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Influence of Sea Weeds Extracts on the Growth, Quality and Productivity of Sesame (*Sesamum indicum*) in the Red and Lateritic Belt of West Bengal

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ABSTRACT

An experiment was carried out during *pre-kharif* season of 2012 at Agricultural farm of Palli Siksha Bhavana, Visva-Bharati, Sriniketan, West Bengal. The experiment consisted of thirteen treatment combinations comprising of four concentrations of liquid extracts of two different sea weed species namely *Kappaphycus* (K) and *Gracilaria* (G) combined different levels of fertilizer which were replicated thrice and was laid out in complete randomized block design (CRBD). The Recommended dose of fertilizer (RDF) was 80:40:40 kg/ha of N:P_2O_5:K_2O. The plant growth, yield and economics were significantly improved by application of the *Gracilaria* extract over that of the water applied plots. The application of seaweed extract along with 100% recommended dose through fertilizers also paid higher gross and net returns, return per rupees invested from summer sesame cultivation. So, use of seaweed extract proved beneficial in terms of improved growth, quality and economics of summer sesame cultivation in red and lateritic soil of West Bengal.

Keywords: *Gracilaria, Kappaphycus,* sea weed extracts, Sesame

Sesame (*Sesamum indicum* L.) commonly known as sesame or til or gingelly belongs to the family Pedaliaceae. This is regarded to be the oldest oil-yielding crop known to man. Sesame occupies well over 32.5 per cent of total acreage and contributes about 21.3 per cent of total output of the world. In India, sesame is grown on an area of 15.85 lakh hectares with an annual production of 5.34 lakh tonnes. The average yield of sesame in India is very low that is 356 kg per ha (Anon. 2010-11). It is cultivated on a large area in the states of india. In Karnataka, it is grown on an area of 0.73 lakh hectares with an annual production of 0.33 lakh tones with a productivity of around 400 kg per ha. In India, sesame ranks third in area and production after groundnut and mustard. In West Bengal the production of sesame was 3.56 lakh tones in the year 2010-11 and sesame is one of the important oilseed crops in Indian Agriculture. The seeds are rich source of food, nutrition, edible oil and bio-medicine. Sesame oil has excellent nutritional, medicinal, cosmetic and cooking qualities for which it is known as 'the queen of oils seed'. Due to the presence of potent antioxidants, sesame seeds are called as 'the seeds of immortality'. Sesame cake

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or meal obtained as a by-product of the oil milling industry is rich in protein, vitamin (*Niacine*) and minerals (Ca and P). India ranks first in area (29%), production (26%) and export (40%) of sesame in the world. The sea weed was around 434 species of red seaweeds, 194 species of brown seaweeds and 216 species of green seaweeds naturally occur in India; it was only until the beginning of the twenty-first century that the country made any concrete progress towards organized seaweed farming. Although the commercial potential of *Kappaphycus alvarezii* had been previously recognized and its culture technology had been perfected by the Central Salt and Marine Chemicals Research Institute (CSMCRI), culture at a commercial scale only began when PepsiCo India Holdings Ltd (PepsiCo) made its entry into the venture with a pilot-scale investment in the early 2000s. The entry of PepsiCo turned out to be decisive, acting as a catalyst to rejuvenate the industry-institutional linkages. Shah *et al*. (2012) reported that the concept of Self Help Groups (SHG) spearheaded by the National Bank for Agricultural and Rural Development (NABARD). Seaweed extracts have been marketed for several years as fertilizer additives and beneficial results from their use have been reported (Booth, 1965). Seaweed extract is definitely capable of promoting growth in both higher plants and prokaryotic organisms (Venkataraman and Mohan, 1994). These extracts have increased the yield of crops, seed germination, resistance to frost and fungal and insect attacks and uptake of inorganic constituents. Similar works have been reported in Potato, which is one of the most important cash crops amongst vegetables, being grown almost all over the world Pramanick *et al.* (2012) Shankar *et al.* (2015) reported the effect of seaweed liquid fertilizers obtained from *Kappaphycus* extract (K) and *Gracilaria* extract (G) on different crop .

MATERIALS AND METHODS

A field experiment was conducted at the Agricultural farm, Palli Siksha Bhavana (Institute of Agriculture), Visva Bharati, Sriniketan, during summer season of 2012. The farm is situated at 23°39 North latitude and 87°42 East longitudes and at an average altitude of 58.9 m above the mean sea level (MSL) in western part of South Bengal. This farm is located in the sub humid, subtropical belt. There were Thirteen treatments namely; T_1 (Control + RDF), T_2 (5% K + 100% RDF), T_3 (7.5% K + 100% RDF), T_4 (10% K + 100% RDF), T_5 (15% K + 100% RDF), T_6 (5% G + 100% RDF), T_7 (7.5% G + 100% RDF), T_8 (10% G + 100% RDF), T_9 (15% G + 100% RDF), T_{10} (7.5% K + 75% RDF), T_{11} (7.5% G + 75% RDF), T_{12} (7.5% K + 50% RDF) and T_{13} (7.5% G + 50% RDF) were designed in CRBD replicated thrice. The fertilizers were applied considering 80:40:40 kg of $N:P_2O_5:K_2O$ ha^{-1} as recommended dose other than decomposed organic manure. The sources of fertilizers were urea for N; Single super phosphate (SSP) for P and Muriate of potash (MOP) for K. Half dose of N and full dose of Pand K were applied as basal dose before sowing of seeds. The remaining half of nitrogen was applied as top dressing at 35 days after sowing i.e. at branching stage. Irrigation a light irrigation was given just after sowing (3 DAS) to facilitate germination since there was moisture shortage at the time of sowing. Thereafter, four irrigations were given to the crop at days after sowing i.e. pre-sowing, pre-flowering, flowering and capsule formation stage, respectively. Other cultural practices were taken care as and when necessary. Sap Spray the sea weed saps of *Kapphaphycus* and *Gracilaria* as per treatments were sprayed in the sesame field on 30, 40 and 50 DAS. The concentration of sap application varied from 5.0%, 7.5%, 10% and 15% (v/v basis) as per treatments using water @ 600 l ha^{-1} in each spray. The water spray in the control plot was also done on the same days with the same amount of water. Adjuvant was mixed in the tanks before spraying. In the laboratory the oil content in sesame seed was estimated after the extraction of oil from the seeds with the help of Soxhlet's oil extraction apparatus (AOAC 1997)

RESULTS AND DISCUSSION

Growth

The data recored at harvest stage which is presented in Table 1, the maximum plant height (112.6 cm) was recorded in the treatment T_9 (15 % *Gracilaria* + 100% RDF) which gave statistically at par T_7 (7.5% *Gracilaria* + 100% RDF), T_8 (10% *Gracilaria* + 100% RDF), T_4 (10% *Kappaphycus* + 100% RDF), T_5 (15% *Kappaphycus* + 100% RDF) and T_6 (5% *Gracilaria* + 100% RDF). The highest dry matter (236.6 g/m^2) was recorded in the treatment T_9 where 15% *Gracilaria*

along with 100% RDF and it was statistically at par with 10% *Gracilaria along* 100% RDF and significantly higher than all other treatments. The lowest dry matter (112.2 g/m^2) production was recorded in T_1 (Water + RDF). Due to maximum plant height and branching directly affect in dry mater with maturity of different crops which was reported by Benjama *et al.* (2011 & 2012) also woke on dry matter production, However, results of the present study were in conformity with the study of Pramanick *et al.* (2012). Whereas, the highest leaf area index (2.85) at 60 DAS was recorded and the treatment T_9 and T_5 where 15% *Gracilaria* and *Kappaphycus* along with 100% RDF was applied which was statistically at par with 10% *Kappaphycus* + 100% RDF, 5% *Gracilaria* + 100% RDF, 7.5% *Gracilaria*+ 100% RDF, and 10% *Gracilaria* + 100% RDF and significantly higher than all other treatments. The lowest leaf area index (1.72) was recorded in T_1 *i.e.* Water + RDF which was statistically at par with both 7.5 % *Kappaphycus* and *Gracilaria* along with 75% RDF and 50% RDF respectively.

Table 1: Effect of seaweed extracts on growth of Sesame at different growth stages

Treatments	Plant height (cm)	Dry matter (g/m^2)	Leaf Area Index
T_1: Water + RDF	87.3	112.2	1.72
T_2: 5 % K+ 100% RDF	98.1	140.8	2.00
T_3: 7.5% K + 100% RDF	103.1	149.6	2.40
T_4: 10 % K + 100% RDF	104.4	160.5	2.70
T_5: 15 % K + 100% RDF	103.7	173.2	2.85
T_6: 5 % G + 100% RDF	104.2	180.8	2.33
T_7: 7.5% G + 100% RDF	104.6	202.5	2.73
T_8: 10 % G + 100% RDF	106.4	226.7	2.80
T_9: 15 % G + 100% RDF	112.6	236.6	2.85
T_{10}: 7.5 % K + 75% RDF	100.9	136.2	1.90
T_{11}: 7.5 % G + 75% RDF	102.8	138.3	1.92
T_{12}: 7.5 % K + 50% RDF	101.3	134.4	1.88
T_{13}: 7.5 % G + 50% RDF	102.3	136.3	1.91
S Em(±)	3.1	7.40	0.09
CD at 5 %	9.1	21.59	0.26
CV (%)	5.3	7.8	6.8

*Recommended dose of fertilizer (**RDF**), Gracilaria (**G**), Kappaphycus (**K**).*

Yield

The observation on seed yield, stick yield and harvest index of sesame were presented in Table 2. Combined application of 100% recommended dose of fertilizer and along with 15% *Gracilaria* produced the maximum yield of 1170.0 kg/ha and it was significantly superior to all other treatments. The increased seed yield due to integrated application of seaweed extracts and inorganic sources was mainly responsible for improved growth attributes like crop growth rate during the vital period of seed filling that result in greater number of capsules per plant, seeds per capsules and higher test weight and ultimately increased seed yield over water + RDF was recorded as the lowest. Seed yield from each plot recorded at maturity of the crop was statistically analyzed. The treatment T_1 having lowest Seed yield (603.3 kg/ha) of pre-*kharif* sesame was due to poor growth of the crop under study. The seed yield of *pre-kharif* sesame increased markedly due to application of sea weed extracts over the yield obtained in water spray has been done. The maximum stick yield (2904.7 kg/ha) was recorded in (T_9) 15% *Gracilaria* + 100% RDF and it was statistically at par with T_4: (10% *Kappaphycus* + 100% RDF), T_5: (15 % *Kappaphycus* + 100% RDF), T_6:(5% *Gracilaria* + 100% RDF), T_7: (7.5 % *Gracilaria* + 100% RDF), T_8: (10 % *Gracilaria* + 75% RDF). Like seed yield, the lowest straw yield of sesame (1817.7 kg/ha) was recorded in the (T_1) Water + RDF. The result indicated that, when sea weed extract were added to higher doses of fertilizers, there was probably better availability of nutrients which might have resulted in better growth and ultimately resulted in better seed and straw yield. The harvest index did not vary significantly among the different fertility treatments under study. The water plots recorded relatively lowest harvest index. Harvest index (24.92%) due to poor growth rate of the crop receiving no added nutrient and it was statistically at par with, T_{10} (7.5% *Kappaphycus* + 75 % RDF), & T_{11} (7.5 % *Gracilaria* + 75 % RDF). The highest harvest index (28.71) was found in treatment T9 (28.71) where 15% *Gracilaria* + 100% RDF was applied and it was statistically at par with T_8 (10% *Gracilaria* +100%RDF), T_7 (7.5 % *Gracilaria* + 100 % RDF), T_6 (5% *Gracilaria* +100 % RDF), T_5 (15% *Kappaphycus* +100 % RDF), T_2 (5% *Kappaphycus* +100 % RDF), T_3 (7.5% *Kappaphycus* +100 % RDF), T_4 (10% *Kappaphycus* +100 % RDF). The harvest index did not vary significantly among the different treatments because both seed and stick yield followed similar trend and respond similarly to the applied nutrients. The present findings were

confirmed with the results obtained by Shah *et al.* (2012) on yield and productivity, Pramanik *et al.* (2012) and Shankar *et al.* (2015).

Table 2: Effect of seaweed extracts yield of sesame

Treatments	Seed yield (kg/ha)	Stick yield (kg/ha)	Harvest index (%)
T_1 : Water + RDF	603.3	1817.7	24.9
T_2 :5 % K+ 100% RDF	890.0	2380.0	27.2
T_3 :7.5% K + 100% RDF	910.7	2390.3	27.5
T_4 :10 % K + 100% RDF	990.1	2560.0	27.8
T_5 :15 % K + 100% RDF	1041.3	2633.1	28.3
T_6 :5 % G + 100% RDF	1040.3	2652.9	28.1
T_7 :7.5% G + 100% RDF	1060.0	2670.2	28.4
T_8 :10 % G + 100% RDF	1077.4	2690.3	28.6
T_9 :15 % G + 100% RDF	1197.0	2904.6	29.1
T_{10} :7.5 % K + 75% RDF	855.0	2325.1	26.8
T_{11} :7.5 % G + 75% RDF	869.7	2355.0	26.9
T_{12} :7.5 % K + 50% RDF	835.3	2326.6	26.4
T_{13} :7.5 % G + 50% RDF	850.0	2360.0	26.4
S Em(±)	39.76	135.0	0.7
CD at 5 %	116.0	394.3	2.0
CV (%)	7.3	9.4	4.4

Recommended dose of fertilizer (RDF), Gracilaria (G), Kappaphycus (K).

Oil content and yield

The data of oil content and oil yield were presented in the Table 3. The oil content of *pre-kharif* sesame increased specifically due to application of sea weed extracts over the T_1 (water+ RDF). The application of 100% recommended dose of fertilizer along with 15% *Gracilaria* (T_9) produced the highest oil content (46.6 %) and it was significantly superior to all other treatments but there were no significant differences in respect of oil content among them. The water + RDF was recorded the lowest oil content (44.9%) of *pre-kharif* sesame due to poor growth of the crop under study. It was significantly lower than all other treatments except the treatments. According to Rathore *et al.* (2009) by the application of sea weed extract, its improving nutrient uptake like N, P, K and S, where oil content is directly effected due to sulphur and its oil yield. The lowest oil yield (271.1 kg/ha) of *pre-kharif* sesame due to poor growth of the crop under study. Combined application of 100% recommended dose of fertilizer and along with 15% *Gracilaria* produced the highest oil yield of (557.6 kg/ha) and it was significantly superior to all other treatments and which was statistically at par with T_7 (7.5% *Gracilaria* + 100% RDF) and T_8 (10 % *Gracilaria* + 100% RDF) respectively significantly higher than all other treatment. The water + RDF (T_1) recorded the lowest oil yield of *pre-kharif* sesame. This might be due to Increase in biochemical properties like amino acid, and mineral some other element contents which indirectly effect on the oil content. as well as it promotes the oil yield by application of seaweed extract along with fertilizer (Sivasankari *et al.* 2006). Increase on yield and biochemical constituents and also similar result was reported by Kumar *et al.* (2012).

Table 3: Effect of seaweed extracts on quality of sesame crop

Treatment	Oil content (%)	Oil yield (Kg/ha)
T_1 : Water + RDF	44.9	271.1
T_2 :5 % K+ 100% RDF	45.0	400.7
T_3 :7.5% K + 100% RDF	45.4	413.2
T_4 :10 % K + 100% RDF	45.9	454.3
T_5 :15 % K + 100% RDF	46.3	481.7
T_6 :5 % G + 100% RDF	45.1	468.9
T_7 :7.5% G + 100% RDF	46.2	489.2
T_8 :10 % G + 100% RDF	46.4	499.5
T_9 :15 % G + 100% RDF	46.6	557.7
T_{10} :7.5 % K + 75% RDF	45.8	391.6
T_{11} :7.5 % G + 75% RDF	46.2	401.7
T_{12} :7.5 % K + 50% RDF	45.4	379.2
T_{13} :7.5 % G + 50% RDF	45.5	386.7
S Em(±)	2.3	23.5
CD at 5 %	NS	68.8
CV (%)	8.9	9.4

*Recommended dose of fertilizer (**RDF**), Gracilaria (**G**), Kappaphycus (**K**).*

Economies

The economics of the *pre-kharif* sesame cultivation was estimated in consultation with the available market price of various input and outputs. The gross return (₹/Ha), net return (₹/Ha), and return per rupee invested (₹/Ha) have been worked out and presented in the Table 4. The T_9 (15% *Gracilaria* + 100% RDF) recorded the maximum gross return net return of sesame cultivation was ₹ 61012 and ₹ 39468 respectively and 15% *Gracilaria* along 100% RDF having highest return per rupee invested of ₹ 1.83, where both seaweed extract with different doses

of RDF recorded highest among all the treatments which was closely followed by 1.80, 1.76 and 1.74. The seed and biological yields of sesame increased significantly increased with the inclusion of seaweed extract and maximum benefit was recorded with the combined application of the two different sources of seaweed extract. Seaweed liquid has been found to be of great economic value in food crop production. Whereas similar result was conformity with Bai *et al*. (2011) and Panda *et al*. (2012) reported that at higher percentage of *Gracilaria* concentration increase yield which dircetly proportational to the economically valuable of crop.

Table 4: Effect of seaweed extracts on economics of sesame

Treatment Levels	Gross Return (₹)	Net Return (₹)	Return/₹ invested
T_1 : Water + RDF	30894	13310	0.76
T_2 :5 % K+ 100% RDF	45452	26518	1.40
T_3 :7.5% K + 100% RDF	46490	26906	1.37
T_4 :10 % K + 100% RDF	50531	30307	1.50
T_5 :15 % K + 100% RDF	53120	31576	1.47
T_6 :5 % G + 100% RDF	53078	34144	1.80
T_7 :7.5% G + 100% RDF	54068	34485	1.76
T_8 :10 % G + 100% RDF	54946	34858	1.74
T_9 :15 % G + 100% RDF	61012	39468	1.83
T_{10} :7.5 % K + 75% RDF	43680	25122	1.35
T_{11} :7.5 % G + 75% RDF	44426	25868	1.39
T_{12} :7.5 % K + 50% RDF	42697	25165	1.44
T_{13} :7.5 % G + 50% RDF	43444	25912	1.48
S Em(±)	1901	982	0.06
CD at 5 %	5550	2868	0.19
CV (%)	6.9	5.9	7.5

Recommended dose of fertilizer (RDF), Gracilaria (G), Kappaphycus (K).

CONCLUSION

From the above results it may be concluded that in *pre-kharif* sesame the seaweed extracts are effective in increasing the growth parameters, yield, economics and vis-à-vis quality of sesame.. Presence of micro-elements and plant growth regulators hormones in *Kappaphycus* and *Gracilaria* extracts is probably responsible for the increased yield and improved nutrition of sesame receiving through foliar application of the extracts. Application of seaweed extract along with 100% recommended dose of fertilizers also showed higher growth and productivity of sesame as compared to all other treatments and paid higher gross return, net returns and return per rupees invested from *pre-kharif* sesame cultivation. Use of seaweed extract particularly improved the oil content in the seeds and oil production.

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