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EFFECT OF SEAWEED SAPS ON NUTRIENT CONTENT, PROTEIN CONTENT, YIELD AND ECONOMICS OF SOYBEAN [*GLYCINE MAX* (L.) MERRILL.]

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ABSTRACT

A field experiment was conducted during the *Kharif* season of 2013 at Research cum Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) to study the effects of seaweed saps on nutrient, protein content, yield economics of Soybean in *Vertisol*of Chhattisgarh. The foliar spray was applied three sprays at different concentrations (0, 2.5, 5.0, 7.5, 10 and 15% v/v) of seaweed saps (namely *Kappa phycus*and *Gracilaria*) at different days (25, 50 and 75 days) after sowing. Foliar applications of seaweed saps were found significantly impact on nutrient content, protein content, yield and economics of soybean.Among all the treatment 15% *Kappaphycus*sap + recommended dose of nutrient (RDN) significantly higher the nitrogen (N), phosphorus (P) and potassium (K) content respectively 5.62%, 0.47% and 1.45% in seed and 1.25%, 0.17% and 1.20% in stover.The highest protein content (35.13%) and protein yield (881.30 kg ha^{-1}) was found under foliar spray of 15% *Kappaphycus*sap + RDN.The highest seed yield (25.10 q ha^{-1}) was recorded with applications of 15% *Kappa phycus*sap + RDN, followed by 15% *Gracilaria* sap + RDN (24.30 q ha^{-1}) saps resulting in an increase by 58.25% and 53.21% seed yield, respectively compared to the control (Water spray + RDN) seed yield (15.86 q ha^{-1}).The highest net return (Rs. 43320 ha^{-1}) and B:C ratio (1.70) were observed with the application of 15% *Kappaphycus*sap + RDN.

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INTRODUCTION

Soybean, *Glycine max* (L.) Merrill, is one of the richest sources of protein and can be a potential source of protein-rich food for the majority of Indian population. Soybean (*Glycine max* (L.) Merrill.) is an important nitrogen-fixing leguminous crop cultivated in several parts of the world for food and feed (Pimental *et al.*, 2006). Soybean oil, soymilk and soymeal are some of the important products of soybean.Owing to its multiplicity of use as food and industrial products, it is called as a "wonder crop". Besides it contains high level of amino acids such as Lysine, Leucine, Lecithin and large amount of phosphorus. Its oil is rich in poly-unsaturated fatty acids and contains more of linoleic acid (54%). It is two dimensional crop as it contains about 40-42 per cent high quality protein and 20-22 per cent oil. It also contains 20-30 per cent carbohydrates.

Marine algal seaweed species are often regarded as an underutilized bio resource, many have been used as a source of food, industrial raw materials and in therapeutic and botanical applications for centuries. Seaweed extracts contain major and minor nutrients, amino acids, vitamins, cytokinins, auxin and abscisic acid like growth promoting substances and have been reported to stimulate the growth and yield of plants, develop tolerance to environmental stress (Zhang *et al.*, 2003), increase nutrient uptake from soil (Turan and Kose, 2004) and enhance antioxidant properties (Verkleij, 1992). Liquid extracts obtained from seaweeds have recently gained importance as foliar sprays for many crops including various grasses, cereals flowers and vegetable species (Crouch and Van Staden, 1994). In recent years, the use of seaweed extracts have gained in popularity due to their potential use in organic and sustainable agriculture (Russo and Beryln, 1990), especially in rainfed crops, as a means to avoid excessive fertilizer applications and to improve mineral absorption. Unlike chemical fertilizers, extracts derived from seaweeds are biodegradable, nontoxic, non-polluting 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 field trials and organization of public awareness programmes (Mohanty*et al.*, 2013). Marine bioactive substances extracted from marine algae are used in agricultural and horticultural crops and many beneficial effects may be achieved in terms of enhancement of yield and quality (Pramanick *et al.*, 2013). Moreover, seaweed and seaweed-derived products have been widely used as amendments in crop production systems due to the presence of a number of plant growth-stimulating compounds. Theobjective of this study the effect of application of different concentrations of seaweed sap on nutrient content, protein content, yield and economic improvement of soybean (*G. max*) grown in rainfed fields.

MATERIALS AND METHODS

Field experiment was carried out during *Kharif*season of 2013 at Research cum Instructional Farm of Indira Gandhi KrishiVishwavidyalaya, Raipur (Chhattisgarh). The experimental site, Raipur comes under the seventh agro climatic region of India *i.e.* Eastern plateau and hills which is termed as sub humid with hot summer and cold winter. Weekly average meteorological data during the span of experimentation, recorded at meteorological observatory, IGKV, Raipur, for the year 2013. The total rainfall of 1324.3 mm was received during *kharif*seasons of 2013. The maximum temperature ranged in crop seasons was 27.9ºC to 34.4ºC during *kharif*season of 2013. The minimum temperatures during the same seasons was 21.4ºC to 25.8ºC. The Sun shines hours and wind velocity ranged from 0.7 to 8.6h day^{-1} and 2 to 11.8 km hr^{1}. The Relative humidity throughout the crop season varied between 56 to 95 %. The average weekly maximum relative humidity varied between 83 to 95 %, while, minimum relative humidity varied between 56 to 84%. The open pan evaporation mean value ranged from 2.1 to 6.2 mm day^{-1} and the vapour pressure (mm) was recorded between the rang 18 to 24.6 mm. The soil of experiment field was '*Vertisol*' (Clay) which is locally known as '*Kanhar*' with pH 7.4, EC 0.28 dsm^{-1}, Organic carbon 0.44%, Available N 200.7 kg ha^{-1}, P 40 kg ha^{-1} and K 329.28 kg ha^{-1}.The pH was analysed by Glass electrode pH meter (Piper, 1967), EC was analysed by Electrical conductivity meter (Jackson, 1973) available N was analysed by the alkaline permanganate method [Subbiah and Asija, 1956]. Phosphorus (P) was analysed by the Olsen's method (Olsen, 1954) and Potassium (K)wasanalysed by flame photometry (Hanway and Heidel, 1952). The field experiments were laid out in randomized block design (RBD) with three replications and the method of analysis of variance as described by Gomez and Gomez (1984). The level of significance used in "F" test was given at 5 per cent. There were ten treatments, which are given in Table 1. Three sprays of *Kappaphycus* and *Gracilaria* extract were applied at different growth stages after 25, 50 and 75 DAS. The quantity of water used was 500-600 liter ha^{-1}with adjuvant.The soybean variety JS 97-52 was used as test crop. The planting was done at a spacing of 30 cm x 5-8 cm. During 2013 the soybean crop was sown on 23st June 2013 and harvested on 15st October, 2013. The recommended nutrient dose of Nitrogen, Phosphorus, Potassium and Sulphur was applied @ 20:60:40:20 Kg ha^{-1}for the soybean 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.

Plant analysis

Plant samples were drawn from the randomly tagged plants of different rows of the treated plots and analyzed. Nitrogen content in seeds and stover of soybean crop at harvest was estimated. Phosphorus and potassium content were determined in the extracts after digesting the plant material with di-acid mixture of 9: 4 (HNO_3: $HClO_4$). The analysis was done by micro kjeldahl, Vanadomolybdateyellow colour and flame photometric methods for nitrogen, phosphorus and potassium, respectively. Protein content was determined by multiplying the nitrogen content of seed X correction factor (6.25).

Preparation and chemical composition of 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, T. N., 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 (20mL) with HNO_3-$HClO_4$ (10:4) di-acid mixture (20mL) and heated at 100ºC for 1 hour and then raise the temperature to about 150ºC (Richards, 1954). The chemical composition of *Kappaphycus* and *Gracilaria* saps given in Table 2 and 3.

RESULTS AND DISCUSSION

Nitrogen, phosphorus and potassium content (%) in soybean

The nitrogen, phosphorus and potassium content in soybean crop were influenced significantly due to foliar application of seaweed sap along with RDN and nutrient content was increased with increasing doses of seaweed sap (Table 4). The N, P and K content in stover higher *i.e.* 1.25%, 0.17% and 1.20%, respectively under foliar spray of 15% K Sap + RDN (T_4) which was on par with 10% K Sap + RDN (T_3), 10% G Sap + RDN (T_7) and 15% G Sap + RDN (T_8) whereas, 5% K Sap + RDN (T_2) was also on par with 15% K Sap + RDN (T_4) with respect to P and K concentration. Significantly the highest N, P and K content *i.e.* 5.62%, 0.47% and 1.45%,respectively in seed were obtained in 15% K Sap + RDN (T_4) which was comparable with 15% G Sap + RDN (T_8). However, 5% K Sap + RDN (T_2), 10% K Sap + RDN (T_3) and 10% G Sap + RDN (T_7) treatments were comparable with 15% K Sap + RDN (T_4) as regards to N content in seed. The enhancing potential of seaweeds might be attributed to the presence of potassium as a main component in the seaweed extract. These results are

Table 1: Treatment details

Different doses of spray	Spray interval (days after sowing)
T_1: 2.5% *K Sap + *RDN	25, 50 and 75 DAS
T_2: 5.0% K Sap + *RDN	25, 50 and 75 DAS
T_3: 10.0% K Sap + *RDN	25, 50 and 75 DAS
T_4: 15.0% K Sap + *RDN	25, 50 and 75 DAS
T_5: 2.5% ***G Sap + *RDN	25, 50 and 75 DAS
T_6: 5.0% G Sap + *RDN	25, 50 and 75 DAS
T_7: 10.0% G Sap + *RDN	25, 50 and 75 DAS
T_8: 15.0% G Sap + *RDN	25, 50 and 75 DAS
T_9: Water Spray+ *RDN	25, 50 and 75 DAS
T_{10}: 7.5 % K SAP+50% *RDN	25, 50 and 75 DAS

*RDN = Recommended dose of nutrients (10 t FYM + 20:60:40:20 N:P2O5:K2O:S kg ha-1); **K sap = Kappaphycus sap and ***G sap = Gracilaria sap. (red algae).

Table 2. *Chemical composition of Kappaphycus* sap

Nutrient	Amountpresent	Nutrient	Amountpresent
Moisture	94.38g/100ml	Iron	8.58mg/100ml
Protein	0.085g/100ml	Manganese	0.22mg/100ml
Fat	0.0024g/100ml	Nickel	0.35mg/100ml
Crudefibre	0.01g/100ml	Copper	0.077mg/100ml
Carbohydrate	1.800g/100ml	Zinc	0.474mg/100ml
Energy	7.54Kcal/100ml	Chromium	3.50mg/100ml
Sodium	18.10mg/100ml	Lead	0.51mg/100ml
Potassium	358.35mg/100ml	Thiamine	0.023mg/100ml
Magnesium	116.79mg/100ml	Riboflavin	0.010mg/100ml
Phosphorous	2.96mg/100ml	B-Carotene	0.0mg/100ml
Calcium	32.49mg/100ml	Iodine	160mg/100ml
Indoleaceticacid	23.36mg/L	Kinetin+Zeatin	31.91mg/L
GibberelinGA	27.87mg/L		

Datacourtesy: National Institute of Nutrition, Hyderabad, India (exceptgrowthhormonedatageneratedby CSMCRI usingquantitative MS-MS and L C-MStechniques)

Table 3: Chemical composition of *Gracilaria* sap

Nutrient	Amountpresent	Nutrient	Amountpresent
Ash	38.91g/100g	Calcium	295.50mg/100g
Crudeprotein	9.58g/100g	Copper	0.20mg/100g
Crudefibre	10.40g/100g	Zinc	1.00mg/100g
Crudelipid	2.00g/100g	Iron	67.35mg/100g
Saturatedfattyacid	48.92%oftotalfattyacids	Manganese	4.16mg/100g
Totalaminoacids	889.78mg/gofprotein	Nickel	0.92mg/100g
Moisture	88.88%	Cobalt	0.24mg/100g
VitaminC	28.50mg/100g	Sulphate	106.20mg/100g
Carbohydrate	45.92%	Chlorine	1170.00 mg/100g
Potassium	8633.00 mg/100g	Lead	1.11mg/100g
Magnesium	549.50mg/100g	Cadmium	0.14mg/100g
Phosphorus	278.50mg/100g	Sodium	158.50mg/100g

Source: (Benjama and Masniyom, 2012). *Gracilaria* extractal socontain svariable amount of phytohormones like Auxin, Cytokinin, Abscisic acidetc. (Yokoya*etal.*,2010)

Table 4: Nitrogen, phosphorus and potassium content (%) in soybean as influenced by foliar spray of seaweed saps

Treatment	Nitrogen content (%)		Phosphorus content(%)		Potassium content(%)	
	Grain	Stover	Grain	Stover	Grain	Stover
T_1: 2.5% K Sap + RDN	5.24	1.17	0.38	0.14	1.38	1.14
T_2: 5% K Sap + RDN	5.43	1.19	0.40	0.15	1.39	1.17
T_3: 10% K Sap + RDN	5.45	1.21	0.42	0.16	1.40	1.18
T_4: 15% K Sap + RDN	5.62	1.25	0.47	0.17	1.45	1.20
T_5: 2.5% G Sap + RDN	5.21	1.16	0.37	0.13	1.36	1.13
T_6: 5% G Sap + RDN	5.30	1.18	0.39	0.14	1.38	1.16
T_7: 10% G Sap + RDN	5.43	1.20	0.41	0.15	1.39	1.17
T_8: 15% G Sap + RDN	5.51	1.23	0.44	0.16	1.43	1.19
T_9: Water Spray+ RDN	5.20	1.15	0.36	0.13	1.36	1.13
T_{10}: 7.5 % K Sap + 50% RDN	5.12	1.13	0.35	0.11	1.34	1.11
SEm ±	0.09	0.02	0.01	0.01	0.01	0.01
CD (p=0.05)	0.26	0.05	0.04	0.02	0.03	0.03

closely similar with obtained by Nour *et al.* (2010) elucidate the effect of foliar spray with seaweed extracts (without, 1g l^{-1} and 2g l^{-1}) on chemical constituents of tomato plants, resulted showed that, in general, it is evident that on tomato plants spraying of seaweed extracts at a rate of 2g l^{-1} and gave the best results of N, P, K and protein content (%).

Protein content (%) and protein yield

The protein content was found significantly higher (35.13%) under foliar spray of 15% K Sap + RDN (T_4) as compared to other, but it was statistically similar to 5% K Sap + RDN (T_2), 10% K Sap + RDN (T_3), 10% G Sap + RDN (T_7) and 15% G Sap + RDN (T_8). However, protein yield was also found significantly higher (881.30 kg ha^{-1}) under foliar spray of 15% K Sap + RDN (T_4) then other, but it was at par with 15% G Sap + RDN (T_8) (Table 5).The protein content in seed increased mainly due to increase in N content in seed.Babu and Rengasamy (2012) also found that protein content increased with the application of seaweed sap on different crop due to growth hormones and micronutrient present in seaweed sap.

Seed and stover yield and harvest index

Seaweed sap of *Kappaphycus spp.* and *Gracilaria spp.* along with RDN showed the significant effect on yield, due to their application seed yield increased as per the increase in the dose of seaweed sap (Table 6). Seed and stover yield were found significantly maximum *i.e.* 25.10 q ha^{-1} and 45.63 q ha^{-1}, respectively under foliar spray of 15% K Sap + RDN (T_4) which were found at par with foliar spray of 10% K Sap + RDN (T_3), 10% G Sap + RDN (T_7) and 15% G Sap + RDN (T_8). When compared to treatment of water spray + RDN (T_9), treatments involving *Kappaphycus spp.* i.e. 2.5% K Sap + RDN (T_1), 5% K Sap + RDN (T_2), 10% K Sap + RDN (T_3), 15% K Sap + RDN (T_4) and 7.5% K Sap + 50% RDN (T_{10}) produced 9.0%, 21.67%, 33.28%, 58.25% and 6.74% more seed yield, respectively. whereas, treatments involving *gracilaria spp. i.e.* 2.5% G Sap + RDN (T_5), 5% G Sap + RDN (T_6), 10% G Sap + RDN (T_7) and 15% G Sap + RDN (T_8) registered 7.94%, 21.43%, 36.44% and 53.21% more seed yield, respectively, as compared with water spray + RDN (T_9). Increase in yield and yield attributes may be due to the presence of plant growth regulators (indole 3 acetic acid, gibberellins GA_3, kinetin and zeatin) present in *K. alvarezii*sap (Zodape *et al.*, 2011). Growth hormones like cytokinin and gibberellins along with other trace element have been detected in the extract of*Kappaphycus spp.* and *Gracilaria spp.* which might be responsible for beneficial effects in the present study. Rathore *et al.* (2009) observed that the highest grain yield was recorded with application of 15% seaweed extract, followed by 12.5% seaweed extract that resulted in 57% and 46% increase, respectively compared to the control and the maximum straw yield was also achieved with 15% seaweed extract application. De *et al.* (2013) reported that application of Biozyme (seaweed) + RDF increase yield (14.65%) in onion. Pramanick *et al.* (2013) reported that the treatment T4(15% *Kappaphycus*-sap + RDN) showed the maximum increase in yield over control to the extent of 38.97% and this treatment was followed by the treatments T8(15% *Gracilaria*- sap + RDN), T3 (10% *Kappaphycus*- sap + RDN), T7 (10% *Gracilaria*- sap + RDN), T2 (5% *Kappaphycus*- sap + RDN) and T6 (5% *Gracilaria*-sap + RDN) recording 33.58, 27.28, 21.17, 19.77 and 13.86% yield increase, respectively over control. Similar kind of results was reported for *Phaseolus aureus* (Bai *et al.,* 2008). Increase in yield of several other crops like *Capsicumannuum*(Arthur *et al.,* 2003), black gram (Venkataraman and Mohan, 1997) and canola plants (*Brassica napus*) (Ferreira and Lourens, 2002) are reported with the foliar application of seaweed extract. Foliar application of aqueous extract gives positive result on the growth and yield of pea and black gram (Ramamoorthy *et al.*, 2006 a, b, 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

Table 5: Protein content and yield of soybean as influenced by foliar spray of seaweed saps

Treatment	Protein content (%)	Protein yield (kg ha^{-1})
T_1: 2.5% K Sap + RDN	32.77	564.26
T_2: 5% K Sap + RDN	33.92	654.39
T_3: 10% K Sap + RDN	34.04	746.24
T_4: 15% K Sap + RDN	35.13	881.30
T_5: 2.5% G Sap + RDN	32.58	559.63
T_6: 5% G Sap + RDN	33.13	636.06
T_7: 10% G Sap + RDN	33.96	734.37
T_8: 15% G Sap + RDN	34.46	-835.98
T_9: Water Spray+ RDN	32.52	515.94
T_{10}: 7.5 % K Sap + 50% RDN	32.02	543.57
SEm ±	0.56	36.83
CD (p=0.05)	1.66	109.44

Table 6: Yield of soybean as influenced by foliar spray of seaweed saps

Treatment	Seed yield(q ha^{-1})	Stover yield(q ha^{-1})	Harvest index (%)
T_1: 2.5% K Sap + RDN	17.29	34.76	33.28
T_2: 5% K Sap + RDN	19.30	35.25	35.39
T_3: 10% K Sap + RDN	21.92	39.11	35.91
T_4: 15% K Sap + RDN	25.10	45.63	35.77
T_5: 2.5% G Sap + RDN	17.12	35.72	32.40
T_6: 5% G Sap + RDN	19.26	34.55	35.76
T_7: 10% G Sap + RDN	21.64	40.42	34.89
T_8: 15% G Sap + RDN	24.30	41.91	36.77
T_9: Water Spray+ RDN	15.86	32.58	32.80
T_{10}: 7.5 % K Sap + 50% RDN	16.93	32.53	34.03
SEm ±	1.23	2.22	2.03
CD (p=0.05)	3.66	6.59	NS

Table 7: Economics of soybean crop as influenced by foliar spray of seaweed saps

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 + RDN	19865	47727	27862	1.40
T_2: 5% K Sap + RDN	20990	52933	31943	1.52
T_3: 10% K Sap + RDN	23240	60018	36778	1.58
T_4: 15% K Sap + RDN	25490	68810	43320	1.70
T_5: 2.5% G Sap + RDN	19865	47400	27535	1.39
T_6: 5% G Sap + RDN	20990	52752	31762	1.51
T_7: 10% G Sap + RDN	23240	59432	36192	1.56
T_8: 15% G Sap + RDN	25490	66390	40900	1.60
T_9: Water Spray+ RDN	18740	43868	25128	1.34
T_{10}: 7.5 % K Sap + 50% RDN	20046	46585	26539	1.32

of *Kappaphycusspp*increase the yield of tomato. The harvest index was not found significant in each and all treatments.

Effect of Seaweed sap on economics of soybean crop

Data related with economics was computed and embodied in Table 7. The cost of cultivation of soybean crop was varied from Rs. 18740 to Rs. 25490 ha^{-1} owing to the use of different level of foliar spray of seaweed sap along with RDN, showed beneficial effect on monitory return of soybean crop production. The application of foliar spray of 15% K Sap + RDN (T_4) gave maximum gross return (Rs 68,810), net return (Rs. 43,320) and B:C ratio of 1.70, this was followed by 15% K Sap + RDN (T_8). Application of seaweed extract enhanced the early growth and yield attribute properties in legume plants and yield return 12-25% more than that of control (Sethi and Adhikary, 2008).

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