1})

An analysis of data (Table 3) indicated that different treatments had a noteworthy influence on Stover yield. The highest Stover yield of 21.47 q ha^{-1} was noted under treatment comprising 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7) that remained statistically at par with 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8), 100% RDF + Biochar (0.2%) + Hairamine (0.4%) (T_9) and 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) recording the Stover yield of 27.16, 26.25, 26.89 q ha^{-1}, respectively. In contrast, lowest Stover yield (18.40 q ha^{-1}) was registered under control (T_1).

Biological Yield (q ha^{-1})

The data (Table 3) revealed that a significantly higher biological yield (37.93 q ha^{-1}) was exhibited by the treatment 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7) which was statistically similar to 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8), 100% RDF + Biochar (0.2%) + Hairamine (0.4%) (T_9) and 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) having biological yield of 37.46, 36.23 and 37.17 q ha^{-1}, respectively, while the control (T_1) exhibited the lowest biological yield (24.50 q ha^{-1}).

Harvest Index (%)

Scrutiny of data (Table 3) revealed that the harvest index was highest (21.63) in the treatment 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7) which was statistically similar to 100% RDF + Hairamine (0.4%) (T_6), 100% RDF + Humic Acid (0.2%) + Hairamine (0.4%) (T_8), 100% RDF + Biochar (0.2%) + Hairamine (0.4%) (T_9), 100% RDF + Seaweed extract (0.2%) + Humic Acid (0.2%) (T_{10}) and represented by values 27.46, 27.62, 27.58, 27.60%, respectively. The lowest value (24.91) was recorded in control (T_1).

Discussion

The different treatments were found to have significant effects on growth parameters, yield attributes and yield. The treatment 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7) exhibited the highest values for all the observations. Seaweed extract holds nutrients like potassium, phosphorus, nitrogen, zinc, copper, iron, manganese. Phosphorus helps to promote root development and thus enhances nutrient extraction from the soil. Potassium accelerates growth by enhancing meristematic growth, photosynthetic translocation and photosynthesis. Calcium helps in cell elongation, stability and activation of enzymes. Manganese, is a constituent of several enzymes as well as chlorophyll and copper, iron and zinc are necessary for respiration and reduction of nitrates and sulphates. 50% of the carbohydrate content found in commercial seaweed preparations is composed of alginic acid, laminarin, and mannitol. Seaweed extract contains various vitamins including B1, B2, B12, C, K, E, pantothenic acid, niacin, folinic acid, and folic acid. Additionally, it contains amino acids like alanine, glutamic acid, and aspartic acid, as well as a plant growth regulator called cytokinin. In addition to constituents mentioned earlier, seaweed extract also has gibberellins and auxins which are very important and beneficial for the reproductive development of the plant. All the above constituents have a major role in plant growth as well as development and thus seaweed extract acts as an overall growth promoter and has considerable effect on all the recorded parameters of growth of this experiment. Hairamine is a protein hydrosolate prepared by the hydrolysis of human hair.

Organic carbon, organic nitrogen, calcium, amino acids and enzymes that promote plant growth are found in abundance in

hairamine. Hairamine boosts nutrient uptake, utilization efficiency and abiotic stress tolerance. This biostimulant is also known to exhibit positive effects on crop quality. From the above description, it can be stated that the treatment 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7) had a large overall constituent profile that are beneficial for plant growth as well as reproductive development. Higher amount of organic nitrogen, carbon, micronutrients and growth hormones in seaweed extract complemented well with higher organic nitrogen, carbon, calcium, amides and amino acids in hairamine to give boost to the plant growth and yield contributing traits. These mentioned nutrients and plant growth promoters could be the reason behind the significant results of the treatment 100% RDF + Seaweed extract (0.2%) + Hairamine (0.4%) (T_7). Similar findings were also observed by Iswarya *et al.* (2019) [6], Pandya and Mehta (2021) [13], Pramanick *et al.* (2013) [15], Kumar *et al.* (2012) [9] and Kavipriya *et al.* (2011) [7] in green gram, Ghosh *et al.* (2020) [3] in black gram, Rathore *et al.* (2009) in soybean, Kumar *et al.* (2023) [11] in winter cereals, Kumar *et al.* (2021) [10] in cotton.

Conclusion

The results revealed complementary effects of mineral fertilizer (N, P, K) applied as basal dose and foliar application of various biostimulants individually or in combination of two biostimulants. However, such effects varied in magnitude from biostimulant to biostimulant and their combination. On overall basis the combination of seaweed extract and Hairamine along with RDF figured most effective in increasing plant growth, seed yield and its attributes in green gram. Therefore, this combination of biostimulants which are abundantly available at affordable prices can be recommended to farmers to increase production per unit area in a sustainable manner.

References

1. Anonymous. Economic Survey 2018-19, Government of India; c2019.
2. Fuentes M, Baigorri R, González-Gaitano G, García-Mina JM. New methodology to assess the quantity and quality of humic substances in organic materials and commercial products for agriculture. J Soils Sediments. 2018;18:1389-1399.
3. Ghosh A, Shankar T, Malik GC, Banerjee M, Ghosh A. Effect of seaweed extracts on growth, yield and nutrient uptake of black gram in the red and lateritic belt of West Bengal. J Appl. Phycol. 2020;32(6):3681-3690.
4. Green gram Outlook December, 2022, Agricultural Market Intelligence Centre, PJTSAU [Internet]. Available from: https://www.pjtsau.edu.in/files/AgriMkt/2022/December/greengram-December-202.pdf. Accessed 2024-06-21.
5. Hussain Z, Khan N, Ullah S, Liaqat A, Nawaz F, Khalil AUR, Shah JA, Junaid M, Ali M. Response of Mung bean to Various Levels of Biochar, Farmyard Manure and Nitrogen. World J Agric Sci. 2017;13(1):26-33.
6. Iswarya S, Latha KR, Srinivasan K. Evaluation of seaweed extract on growth determinants, yield and biochemical parameters of green gram (*Vigna radiata*). J Pharmacogn. Phytochem. 2019;8(3):1861-1864.
7. Kavipriya R, Dhanalakshmi PK, Jayashree S, Thangaraju N. Seaweed extract as a biostimulant for legume crop, green gram. J Ecobiotechnol. 2011;3(8):16-19.
8. Khattak RA, Muhammad D. Effect of Pre-Sowing Seed Treatments with Humic Acid on Seedling Growth and Nutrient Uptake. Internship Report, Department of Soil and Environmental Science, NWFP Agriculture University, Peshawar. 2006.
9. Kumar NA, Vanlalzarzova B, Sridhar S, Baluswami M. Effect of liquid seaweed fertilizer of Sargassum wightii grev. on the growth and biochemical content of green gram (*Vigna radiata* (L.) R. wilczek). Recent Res Sci Technol. 2012;4(4):40-45.
10. Kumar P, Behl JK, Singh M, Behl RK. Efficacy of protein hydroslate (plant force advance) based formulation on cotton yield. Ekin J Crop Breed Genet. 2021;7(1):43-47.
11. Kumar P, Yadav P, Kumar PS, Singh M, Behl RK. Genetic variability based among winter cereal genotype for response to protein hydrolysate (pH) for grain yield and its attributes. Ekin J Crop Breed Genet. 2023;9(1):91-97.
12. Nardi S, Ertani A, Francioso O. Soil-root cross-talking: the role of humic substances. J Plant Nutr Soil Sci. 2017;180:5-13.
13. Pandya M, Mehta S. Effect of Ulva lactuca L. Seaweed Biostimulant on Seed germination, Growth, and some Biochemical properties of *Vigna radiata* L. Int J Environ Agric Biotechnol. 2021;6(5):042-053.
14. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. New Delhi: ICAR; 1985.
15. Pramanick B, Brahmachariv K, Ghosh A. Effect of seaweed saps on growth and yield improvement of Green gram. Afr J Agric Res. 2013;8(13):1180-1186.
16. Rathore SS, Chaudhary DR, Boricha GN, Ghosh A, Bhatt BP, Zodape ST, Patolia JS. Effect of seaweed extract on the growth, yield and nutrient uptake of soybean (Glycine max) under rainfed conditions. S Afr J Bot. 2009;75(2):351-355.
17. Shah ZH, Rehman HM, Akhtar T, Alsamadany H, Hamooh BT, Mujtaba T. Humic substances: determining potential molecular regulatory processes in plants. Front Plant Sci. 2018;9:263.
18. Sharif M, Khattak RA, Sarir MS. Residual Effect of Humic Acid and Chemical Fertilizers on Maize Yield and Nutrient Accumulation. Sarhad J Agric. 2003;19:543-550.
19. Tilman D. Global environmental impacts of agricultural expansion: the need for sustainable and efficient practices. Proc Natl Acad Sci USA. 1999;96(11):5995-6000.
20. Wu S, Li R, Peng S, Liu Q, Zhu X. Effect of humic acid on transformation of soil heavy metals. IOP Conf Ser Mater Sci Eng. 2017;207:012089.