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IMPACT OF NATURAL ORGANIC FERTILIZER (SEAWEED SAPS) ON PRODUCTIVITY, NUTRIENT UPTAKE AND ECONOMICS OF GREENGRAM (*PHASEOLUS RADIATA* L.)

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ABSTRACT

A field experiment was conducted during the *Kharif* season of 2013 at Research Farm of Indira Gandhi Krishi Vishwa vidyalaya, Raipur (Chhattisgarh) to study the effects of seaweed saps on growth, yield, nutrient uptake and economic of greengram in *Vertisol* of Chhattisgarh. The foliar spray was applied twice at different concentrations (0, 2.5, 5.0, 7.5, 10 and 15% v/v) of seaweed extracts (namely *Kappaphycus* and *Gracilaria*). Foliar applications of seaweed extract significantly enhanced the growth, yield, nutrient uptake and benefit cost ratio parameters. The highest grain yield (12.77 q ha^{-1}) was recorded with applications of 15% *Kappaphycus* sap + recommended dose of fertilizer (RDF), followed by 15% *Gracilaria* sap + RDF (12.28 q ha^{-1}), the yield increment was computed 41.57% and 36.14% respectively compare to the water spray + RDF (9.02 q ha^{-1}). The highest nutrient uptake [72.07 kg ha^{-1} nitrogen (N), 7.46 kg ha^{-1} phosphorus (P) and 47.93 kg ha^{-1} potassium (K)] by crop were observed under 15% K Sap + RDF. Presence of some macro and microelements and plant growth regulators, especially cytokinins, IAA, GA in *Kappaphycus* and *Gracilaria* extracts are responsible for enhancing yield and improving nutrition of greengram.

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INTRODUCTION

Seaweed extract is a new generation of natural organic fertilizers containing highly effective nutritious and promotes faster germination of seeds and increase yield and resistant ability of many crops. Unlike, chemical fertilizers, extracts derived from seaweeds are biodegradable, non-toxic, nonpolluting and non-hazardous to humans, animals and birds (Dhargalkar and Pereira, 2005).Hence there is a need for popularizing the use of seaweed as health food and liquid organic fertilizer through mass scale trials and organization of public awareness programmes (Mohanty *et al.,* 2013). Liquid seaweed fertilizer is a unique combination of N, P, K, trace elements, alginates and simple sugars that are in dissolved form. These are easily absorbed through roots and leaves, besides releasing trace elements bound to the soil (Chapman and Chapman, 1980; Thivey, 1982). Commercial use of concentrated seaweed extracts as foliar spray, in seed treatments and root dips have increased more rapidly than use of seaweed meals a soil additive (Metting *et al.,* 1990). Now days, application of bio-stimulants has become an alternative approach to minimize the use of chemical fertilizers. Seaweeds are the macroscopic marine algae found attached to the bottom in relatively shallow coastal waters. They grow in the intertidal, shallow and deep sea areas up to 180 meter depth and also in estuaries and backwaters on the solid substrate such as rocks, dead corals and pebbles (Thirumaran *et al.*, 2009a). Seaweed liquid extract (SLE) which contains macro nutrients, trace elements, organic substances like amino acids and plant growth regulators such as auxin, cytokinin and gibberellins are applied to improve nutritional status, vegetative growth, yield and fruit quality in some plants (Eman *et al.*, 2008; Spinelli *et al.*, 2009). At present, the use of natural seaweed products as substitutes to conventional inorganic fertilizers has gained importance. Seaweed fertilizers are better than other fertilizers and are very economical. Recent, research demonstrated that seaweed fertilizers can compete with other fertilizers and are very economical (Gandhiyappan and Perumal, 2001). This study was undertaken to investigate the effect of seaweed liquid extract on the productivity and nutrient uptake of *Phaseolus mungo*.

Being pulses, the greengram take contribution for the world's diet major source of plant protein. In Chhattisgarh, the growing of pulses in the cropping system is now a days not a common practice, but it is well known that inclusion of any pulse crop in the sequence has all-round advantages. So, if we are to achieve nutritional security we must have to go for crop diversification in cropping pattern introducing crops like pulses for example, green gram, black gram etc. in *Zaid* (Summer) season and lentil, chickpea, garden pea etc. in *Rabi* (Winter) season. The productivity of greengram is declined due to inadequate plant stand, heavy flower drop and immature pod abscission leading to poor seed setting besides unfavorable environment, water and nutrient deficiencies at critical periods. Therefore, the solution to increase the productivity is to develop a method by which improve vegetative growth, flowering and pod filling could be maintained. Biological inputs through seed and foliar nutrition are ideal for improving crop yield and environmentally safe. Hence, it is important to find out the organic sources for seed and foliar treatments, for effective maintenance of vigour and viability. Therefore, the objective has been taken towards the balancing nutrients requirement for the optimum productivity of greengram crop by foliar application of sea weeds sap to enhance growth, yield and nutrient uptake of greengram.

MATERIALS AND METHODS

Field experiment was carried out during *Kharif* season of 2013 at Research Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh). Weekly average meteorological data during the span of experimentation, recorded at meteorological observatory, IGKV, Raipur. The total rainfall of 1206 mm was received during *Kharif* season. The maximum temperature ranged in crop seasons was 27.9ºC to 34.4ºC and minimum temperatures during the same season was 23.8ºC to 25.8ºC. The Sun shines hours and wind velocity ranged from 0.7 to 6.2 hr day^{-1} and 2 to 11.8 km hr^{-1}. The Relative humidity throughout the crop season varied between 67 to 95%. The open pan evaporation mean value ranged from 2.1 to 6.2 mm day^{-1} and the vapor pressure was recorded between the ranges 21 to 24.6 mm. The experiment comprised of ten treatments, the details of treatments are T_1: 2.5% K Sap + RDF, T_2: 5.0% K Sap + RDF, T_3: 10% K Sap + RDF, T_4: 15% K Sap + RDF, T_5: 2.5% G Sap + RDF, T_6: 5.0% G Sap + RDF, T_7: 10% G Sap + RDF, T_8: 15% G Sap + RDF, T_9: Water Spray + RDF and T_{10}: 7.5 % K Sap + 50% RDF. Two sprays of *Kappaphycus* and *Gracilaria* extract were applied at different growth stages (30 and 50 days after sowing) through knapsack sprayer. Spraying of sea weed saps was done in the field as per the treatment. The quantity of water used was 500-600 liter ha^{-1} with adjuvant. The soil of experiment field was 'vertisols' (clayey) which is locally known as 'Kanhar' with pH 7.4, EC 0.35 dSm^{-1}, organic carbon 0.51%, available N 202.5 kg ha^{-1}, P 39.6 kg ha^{-1} and K 348 kg ha^{-1}. The recommended nutrient dose of N, P_2O_5, K_2O and S was applied @ 20:40:20:15 kg ha^{-1} for the greengram crop. Full dose of nitrogen, phosphorus, potassium and sulphur were applied through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively as basal at the time of sowing. The sulphur content available in SSP, provide recommended dose of sulphur through their application.The observations, for growth, yield and yield attributing character were recorded as per the standard method from each plot of each replication separately.Soil and plant samples were drawn from the treated plots and analyzed. The analysis was done by micro kjeldahl, Vanadomolybdophosphoric yellow color and flame photometric methods for nitrogen, phosphorus and potassium, respectively.The uptake of Nitrogen (N), Phosphorus (P) and Potassium (K) by greengram crop was computed on the basis of dry matter accumulation and expressed as kg ha^{-1}. The field experiment was laid out in randomized block design (RBD) replicated thrice to evaluate the effect of a seaweed saps. The data was analyzed by the method of analysis of variance as described by Gomez and Gomez (1984).

Preparation and chemical compositionof liquid sea weed extract

The seaweed extract used in this study was obtained from *Kappaphycus sp.* and *Gracilaria sp.* The algae were handpicked from the coastal area of Rameswaram, Tamilnadu, India during September, 2011. It was washed with seawater to remove unwanted impurities and transported to the field station at Mandapum, Rameswaram. Here, samples were thoroughly washed using tap water. After that, fresh seaweed samples were homogenized by grinder with stainless steel blades at ambient temperature, filtered and stored (Eswaran *et al.*, 2005). The liquid filtrate was taken as 100% concentration of the seaweed extract and further diluted as per the treatments. The nitrogen (N) content of seaweed extract (100% concentrate) was determined by taking 20 ml of filtrate which was oxidized and decomposed by concentrate sulphuric acid (10 ml) with digestion mixture (K_2SO_4 : $CuSO_4$ = 5:1) heated at 400ºC temperature for 2½ h as described in the semi-micro Kjeldahl method [AOAC International, 1995, method No. Ba 4b-87(90)], and other nutrient elements were analyzed by inductively coupled plasma-optical emission spectroscopy (ICP-OES), after wet digestion of filtrate (20 mL) with HNO_3-$HClO_4$ (10:4) di-acid mixture (20 mL) and heated at 100ºC for 1 hour and then raise the temperature to about 150ºC (Richards, 1954).

RESULTS AND DISCUSSION

Growth and yield attributing character of greengram crop

Seaweed saps act as a growth regulator and its application significantly influenced as increase level of doses of sap spray along with recommended dose of fertilizer (RDF) on greengram crop. The data pertaining to growth and yield attribute was recorded and embodied in table 1. The statistically significant higher plant height (cm) was observed under foliar spray of 15% K Sap + RDF (T_4) *i.e.* 71.2 cm due to higher dose of foliar spray of K Sap along with RDF. Data related to dry matter accumulation (g), pods $plant^{-1}$ and seeds $plant^{-1}$ were observed significantly higher under foliar spray of 15% K Sap + RDF (T_4) which was at par with 10% K Sap + RDF (T_3) and 15% G Sap + RDF (T_8). Whereas, seed pod^{-1} and 1000 - seed weight (g) were also recorded maximum under foliar spray of 15% K Sap + RDF (T_4) and it was at par with 10% K Sap + RDF (T_3), 10% G Sap + RDF (T_7) and 15% G Sap + RDF (T_8). The findings of Gurusaravanan *et al.* (2010) was also reported that the application of seaweed extracts was increase the growth and productivity of greengram. The increase in growth and yield attributes may be due to the presence of some growth promoting substances, like IAA, IBA, GA, cytokinins, microelements, vitamins and amino acids (Lingakumar *et al.*, 2002). Therefore application of seaweed increase the growth and yield attributing character as compare with water spray. It was observed that the 10% and 15% application of K sap foliar spray along with RDF, provide all essential element and growth regulators in plant available form, which was followed by G sap higher dose treatment i.e. 10% and 15% along with RDF.

Yield of greengram crop

Higher sustainable crop yield is main aim of the crop cultivation due to definite agro-inputs, increases in seed yield as increased doses of seaweed sap along with RDF was recorded and represent in Table 1. The foliar application of 15% K sap + RDF (T_4) produced maximum seed and stover yield as compare to other foliar spray, but, it was at par with foliar application

Table 1: Effect of seaweed sap on growth, yield attributes and yield of greengram crop

Treatment	Plant height (cm)	Dry matter accumulation (g) plant^{-1}	No. branches plant^{-1}	Pods plant^{-1} (No.)	Seeds pod^{-1} (No.)	Seeds plant^{-1} (N0.)	1000 – seed weight(g)	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
T_1: 2.5% K Sap + RDF	66.9	13.60	3.13	14.6	7.27	107.13	36.17	10.11	24.16	29.51
T_2: 5% K Sap + RDF	67.8	14.53	3.20	15.5	7.40	115.33	36.30	10.47	24.70	29.81
T_3: 10% K Sap + RDF	68.3	15.67	3.40	17.3	8.13	140.13	39.44	11.00	24.96	30.58
T_4: 15% K Sap + RDF	71.2	16.87	3.80	19.8	8.53	168.80	40.45	12.77	27.94	31.37
T_5: 2.5% G Sap + RDF	66.4	12.87	2.93	14.3	7.33	103.93	35.93	9.85	23.79	29.25
T_6: 5% G Sap + RDF	67.6	14.00	3.13	15.3	7.40	112.40	36.24	10.40	24.26	29.99
T_7: 10% G Sap + RDF	68.1	14.80	3.33	16.4	8.00	130.67	38.85	10.70	24.73	30.18
T_8: 15% G Sap + RDF	69.9	15.93	3.67	18.0	8.33	149.67	39.00	12.28	27.07	31.21
T_9: Water Spray+ RDF	66.0	12.20	2.87	12.7	7.27	93.00	35.85	9.02	23.22	27.96
T_{10}: 7.5 % K Sap +50% RDF	65.5	12.27	2.67	13.3	7.13	94.20	35.52	9.61	23.76	28.81
SEm ±	0.29	0.41	0.11	1.06	0.26	9.92	0.80	0.40	0.57	0.77
CD (P=0.05)	0.88	1.24	0.32	3.17	0.77	29.48	2.40	1.20	1.85	NS

Table 2: Effect of seaweed sap on nutrient uptake and available nutrient status in soil

Treatment	Nitrogen uptake(kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake(kg ha^{-1})			Available nutrient status in soil(kg ha^{-1})		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total	N	P	K
T_1: 2.5% K Sap + RDF	32.96	21.89	54.85	2.97	1.21	4.18	10.18	22.17	32.34	145.3	25.39	384.9
T_2: 5% K Sap + RDF	34.99	23.30	58.29	3.24	1.97	5.21	11.48	23.38	34.86	146.3	28.97	393.5
T_3: 10% K Sap + RDF	37.31	23.73	61.05	3.65	2.25	5.90	12.14	25.03	37.17	162.0	30.17	399.1
T_4: 15% K Sap + RDF	44.26	27.82	72.07	4.73	2.72	7.46	15.40	32.54	47.93	166.2	34.05	418.9
T_5: 2.5% G Sap + RDF	33.52	20.24	53.76	3.26	1.27	4.53	10.44	23.07	33.51	148.4	24.79	384.2
T_6: 5% G Sap + RDF	34.76	21.29	56.05	3.50	1.70	5.19	11.27	23.45	34.72	152.6	26.28	394.6
T_7: 10% G Sap + RDF	35.96	22.04	58.00	3.75	1.97	5.72	11.84	24.73	36.57	153.7	29.27	396.9
T_8: 15% G Sap + RDF	42.70	25.39	68.09	4.76	2.54	7.30	14.47	29.02	43.49	161.0	32.55	411.4
T_9: Water Spray+ RDF	29.50	19.49	48.98	2.63	1.08	3.72	8.75	20.86	29.62	147.4	24.19	377.1
T_{10}: 7.5 % K Sap + 50% RDF	28.99	18.89	47.88	2.37	1.02	3.39	9.07	19.98	29.05	139.0	18.82	365.9
SEm ±	1.85	0.84	2.00	0.27	0.28	0.46	0.82	1.46	1.44	4.10	2.24	9.56
CD (P=0.05)	5.51	2.50	5.96	0.83	0.85	1.36	2.43	4.35	4.28	12.20	6.66	28.42

Table 3: Effect of Seaweed sap on economics of greengram crop

Treatment	Cost of Cultivation(Rs.ha-1)	Gross Return(Rs.ha-1)	Net Return(Rs.ha-1)	B:C ratio
T_1: 2.5% K Sap + RDF	18424	47908	29483	1.60
T_2: 5% K Sap + RDF	19174	49597	30422	1.59
T_3: 10% K Sap + RDF	19924	52002	32078	1.61
T_4: 15% K Sap + RDF	20674	60254	39580	1.91
T_5: 2.5% G Sap + RDF	18424	46682	28257	1.53
T_6: 5% G Sap + RDF	19174	49226	30052	1.57
T_7: 10% G Sap + RDF	19924	50641	30716	1.54
T_8: 15% G Sap + RDF	20674	57989	37315	1.80
T_9: Water Spray+ RDF	17674	42908	25234	1.43
T_{10}: 7.5 % K Sap +50% RDF	17480	45638	28158	1.61

15% G Sap + RDF (T_8). As compare to treatment water spray + RDF (T_9), seaweed sap of *Kapphaphycus spp.* foliar spray treatments along with RDF i.e. 2.5% K Sap + RDF (T_1), 5% K Sap + RDF (T_2), 10% K Sap + RDF (T_3), 15% K Sap + RDF (T_4) and 7.5% K Sap + RDF (T_{10}) produced 12.08, 16.11, 21.97, 41.56% and 6.58% more seed yield, respectively. While, seaweed sap of *Gracilaria spp.* foliar spray treatments along with RDF *i.e.* 2.5% G Sap + RDF (T_5), 5% G Sap + RDF (T_6), 10% G Sap + RDF (T_7) and 15% G Sap + RDF (T_8) produced 9.15, 15.30, 18.67% and 36.20% more yield, respectively as compare with water spray + RDF (T_9). Seaweed saps improve plant biomass and it improves grain development at harvest. Harvest index (%) of crop was shown non-significant result; lowest harvest index (%) was recorded under water spray + RDF (T_9).Foliar application of aqueous extract of gives positive result on the growth and yield of pea and black gram (Ramamoorthy *et al.,* 2006a, Ramamoorthy *et al.,* 2006b and Ramamoorthy *et al.,* 2007). Seaweed extracts not only increase the vegetative growth of the plant but it also triggers the early flowering, fruiting in crops and ultimately on seed yield. Zodape *et al.* (2011) also reported that foliar application of liquid extract of *Kappaphycus spp.* increase the yield tomato.

Nitrogen, phosphorus and potassium uptake of greengram

Nitrogen, phosphorus and potassium uptake in greengram was differed significantly due to different doses of foliar spray along with RDF (Table 2). The higher dose of *Kappapycus* seaweed sap along with i.e. 15% K Sap + RDF (T_4) recorded significantly higher uptake of nutrient over other treatments. Contrary to comparable performance of foliar spray 15% K Sap + RDF (T_4) and 15% G Sap + RDF (T_8) in respect to grain and dry matter of the crop which removed higher amount of nutrient when compare with other treatments. In greengram, higher nitrogen and potassium uptake was recorded in application of foliar spray 15% K Sap + RDF (T_4) but, being at par with foliar spray of 15% G Sap + RDF (T_8) in case of grain, stover and total nutrient uptake of nitrogen and potassium. While, in case of maximum phosphorus uptake in grain, stover and total was also recorded in application of foliar spray 15% K Sap + RDF (T_4) which found at par with foliar spray of 15% G Sap + RDF (T_8). However, 5% K Sap + RDF (T_2), 10% K Sap + RDF (T_3) and 10% G Sap + RDF (T_7) were also found *at par* in case of stover with maximum phosphorus uptake treatment i.e. 15% K Sap + RDF (T_4). The foliar application of seaweed *Kapphphycus spp.* and *Gracilaria spp.*to crop plant gave better result in all aspect of growth to yield, nutrient uptake and soil nutrient content after harvest when compared with water spray + RDF (T_9). It is probably due to presence of growth promoting hormones and nutrient in seaweed is more and in easily available form (Thirumaran *et al.*, 2009b). Finding of Ramya *et al.* (2011), Zodape *et al.* (2010) and Shehata *et al.* (2011) were also reported that foliar application of seaweed extract increased yield and improved nutrient content and uptake of nutrient in grain and stover, due to presence of trace elements, plant growth regulators and especially cytokinin, GA, etc., beneficial for crop growth.

Nutrient status of soil after harvest of greengram crop

Seaweed liquid extract enhanced soil fertility by improving the moisture holding capacity and also helps in the growth of soil micro-biota. Data related with available nitrogen, phosphorus and potassium in soil after harvesting were influenced significantly due to different doses of foliar spray, which is representing in Table 2. Available nitrogen recorded maximum under foliar spray of 15% K Sap + RDF (T_4), while, it was at par with 10% K Sap + RDF (T_3) and 15% G Sap + RDF (T_8). Application of foliar spray 15% K Sap + RDF (T_4) recorded maximum available phosphorus and potassium but, being on par with application of foliar spray 5% K Sap + RDF (T_2), 10% K Sap + RDF (T_3), 10% G Sap + RDF (T_7) and 15% G Sap + RDF (T_8) however, application of foliar spray 5% G Sap + RDF (T_6) was also found at par in case of available potassium. Some of the seaweed sp applied by foliar or by manure form, it enhanced the early growth and yield attribute properties in leguminous crop and the response was 20-30% higher than that of control (Zodape*et al.*, 2010). Seaweed extract of *Gracilaria edulis* when added to soil bed was showed positive response (Lingakumar *et al.*, 2002).

Effect of Seaweed sap on economics of greengram crop

Cost of cultivation of green gram crop was varied from Rs. 17,480 to Rs. 20,674 ha^{-1} owing to the use different level of foliar spray of seaweed sap along with RDF (Table 3). Application of foliar spray 15% K Sap + RDF (T_4) and 15% G Sap + RDF (T_8) fetched higher cost of cultivation. The maximum gross return, net return and B:C ratio was Rs. 60,254, Rs. 39,580 and 1.91 were computed with maximum yield producing treatment, 15% K Sap + RDF (T_4). As compare with water spray + RDF (T_9), *Kapphapycusspp.* treatments i.e. 2.5% K Sap (T_1), 5% K Sap (T_2), 10% K Sap (T_3), 15% K Sap (T_4) along with RDF and 7.5% K Sap + 50% RDF (T_{10}) were gave additional net returnRs.4,249, Rs. 5,189, Rs. 6,844, Rs. 14,346 and Rs. 2,924 per hectare, respectively. While water spray + RDF (T_9) was also compared with *Gracilaria spp.* treatments i.e. 2.5% G Sap (T_5), 5% G Sap (T_6), 10% G Sap (T_7) and 15% G Sap (T_8) along with RDF were gave additional net return Rs. 3023, Rs. 4818, Rs. 5482 and Rs. 12081 per hectare, respectively. Bai *et al.* (2011) applied seaweed liquid extract and got maximum yield and ultimately profit from maximum production of pulses.

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