The Bioscan 10(1): 479-483, 2015 (Supplement on Agronomy)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

IMPACT OF SEAWEED SAPS ON GROWTH, FLOWERING BEHAVIOR AND YIELD OF SOYBEAN [*GLYCINE MAX* (L.) MERRILL.]

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KEYWORDS
Seaweed saps
Kappaphycus
Gracilaria
Growth
Flowering behavior
Yield of Soybean

Received on :
05.12.2014

Accepted on :
19.02.2014

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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 growth, flowering behavior and yield 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 extracts (namely *Kappaphycus* and *Gracilaria*) at different days (25, 50 and 75 days) after sowing. Foliar applications of seaweed extract were found significantly impact on growth, flowering behavior and yield. Among all the treatments 15% *Kappaphycus* sap + recommended dose of nutrient (RDN) increased the plant height (90.50 cm), dry matter accumulation (40.32 g plant^{-1}), pod setting index (87.35 %), number of pods plant^{-1} (93.43) and 100 seed weight (10.37g). The lowest number of drop flower plant^{-1} (13.3) was obtained under treatment 15% K sap + RDN (T_4). The highest seed yield (25.10 q ha^{-1}) was recorded with applications of 15% *Kappaphycus* sap + RDN, followed by 15% *Gracilaria* sap + RDN (24.30 q ha^{-1})extract 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}).

INTRODUCTION

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. It is one of the important and cheapest sources of vegetable proteins and oils. 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. The protein quality of soybean is equivalent to that in meat, milk products and eggs. Other fractions and derivatives of the seed have substantial economic importance in a wide range of industrial, food, pharmaceutical and agricultural products (Smith and Huyser, 1987). 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. The effective study on seaweeds sap especially *Kappaphycus* sap *and Gracilaria* sap in agriculture and as a source of biofertilizer was chosen for crops grown extensively throughout India. The main objective of this study the impact of application of different concentrations of seaweed sap on growth, flowering behavior and yield of soybean (*G. max*) grown in fields.

MATERIALS AND METHODS

Field experiment was carried out during *Kharif* season of 2013 at Research cum Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya, 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 27.9 ^{0}C to 34.4 ^{0}C during *kharif* season of 2013. The minimum temperatures during the same seasons was 21.4 ^{0}C to 25.8 ^{0}C. The Sun shines hours and wind velocity ranged from 0.7 to 8.6 hr 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)was analysed 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.

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. 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 400°C 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 100°C for 1 hour and then raise the temperature to about 150°C (Richards, 1954).

RESULTS AND DISCUSSION

Growth and yield attributing character of soybean crop

Different doses of seaweed extract along with recommended dose of fertilizer showed the significant effect on growth, flowering behavior and yield attributes *viz.* plant height (cm), dry matter accumulation (g) plant^{-1}, flowering and podding behavior, pod setting index, pods plant^{-1}, seeds pod^{-1} and seeds plant^{-1} which is embodied in Table 4. From data recorded, plant height (cm) was found significantly higher i.e. 90.50 cm under foliar spray of 15% K Sap + RDN (T_4), however, it was found statistically at par with foliar spray of 10% K Sap + RDN (T_3) and 15% G Sap + RDN (T_8). The maximum plant height is due to the seaweed extracts contains major and minor nutrients, amino acids, vitamins, cytokinins, auxin and abscisic acid like growth promoting substances (Mooney and Van Staden, 1986). Similar results were obtained in soybean by Rathore *et al.* (2009), in *Cajanus cajan* (L.) Millsp., by Mohan *et al.* (1994), in *Vigna sinensis* L. by Sivasankari *et al.* (2006) and in green gram by Pramanick *et al.* (2013). The data pertaining to dry matter accumulation (g) plant^{-1} was found significantly higher *i.e.* 40.32 g under foliar

Table 1: Treatment Details

Treatment			Spray days after sowing (DAS)
T1	:	2.5 % **K sap + *RDN	25, 50 and 75
T2	:	5 % K sap + RDN	25, 50 and 75
T3	:	10 % K sap + RDN	25, 50 and 75
T4	:	15 % K sap + RDN	25, 50 and 75
T5	:	2.5 % ***G sap + RDN	25, 50 and 75
T6	:	5 % G sap + RDN	25, 50 and 75
T7	:	10 % G sap + RDN	25, 50 and 75
T8	:	15 % G sap + RDN	25, 50 and 75
T9	:	Water spray + RDN	25, 50 and 75
T10	:	7.5 % K sap+50% RDN	25, 50 and 75

*RDN = Recommended dose of nutrients (10 t FYM + 20:60:40:20 N:P_2O_5:K_2O:S kg ha^{-1}); **K sap = *Kappaphycus* sap and ***G sap = *Gracilaria* sap. (red algae).

Table 2: Chemical composition of Kappaphycus sap

Nutrient	Amount present	Nutrient	Amount present
Moisture	94.38 g/100 mL	Iron	8.58 mg/100 mL
Protein	0.085 g/100 mL	Manganese	0.22 mg/100 mL
Fat	0.0024 g/100 mL	Nickel	0.35 mg/100 mL
Crude fibre	0.01 g/100 mL	Copper	0.077 mg/100 mL
Carbohydrate	1.800 g/100 mL	Zinc	0.474 mg/100 mL
Energy	7.54 Kcal/100 mL	Chromium	3.50 mg/100 mL
Sodium	18.10 mg/100 mL	Lead	0.51 mg/100mL
Potassium	358.35 mg/100 mL	Thiamine	0.023 mg/100 mL
Magnesium	116.79 mg/100 mL	Riboflavin	0.010 mg/100 mL
Phosphorous	2.96 mg/100 mL	B-Carotene	0.0 mg/100 mL
Calcium	32.49 mg/100 mL	Iodine	160 mg/100 mL
Indole acetic acid	23.36 mg/L	Kinetin + Zeatin	31.91 mg/L
Gibberelin GA	27.87 mg/L		

Data courtesy: National Institute of Nutrition, Hyderabad, India (except growth hormone data generated by CSMCRI using quantitative MS-MS and LC-MS techniques)

Table 3: Chemical composition of *Gracilaria* sap

Nutrient	Amount present	Nutrient	Amount present
Nutrient	Amount present	Nutrient	Amount present
Ash	38.91 g/100 g	Calcium	295.50 mg/100 g
Crude protein	9.58 g/100 g	Copper	0.20 mg/100 g
Crude fibre	10.40 g/100 g	Zinc	1.00 mg/100 g
Crude lipid	2.00 g/100 g	Iron	67.35 mg/100 g
Saturated fatty acid	48.92% of total fatty acids	Manganese	4.16 mg/100 g
Total amino acids	889.78 mg/g of protein	Nickel	0.92 mg/100 g
Moisture	88.88%	Cobalt	0.24 mg/100g
Vitamin C	28.50 mg/100 g	Sulphate	106.20 mg/100 g
Carbohydrate	45.92%	Chlorine	1170.00 mg/100g
Potassium	8633.00 mg/100 g	Lead	1.11 mg/100 g
Magnesium	549.50 mg/100 g	Cadmium	0.14 mg/100 g
Phosphorus	278.50 mg/100 g	Sodium	158.50 mg/100 g

Source: (Benjama and Masniyom, 2012). *Gracilaria* extract also contains variable amount of phytohormones like Auxin, Cytokinin, Abscisic acid etc. (Yokoya *et al.,* 2010)

spray of 15% K Sap + RDN (T_4), however, it is found statistically at par with foliar spray of 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). This is due to increase in plant height and branches plant^{-1} helped in increasing the dry matter accumulation plant^{-1}. The similar findings have been reported in green gram by Pramanick *et al.* (2013) and in *Arachis hypogea* L. by Selvam and Sivakumar (2014).

The number of flower drop plant^{-1} was observed significantly higher i.e.24.7 under the treatment of water spray + RDN (T_9), however, it was found statistically at par with 7.5% K sap + 50% RDN (T_{10}), 2.5% G sap + RDN (T_5), 2.5% K sap + RDN (T_1), 5% G sap + RDN (T_6) and 10% G sap + RDN (T_7). The lowest number of drop flower plant^{-1} (13.3) was obtained under treatment 15% K sap + RDN (T_4). This behaviour might be due to seaweed sap contain of high cytokines activity, which could be responsible for the many effects such as plant growth, flowering and chemical constituents (Brain *et al.*, 1973). Cytokines are active at very low concentrations and regulate a number of plant functions including cell division (Koda and Okazawa, 1983). Sarhan and Ismael (2014) and El-Yazied *et al.* (2012) have also reported the similar findings.Whereas, the highest number of pod plant^{-1} i.e.93.43 were observed under the treatment 15% K sap + RDN (T_4), which was at par with 15% G sap + RDN (T_8) and 10% K sap + RDN (T_3). The treatment 15% K sap + RDN (T_4) also gave the highest pod setting index i.e. 87.35% which was at par with 15% G sap + RDN (T_8). Seeds pod^{-1} and 100- seed weight were also found significantly maximum i.e. 3.03 and 10.37 g, respectively under foliar spray of 15% K Sap + RDN (T_4) which was found at par with foliar spray of 15% G Sap + RDN (T_8) and 10% K sap + RDN (T_3) in both observation. Seeds plant^{-1} was also found significantly maximum *i.e.* 284.91 under foliar spray of 15% K Sap + RDN (T_4) which was found at par with foliar spray of 15% G Sap + RDN (T_8), growth and yield attributing character was found to be lowest under treatment water spray + RDN (T_9). The foliar spray of seaweed sap during important growth stages of soybean crop, increased their metabolism activity and act as growth stimulant for healthy plant development. Increase in 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). The increased yield attributes may be due to the presence of some growth promoting substances such as IAA and IBA, gibberellins, cytokinins, micronutrients, vitamins and amino acids (Challen and Hemingway, 1965). Growth hormones like cytokinin and gibberellins have been detected in the extract of K sap and G sap which might be responsible for beneficial effects in the present study. Significant increase in seed yield of black gram (Venkataraman and Mohan, 1997) and marketable bean by 24% has been reported with the foliar application of seaweed extract (Temple and Bomke, 1989). Similar result was reported by Pramanick *et al.*, (2013), who noticed maximum numbers of pods plant^{-1} and seeds pod^{-1} in green gram were observed under the treatment foliar application of 15% *Kappaphycus* sap along with RDN (T_4)

Table 4: Effect of seaweed sap on growth, flowering and podding behavior, yield attributing character and yield of soybean crop

Treatment	Plant height (cm)	Dry matter accumulation (g) plant^{-1}	Flower drops plant-1 (No.)	Pod setting index (%)	Pods plant^{-1} (No.)	Seeds pod^{-1} (No.)	Seeds plant^{-1} (N0.)	100 – seed weight (g)	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
2.5 % K sap + RDN	80.33	30.34	22.0	74.46	63.87	2.30	145.80	9.45	17.29	34.76	33.28
5 % K sap + RDN	82.92	33.53	20.0	77.16	68.20	2.43	167.71	9.66	19.30	35.25	35.39
10 % K sap + RDN	83.58	35.17	19.0	80.87	79.83	2.60	207.81	9.81	21.92	39.11	35.91
15 % K sap + RDN	90.50	40.32	13.3	87.35	93.43	3.03	284.91	10.37	25.10	45.63	35.77
2.5 % ***G sap + RDN	79.92	30.42	23.0	71.85	59.43	2.27	134.67	9.41	17.12	35.72	32.40
5 % G sap + RDN	80.17	32.25	22.0	75.15	66.70	2.40	159.34	9.64	19.26	34.55	35.76
10 % G sap + RDN	82.78	33.53	20.7	78.80	78.03	2.50	198.12	9.78	21.64	40.42	34.89
15 % G sap + RDN	89.33	39.35	15.7	84.84	88.17	2.97	261.03	10.29	24.30	41.91	36.77
Water spray + RDN	79.30	29.53	24.7	67.69	52.44	2.20	114.56	9.22	15.86	32.58	32.80
7.5 % K sap+50% RDN	76.89	28.92	24.3	70.17	57.53	2.23	129.26	9.32	16.93	32.53	34.03
SEm ±	2.46	2.34	1.42	1.89	4.62	0.14	19.57	0.20	1.23	2.22	2.03
CD(p = 0.05)	7.30	6.95	4.24	5.61	13.72	0.43	58.13	0.58	3.66	6.59	NS

which was closely followed by 15% *Gracilaria* - sap + RDN (T_8) .

Yield of soybean crop

Seaweed sap of *kappaphycus spp.* and *gracilaria spp.* along with RDN showed the significant effect on yield, due to their application seed yield increase as per the increase dose of seaweed sap (Table 4). Seed yield (q ha^{-1}) and stover yield (q ha^{-1}) were also found significantly maximam 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) in both case of yield. As compare to treatment water spray + RDN (T_9), seaweed sap of the *Kappaphycus spp.* foliar spray treatment along with RDN 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%, 38.20%, 58.25% and 6.74% more seed yield, respectively. However, seaweed sap of the *gracilaria spp.* treatment along with RDN *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) also produced 7.94%, 21.43%, 36.44% and 53.21% more seed yield as compare with water spray + RDN (T_9), respectively. 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 applications of 15% seaweed extract, followed by 12.5% seaweed extract that resulted in 57% and 46% increases respectively compared to the control and the maximum straw yield was also achieved with 15% seaweed extract application. Similarly De *et al.,* (2013) reported that application of Biozyme (seaweed) + RDF increase yield (14.65%) in onion. Foliar application of aqueous extract of 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 of *Kappaphycus spp* increase the yield of tomato. The harvest index was not found significant in each and all treatments.

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