Available online at: www.mbai.org.in doi:10.6024/jmbai.2021.63.1.2244-17

Mulching brown seaweed *Sargassum wightii* during transplant on the growth and yield of paddy

P. Kaladharan[1*], Shinoj Subramannian[2], Pushparaj Anjelo[2], Arun Thulasidharan[2] and P. Vysakhan[1]

[1]ICAR- Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India.

[2]ICAR-CMFRI- Krishi Vigyan Kendra, Narakkal, Kochi-682 505, Kerala, India.

[*]Correspondence e-mail: kaladharanep@gmail.com

Received: 4 Nov 2020 Accepted: 18 Jun 2021 Published: 30 Jun 2021

Original Article

Abstract

Seaweeds gain importance recently in agriculture as several studies have shown that chemicals extracted from seaweeds are used as soil amendments to increase crop yield. We report here the positive effects of brown seaweed *Sargassum wightii* on paddy when applied as mulch during transplantation trials carried out in a progressive farmer's field. Besides appreciable levels of Na, Ca, Mg, Fe and Zn, the NPK ratio in dry *Sargassum* mulch was 1:0.1: 1.8. The advantage of mulching dry seaweed to the paddy field was exhibited by mild increase (2.6%) in the organic carbon content of soil within 30 days of mulching and considerably higher (23.6% after 45 days and 35.2% after 80 days) over the control field. Height of the saplings also exhibited significantly higher value over the control ($p<0.05$, $n=25$), whereas the number of tillers were slightly more in control plot. Mulching *Sargassum* to paddy also increased the number of seeds in a panicle as well as the grain weight than the control.

***Keywords**: Seaweed manure, micronutrients, plant growth hormones, soil organic carbon, proximate composition*

Introduction

From the time immemorial seaweeds have been used as manure for field crops in the coastal areas. As the minerals and trace elements that occur in seaweeds are in water soluble form, they are readily absorbed by plants, when they are applied. In agriculture and horticulture, diluted extracts of seaweed are applied to promote seed germination, plant growth, prevent pests and diseases and improve the quality of the products. Seaweed extracts are known to contain Cytokinin (Brain *et al.*, 1973; Verkleij, 1992; Stirk and van Staden, 1997; Kaladharan and Sridhar, 1999), auxins (Crouch *et al.*, 1990) and ABA like substances which can promote early ripening of crops (Bulgeri *et al.*, 2015) and have proven to accelerate the health and growth of plants. Besides plant growth promoters, they contain N P K as well as trace minerals like Zn, Mn, Mg, Fe, etc in appreciable quantities. Hence seaweeds can be considered as better alternative to inorganic fertilizers.

Chelation makes micro elements readily available to the crops (Verkleij, 1992) and such chelating properties are offered by the algal polysaccharides found in fresh seaweed or dried seaweed meal as well as liquid seaweed extracts. In recent years, seaweed extracts are produced and marketed as liquid fertilizer and when applied in higher concentrations it will lead to toxicity and inhibits plant growth (Arun *et al*., 2014). Field trials conducted by CSMCRI and other R & D institutions have revealed that application of seaweeds or seaweed products can produce amazing results in plants. Application of liquid extracts of some common seaweeds increased yield by 27 %, 26%, 39%, 57%, 61% and 20% of brinjal (Sreelatha *et al*., 2018), rice (Kavitha *et al*., 2008), greengram (Zodape *et al*., 2010), soyabean (Rathore *et al*., 2009), tomato (Zodape *et al*., 2011; Yao *et al*., 2020) and okra (Zodape *et al*., 2008) respectively. Superior yields after seaweed treatments were measured in watermelon (Abdel- Mawgoud *et al*., 2010), wheat (Zodape *et al*., 2009), Potato (Lopez-Musquera and Pazas, 1997) and grape (Norrie and Keathley, 2006).

As in other seaweeds, the sap of *Kappaphycus alvarezii* is also estimated to possess macro and micro nutrients besides plant growth hormones such as indole 3-acetic acid, gibberellic acid, kinetin, and zeatin (Prasad *et al*., 2010). A recent study also confirmed the presence of choline and glycine betaine in the sap which can impart abiotic stress resistance to crops (Mondal *et al.* 2015). This seaweed sap is known to improve grain and biomass yield in wide range of crops ascertained across 20 States in India. The sap production of M/s. Aquagri Processing Pvt. Ltd. has escalated from 5.25 kL in 2008 to 1875 kL in 2015. Indian Farmers Fertilizer Cooperative Limited (IFFCO) is marketing another plant bio-stimulant produced from seaweeds (Mantri *et al*., 2017). Rice, the cereal grain obtained from paddy (*Oryza sativa*, L.) is the most widely cultivated crop and widely consumed staple food grain in Asia and Africa. This communication investigates the manurial value of brown seaweed *Sargassum wightii* on paddy carried out during 2015-2016 in a progressive farmer's field located in Thiruvaniyur Village, Ernakulam District, Kerala.

Material and methods

Study site

A rectangular 10 cents paddy field belonging to a progressive farmer bearing Land Survey no: 273/4, located at Thiruvaniyur Village, Vadavucode Block, Ernakulam District, Kerala (Fig.1) was selected for the field trial.

Seaweed

Brown seaweed *Sargassum wightii* collected from Mandapam, Ramanathapuram coast Tamil Nadu, was washed thoroughly with freshwater, dried in sun and transported to the paddy field by road. The dry seaweed samples were weighed and were chopped into small pieces of approximately 3-5 cm size. Proximate composition of dry seaweed sample was estimated using standard procedures (AOAC., 2016).

Field preparation and transplant

After preparation of the land the tilled field was divided into two equal plots of 5 cents each. The experimental plot was applied

Fig.1. Paddy field located at Thiruvaniyur Village, Vadavucode Block, Ernakulam District, where the mulching trial was conducted and the adjoining left side plot is the control.

with 200 kg of chopped *Sargassum* mulch as basal dressing and the adjoining control plot with 200 kg of green foliage as basal dressing. Paddy saplings (var. IR-5, duration 120 days) was transplanted with equal spacing to ensure more or less equal number of saplings in both the plots. Irrigation, chemical fertilizer dosage, weed removal and pesticide application in both the plots were similar and carried out on same time. Organic carbon content in soil samples collected from the fields were monitored periodically according to the method of Walkley and Black (1934) and shoot length, number of tillers, number of grains in a panicle and weight of seeds were assessed during the harvest.

Results and discussion

The nutrient composition of dry biomass of *Sargassum wightii* revealed NPK ratio of 1:0.1:1.8 and the micronutrients registering highest levels of Ca (3.31 ± 0.86 ppm) followed by 2.24 ± 0.63 ppm of Na and the lowest levels of Fe (0.45 ± 0.03 ppm). The levels of Zn and Mg were 1.44 ± 0.15 ppm and 0.97 ± 0.11ppm respectively (Table 1). Seaweed mulching during transplantation of paddy did improve the organic carbon content in the soil considerably registering mild increase of 2.39 ± 0.44% within 30days after mulching from the initial value of 2.30±0.03% to 2.88 ± 0.08% on 45th day and 3.34 ± 0.75% on 85th day. While the control plot recorded only 2.47±0.27% on 85th day from the initial level of 2.31± 0.04 (Table 2).

Seaweed mulching encouraged the vegetative growth as well as grain yield in paddy (Fig. 1). As shown in Table 3 seaweed mulching promoted vertical growth of the plant significantly ($p<0.05$, n= 26) and registered mean height of 77.8 ± 3.69 cm as against a mean height of 61.8 ± 1.31 cm by the plants from control plot. However, number of tillers per plant did not show any increase over the control plot, rather the control (C) plant recorded a mean number of 21.47±1.72 tillers as against 20.8± 2.06 tillers (Table 3) in the experimental (E) plot. Weight of rice seeds from the E plot which received basal dressing of seaweed mulch was noticeably higher (2.97 ±0.025 g) than that of the plants from C plot (2.75 ±0.038 g).

The use of seaweeds in modern agriculture has been investigated by many workers (Whapham *et al.*, 1993; Lopez-Musquera and Pazas, 1997; Arun *et al.*, 2014; Sreelatha *et al.*, 2018; Kaladharan *et al.*, 2019). Organic fertilizers produced from seaweeds enhance the seed germination, growth and yield characteristics (Renukabai *et al.*, 2014; Dogra and Rakesh, 2012; Rathore *et al.*, 2009). Seaweed extracts do possess natural plant growth substances like auxins, gibberllins, cytokinins, betaines, various vitamins like B1 (thiamine), B_2 (riboflavin), B_{12}, vitamin E (tocopherol), vitamin K and vitamin C (ascorbic acid) as well as pantothenic acid, folic acid, folinic acid etc. (Biswajit *et al.*, 2014). The favourable effect of basal dressing of *Sargassum wightii* during paddy transplant on soil organic carbon content and the yield characters must be due to the presence of NPK, trace elements and plant growth promoters. The concentrations of plant growth promoters such as auxins, cytokinins, and gibberellins estimated from the sap of *Kappaphycus alvarezii* are 56.04, 77.20 and 128.42 ppm respectively (Prasad *et al.*, 2010). A recent study also confirmed the presence of choline (60.71 mg/L) and glycine betaine (78.47 mg/ L) in pristine sap of *Kappaphycus alvarezii* which did impart abiotic stress resistance to crops (Mondal *et al.*, 2015). The aqueous extract from *Sargassum horneri* at the rate of 60 kg/ ha has been reported to achieve 6.9 % increase in yield of tomato (Yao *et al.*, 2020).

Sunarpi *et al.* (2010) have proved that foliar spray of extracts of brown seaweeds such as *Sargassum* and *Hydroclathrus* could enhance the plant height and number of tillers in paddy. Similarly foliar spray of *Kappaphycus* sap along with recommended dose of chemical fertilizers to paddy has been found beneficial to increase grain yield to 41% (Biswajit *et al.*, 2014). Biswajit *et al.* (2020) have also found that the foliar application of *Kappaphycus* sap could improve the quality of rice besides improving yield, positive

Table 1. Proximate composition of *Sargasssum* mulch (ppm, Mean± SD, n=4)

N	P	K	Na	Ca	Mg	Fe	Zn
1.78± 0.22	0.16± 0.07	3.31± 0.86	2.24± 0.63	3.53± 0.7	0.97± 0.11	0.45± 0.03	1.44± 0.15

Table 2. Organic carbon content (% ± SE, n= 4) in paddy field mulched with seaweed (E) and control (C) plots

Days after transplant	Plot- E	Plot- C	% increase in E over C
0	2.30 ±0.03	2.31± 0.04	-100.4
30	2.39 ±0.44	2.33 ±0.36	102.6
45	2.88 ±0.08	2.34 ±0.18	123.6
85	3.34 ±0.75	2.47 ±0.27	135.2

Table 3. Effect of *Sargassum* mulch on the vegetative growth and grain yield

Plant characters		Plot - E	Plot - C
Plant height (cm)	Mean	77.8	61.8
	(Range)	(60 -104)	(50 -75)
	Std Error	3.69	1.31
	n	26	26
Number of tillers/plant	Mean	20.8	21.47
	(Range)	(9 - 32)	(12 - 32)
	Std Error	2.06	1.72
	n	26	26
Number of seeds per panicle	Mean	116	104
	(Range)	(93 -138)	(74 - 135)
	Std Error	6	9
	n	26	26
Weight of 100 seeds (g/100 seeds)	Mean	2.97	2.75
	(Range)	(2.92-2.99)	(2.63-2.84)
	Std Error	0.025	0.038
	n	4	4

N balance and better system efficiency. Although many studies on the foliar application of seaweed sap on paddy has been reported, our investigation on the beneficial effect of seaweed mulch as basal dressing during paddy transplantation is the first of its kind. It has been estimated that the total methane emitted from the 42.23 million hectares of paddy cultivation land is nearly 5 T gm *ie*., 5x10^{12} gm (Adhya *et al*., 2000). Basal application of seaweed mulch to paddy field may help reduce methane emission considerably as seaweed mulching can reduce the use of farmyard manure while transplanting and results progressive increase in organic carbon content in the sediment (Table 2). Dry biomass of seaweed *Sargassum* can be procured at the rate of Rs 14000/ ton or can be collected from the coastal region during the lowtide hours. Additional expenditure of Rs. 2400 for the 200 kg of dry *Sargassum* shall be compensated by the marginal benefit from increase in the grain and straw yield. Supplementing seaweed biomass as basal dressing or its extract to paddy can reduce the application dose of chemical fertilizers thereby the soil health can be restored and also the farmyard manure considerably which might help reduce the cost of farming.

References

Abdel-Mawgoud, A. M. R., A. S. Tantawy, M. M. Hafez and A. M. Hoda. 2010. Seaweed extract improves growth, yield and quality of different watermelon hybrids Research. *J. Agri. Biol. Sci*., 6(2): 161-186.

Adhya, T., K. Bharati, S. R. Mohanty, B. Ramakrishnan, V.R. Rao and S. Sethunathan. 2000. Methane Emission from Rice Fields at Cuttack, India. *Nutrient Cycling in Agroecosystems*, 58: 95 - 105.

AOAC. 2016. *Official Methods of Analysis of AOAC International*; Association of Official Analytical Chemist: Washington, DC, USA: ISBN 0935584870.

Arun, D., P. K. Gayathri, M. Chandran and D. Yuvaraj. 2014. Studies on effect of seaweed extracts on crop plants and microbes. *Intl. J. Chem. Tech. Res*., 6 (9):4235-4240.

Biswajit, P., B. Koushik, A. Ghosh and S. T. Zodape. 2014. Effect of seaweed saps on growth and yield improvement of transplanted rice in old alluvial soil of West Bengal. *Bangladesh J. Bot*., 43(1):53-58.

Biswajit, P., B. Koushik, S. Kar and B. S. Mahapatra. 2020. Can foliar application of seaweed sap improve the quality of rice grown under rice - potato - greengram crop sequence with better efficiency of the system?. *J. Appl. Phycol*., 32:3377 - 3386.

Brain, K. R., M. C. Chalopin, T. D. Turner, G. Blunden and P. B. Wildgoose. 1973. Cytokinin activity of commercial aqueous seaweed extract. *Plant Sci. Lett*., 1: 241 245.

Bulgari, R., G. Cocetta, A. Trivellini , P. Vernieri and A. Ferrante. 2015. Biostimulant and crop responses: a review. *Biol. Agric. Hortic*., 31: 1 - 17.

Crouch, I. J., R. P. Beckett and J. van Staden. 1990. Effect of seaweed concentrate on the growth and mineral nutrition of nutrient stressed lettuce. *J. Appl. Phycol*., 2: 269-272.

Dogra, B. S. and K. M. Rakesh. 2012. Effect of seaweed extract on growth and yield of onion. *Intl. J. Farm Sci*., 2(1): 59-64.

Kaladharan, P. and N. Sridhar, 1999. Cytokinin production from green seaweed, *Caulerpa racemosa. Fish. Technol.,* 36(2): 87-89.

Kaladharan, P., T. V. Sathianandan, S. J. Edison, T.S. Shahana and P. Vysakhan. 2019. Effects of basal application of mulch and foliar spray of Sargassum wightii extract on certain vegetable crops. *Fishery Technology*, 56: 44-48.

Kavitha, M. P., V. Ganesaraja and K. Paulpandi. 2008. Effect of foliar spraying of seaweed extract on growth and yield of rice (*Oryza sativa*, L.). *Agric. Sci. Digest*, 28 (2): 127 - 129.

Lopez-Musquera, M. E. and P. Pazas.1997. Effect of seaweed on potato yield and soil chemistry. *Biol. Agri. Horti*., 14:199-205.

Mantri, A. V., K. Eswaran, M. Shanmugam, M. Ganesan, V. Veeragurunathan, S. Thiruppathi, C. Reddy and A. Seth. 2017. An appraisal on commercial farming of *Kappaphycus alvarezii* in India: success in diversification of livelihood and prospects, *J. Appl. Phycol*., 29: 335 - 357.

Norrie, J. and J. P. Keathley. 2006. Benefits of *Ascophyllum nodosum* marine-plant extract applications to 'Thompson seedless' grapes. *Acta. Horticulture*, 727:243 - 247.

Mondal, D., A. Gosh, K. Prasad, S. Singh, N. Bhatt, S.T. Zodape, J. P. Chaudhary and J. Chaudhary. 2015. Elimination of gibberellin from *Kappaphycus alvarezii* seaweed Sap foliar spray enhances corn stover production without compromising the grain yield advantage. *Plant Growth Regulator*, 75(3): 657-666.

Prasad, K., A. K. Das, M. Oza, H. Brahmbatt, A. K. Siddhanta, R. Meena, K. Eswaran, M. R. Rajyaguru and P. K. Gosh. 2010. Regulation in a seaweed based foliar spray employing a mass spectrometric technique san chromatographic separation. *J. Agric. Food. Chem*., 58(8): 4594-4601.

Rathore, S. S., D. R. Chaudhary, G. N. Boricha, A. Ghosh, B. P. Bhatt, S. T. Zodape and J. S. Patolia. 2009. Effect of seaweed extract on the growth, yield and nutrient uptake of soybean (*Glycine max*) under rainfed conditions *S. Afr. J. Bot*., 75: 351-355.

Renukabai, N., T. Christy Kala, R. Mary Christi, S. Ani Besant and A. K. Amia Sahnaz. 2014. Effect of seaweed liquid fertilizers on growth and yield characteristics in *Vigna mungo* (L.) Hepper. *Seaweeed Res. & Utiln*., 36(1&2):84-90.

Sreelatha, K., Lizzy Mathew and P. Kaladharan, 2018. Drenching aqueous extracts of seaweeds for enhancing growth, biochemical constituents and yield of *Solanum melongena,* L. *J. Mar. Biol. Assn. India*, 61 (1):18-23.

Stirk, W. A. and J. van Staden. 1997. Isolation and identification of cytokinins in a new commercial seaweed product made from *Fucus serratus* L. *J. Appl. Phycol*., 9: 327 - 330.

Sunarpi, A. Jupri, R. Kurnianingsih, N. I. Julisaniah and A. Nikmatullah. 2010. Effect of seaweed extracts on growth and yield of rice plants. *Nusantara Bioscience* 2: 73-77.

Verkleij, F. N. 1992. Seaweed extracts in agriculture and horticulture: a review. *Biol. Ag. Hort*., 8:309 - 324.

Walkley, A. and I. A. Black. 1934. An examination of vegetative method for determination of soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci*., 37(1): 29-38.

Whapham C. A., G. Blunden, T. Jenkins and S. D. Hankins. 1993. Significance of betaines in the increased chlorophyll content of plants treated with seaweed extract. *J. Appl. Phycol*., 5(2):231-234.

Yao, Y., X. Wang, B. Chen, M. Zhang and J. Ma. 2020. Seaweed extract improved yields, leaf photosynthesis, ripening time, and net returns of tomato (*Solanum lycopersicum* Mill.). *ACS Omega*, 5(8):4242-4249.

Zodape, S. T., V. J. Kawarkhe, J. S. Patolia and A. D. Warade. 2008. Effect of liquid seaweed fertlizer on yield and quality of okra (*Abelmoschus esulentus* L.). *J. Sci. Ind. Res.* 67: 1115-1117.

Zodape, S. T., S. Mukherjee, M. P. Reddy and D. R. Chaudhary. 2009. Effect of *Kappaphycus alvarezii* (Doty) Doty ex silva. extract on grain quality, yield and some yield components of wheat (*Triticum aestivum*, L.) *Int. J. Plant Prod*., 3: 97-101.

Zodape, S. T., S. Mukhopadhyay, K. Eswaran, M. P. Reddy and J. Chikara. 2010. Enhanced yield and nutritional quality in green gram (*Phaseolus radiata* L) treated with seaweed (*Kappaphycus alvarezii*) extract. *J. Sci. Ind. Res*., 69:468 - 471.

Zodape, S. T., A. Gupta, S. C. Bhandari, U. S. Rawat, D. R. Chaudhary, K. Eswaran and J. Chikara. 2011. Foliar application of seaweed sap as biostimulant for enhancement of yield and quality of tomato (*Lycopersicon esculentum* Mill.). *J. Sci. Ind. Res*., 70: 215 - 219.