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Exploring the Potential of Seaweeds of South Andaman Coast for Agricultural Use

T.P.Swarnam[#], Velmurugan A, Shajeeda Banu V and Kavita G
|*ICAR- Central Island Agricultural Research Institute, Port Blair-744105, India*
[#]**Corresponding author:** *swarna_8@yahoo.com*

Abstract

Six species of seaweeds viz., *Caulerpa racemosa, Halimeda opuntia*, *Padina tetrastromatica, Sargassum wightii, Gracilaria salicornia* and *Tricleocarpa fragilis* were collected from different locations of South Andaman coast. The chemical and biochemical characterization was done by standard procedures and assessed for their potential organic source for managing soil nutrient management. In general, total N content varied from 0.71 to 2.32 % with mean value of 1.62 ± 0.6 %. The brown seaweeds recorded higher N (2.27 ± 0.09%), followed by green (1.44 ± 0.4%) and red seaweeds (1.25 ± 0.6%). The mean total phosphorus concentration is 0.43% and total K concentration varied from 0.95 to 1.60 % with higher values recorded in brown seaweeds viz., *P. tetrastromatica* followed by red seaweeds viz. *T. fragilis and G. salicornia.* Again red algae *T. fragilis* recorded highest Ca (20.7 ± 0.16 g kg^{-1}), followed by *H.opuntia* (14.98 ± 0.040 g kg^{-1}). In the present study, IAA concentration varied from 15.61 µg g^{-1} in *G. salicornia* to 19.56 µg g^{-1} in *P. tetrastromatica and* no significant differences were found among the species studied. *In comparison to common green manure crops grown in Andaman Islands, seaweeds contain comparable quantity of macro nutrients especially N and K, recorded higher amounts of Ca, Mg and trace elements like Fe. The higher carbohydrate content will provide energy for soil microbes and the presence of plant hormones is an added advantage for exploiting the seaweed resources especially brown seaweeds for enhancing crop production in the islands.*

Key words: *Seaweeds, chemical, biochemical characterization, growth promotion, tropical*

Introduction

In recent times, seaweeds are gaining importance due to their ubiquitous presence, renewable nature and wider range of applications. In agriculture they are used as natural source of bio-fertilizer, plant growth regulators and bio-stimulants. In coastal regions, collection and application of seaweed is a traditional soil fertility management strategy, especially in low input agricultural systems which, relies on use of local resources (Cuomo *et al*., 1995). As a readily-available, low-cost material to supplement soil fertility, application of seaweed biomass is often an integral component of traditional, small-scale, diversified agriculture (Angus and Dargie, 2002). In organic or reduced-input agricultural systems, seaweed-based agricultural products are gaining importance worldwide.

The traditional practice of seaweed application may have modern application in coastal regions to reduce dependence on application of synthetic fertilizers, while make use of an abundant bioresource for improving soil quality and enhancing agricultural production. The practice may be an additional strategy to manage soil fertility that addresses the dual problems of reliance on chemical fertilization and wasting of valuable, nutrient-rich biomass. This allows the utilization of seaweed biomass in coastal areas with minimal cost. Nutrient enrichment of coastal waters by agricultural runoff and domestic waste can cause excessive seaweed growth causing detrimental ecological impacts and also lead to negative economic consequences. Beach-cast (drift) biomass is often removed and disposed of in landfills. Although the species composition and properties of drift seaweed varies, the coordination of accumulated seaweed biomass removal with agricultural application may provide a low-cost, locally available resource for enhancing crop production in coastal and small island areas.

Of the total estimated seaweed production potential of India, 30% is found in Andaman and Nicobar Islands (Narayanakumar & Krishnan, 2011). Previous studies show rich seaweed diversity of South Andaman coast compared to North Andaman Islands. The estimates of seaweed biomass showed a standing stalk of around 25000 tonnes (FW) for Andaman Island besides a drift seaweed potential of 1260 tonnes (Subba Rao & Mantri, 2006). The coast of Burmanallah, Kodiyaghat, Wandoor have abundance of *Gracilaria, Caulerpa*, *Sargassum wightii*, *Padina tetrastomatica* and the red algae *Tricleocarpa fragilis* was found in Wandoor and Kodiyaghat (Karthick *et al*., 2013). Around 600-700 kg beach cast (drift) seaweeds were collected on daily basis from Marina Park alone during October to January, which were collected and dumped in landfills as waste.

The potential of these seaweeds can be exploited for promoting organic agriculture in these Islands for which characterization of seaweed biomass especially chemical characteristics relevant to soil quality and plant nutrition is very much required. Hence, an attempt was made to characterize their nutritional and biochemical parameters of the most abundant seaweeds found in different parts of South Andaman coast to explore their potential use for enhancing agricultural production.

Materials and Methods

Sample collection and preparation

The seaweeds were collected from the coastal areas of Burmanallah, Kodiyaghat, Chidiyatapu, Wandoor, and Marina Park of South Andaman, India during November- December 2020. The samples were first washed with seawater and packed in the sampling bag for transportation to the Laboratory of ICAR- CIARI, Port Blair. In laboratory the samples were washed again in tap water to remove sand, salt, debris and epiphytes attached. The cleaned samples were shade dried at an ambient temperature for a week. The dried samples were powdered before storing at 4°C.

Nutrient analysis

The air dried samples were used for estimation of various biochemical and nutrient properties by standard procedures and the results were expressed on dry weight basis. Moisture content was estimated by oven dry method at 105° C for 6 hrs. Ash content was carried out by dry ashing method by heating in muffle furnace at 600°C for 24hrs. The ash was wet with distilled water, and dissolved with 1 mL of HNO_3. The mixture was shaken and filtered using filter paper. The filtrate was used for mineral determination (Yaich *et al*., 2011). The total nitrogen estimation was done by Kjeldhal method, P by metavanadate method and measured in Spectrophotometer. Other macro minerals: calcium (Ca), potassium (K) and magnesium (Mg), and trace minerals: iron (Fe), zinc (Zn), manganese (Mn), copper (Cu) were determined using atomic absorption spectrophotometer (AAS). The results were expressed in mg kg^{-1} on dry weight (DW) basis and all measurements were performed in triplicate.

Biochemical analysis

The air dried samples were used for biochemical assay of total phenols, flavonoids, antioxidant activity, carbohydrate, protein, lipid and Indole acetic acid (IAA) as per the standard procedures listed in table 1. All the results were expressed in dry weight (DW) basis and all measurements were performed in triplicate.

Table 1 Standard methods used for estimation of different biochemical parameters

Sl. No	Parameter	Reference
1	Carbohydrate	Sadasivam *et al*.,2008
2	Protein	Total N x 6.25
3	Lipid	Folch *et al*.,1956
4	Phenols	Singleton *et al*.,1999
5	Flavonoids	Bao *et al*.,2005
6	IAA	Modified from Shraddha Gang *et al*.,2009
7	Antioxidant activity	DPPH method - Rattanachitthawat *et al*. 2010

Statistical analysis

All the analysis was conducted in triplicate, and values were presented as mean ± SD using MS Excel 2007.

Results and discussion

Mineral characterization

There are 6 species of seaweeds collected from different locations of South Andaman coast. They included 2 species of green algae viz., *Caulerpa racemosa, Halimeda opuntia,* 2 species of brown algae including *Padina tetrastromatica, Sargassum wightii* and 2 species of red algae viz., *Gracilaria salicornia* and *Tricleocarpa fragilis*.

The mineral assay of the seaweeds indicated higher amounts of minerals such as calcium, potassium, iron and copper at much higher levels than in terrestrial plants because of their marine habitat which allow them to absorb a wide diversity and high amounts of minerals (Rupérez, 2002). The mean concentrations of macro minerals present in the study are depicted in Fig1.

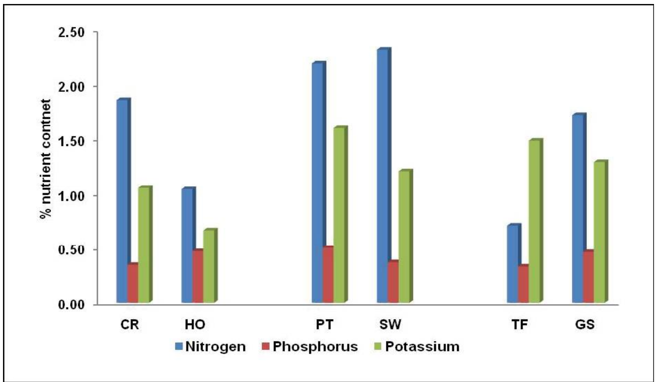

Fig. 1 Mean concentration of total N, P and K in some of the seaweeds

In general, total N content varied from 0.71 to 2.32 % with mean value of 1.62 ± 0.6 %. The brown seaweeds recorded higher N (2.27 ± 0.09%), followed by green (1.44 ± 0.4%) and red seaweeds (1.25 ± 0.6%). The mean total phosphorus concentration is 0.43% in this study. Though higher values were found in *G. salicornia* (0.50%) and *S. wightii* but no significant differences were found between the species studied. The mean total K concentration of different species varied from 0.95 to 1.60 % with higher values recorded in brown seaweeds viz., *P. tetrastromatica* followed by red seaweeds viz. *T. fragilis and G. salicornia.*

The seaweeds are abundant in calcium and magnesium minerals. The red algae *T. fragilis* recorded highest Ca (20.7 ± 0.16 g kg^{-1}), followed by *H.opuntia* (14.98 ± 0.040 g kg^{-1}). Both are calcareous macroalgae commonly found in tropical shallow and deep reefs which play an important role in carbonate sediment formation.

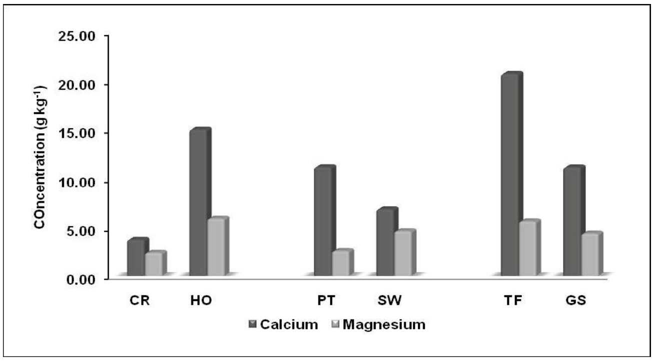

Fig. 2 Mean concentration of Ca & Mg in selected seaweeds of South Andaman

The brown seaweeds *P. tetrastromatica* (11.16 ± 0.06 g kg^{-1}) and *S. wightii* (6.85 ± 0.088 g kg^{-1}) also contained comparable quantity of calcium. The magnesium content ranged from 2.52 ± 0.028 g kg^{-1} to 5.90 ± 0.028 g kg^{-1}. Based on the average nutrient analysis, *T.fragilis* and *H opuntia* are rich source of calcium and magnesium which can be used as soil amendment for acid soils. Besides, the brown algae are also the source of calcium alginate which has many industrial uses and have a greater scope for agricultural use in the form of hydrogel for water stress management in many agricultural crops.

As observed in table 1, higher level of microelements viz., iron, manganese, zinc and copper was observed from brown seaweeds *S. wightii* and *P. tetrastromatica* while, the lowest values were obtained from the red algal species *G. salicornia*.

Table 1. Mean concentration of microelements found in selected seaweeds

Name	Concentration (ppm)			
	Fe	Mn	Zn	Cu
Green seaweeds				
Caulerpa racemosa	1407.1±3.83	324±0.2	305.04±0.12	8.86±0.14
Halimeda opuntia	1403.3±7.02	235.2±0.21	24.02±0.05	18.26±0.03
Brown seaweeds				
Padina tetrastromatica	2643.3±4.1	459.1±0.42	76.07±0.22	23.3±0.30
Sargassum wightii	2791.3±8.3	400.4±0.36	283.89±0.21	23.5±0.16
Red seaweeds				
Tricleocarpa fragilis	2232.2±2	216.6±0.64	11.81±0.04	16.2±0.2
Gracilaria salicornia	393.6±2.4	396.4±0.23	36.24±0.19	25.6±0.2

The high mineral content of seaweeds is related to their capacity to retain inorganic marine substances, due to the characteristics of their cell surface polysaccharides. The variation in mineral concentration might be due to the amount of variation in number of minerals and organic components on the bottom of the water and the nature of the depth of the water, the distance from the soil and the environment affect the number of minerals present in seaweed.

Biochemical characterization

The biochemical analysis of seaweeds indicated that the ash content varied from 25.2 to 55.9%, much higher than the terrestrial plants (5-10%) indicating the presence of appreciable amounts of diverse minerals (Chan & Matanjun 2016). The ash content of the selected samples varied from 24.6 to 56.7 % and highest ash content (55.9 ±1.0 %) was recorded in calcareous green algae (*H. opuntia*) followed by *T. fragilis* (45.5±1.66%) both of them are known for higher calcium carbonate deposition in their cells. These algae produces calcium carbonate by precipitation from Ca2+ and HCO3 ions in solution and deposit calcium carbonate in the form of aragonite in the intercellular spaces (Mayakun *et al*.2014). The values are comparable to those reported by other studies for the region and it may be due to higher mineral content as reported by Shajeeda Banu and Mishra 2018.

Table 2. Proximate composition of different seaweeds collected from South Andaman

Name	Proximate composition (%)								
	DM	Moisture	Ash	CHO	Proteins	Lipids	Phenols*	Flavanoids**	AOA+
Green seaweeds									
Caulerpa racemosa	11.31	88.69	36.4	49.80	11.62	1.40	196.8	41.0	516.7
Halimeda opuntia	57.24	42.76	55.9	9.13	6.42	0.80	310.5	191.3	483.3

Brown seaweeds									
Padina tetrastromatica	11.87	88.23	30.6	31.24	13.72	2.40	299.0	188.3	603.3
Sargassum wightii	9.74	90.26	26.9	56.06	14.51	2.50	249.2	145.3	613.3
Red seaweeds									
Tricleocarpa fragilis	24.15	75.85	45.5	26.19	4.32	2.30	209.2	65.5	440.0
Gracilaria salicornia	17.06	82.94	25.2	43.51	11.27	0.68	235.9	157.6	573.3

*mg GAE/100g, ** (mg Rutin/100g) and AOA – anti oxidant activity by DPPH method ($^{+}$ mg BHA/100g)

The total carbohydrate content of seaweeds is also higher and contains soluble sugars, uronic acid and soluble fibers like starch. These sugars and sugar polymers decompose easily and can act as energy source for soil microbial population. In general, brown algae recorded higher carbohydrate (31.24 to 56.06%), protein content (13.66 to 15.06%) than that of green and red algae which varied from 9.13 to 49.8%, and 4.03 to 12.43% respectively. The total carbohydrate content varied from 9.13% in *H.opuntia* to 56.06% in *S. wightii*, which can be a rich source of energy for soil microbes when applied into the soil. The total phenol and flavonoid content is also recorded higher for brown seaweeds compared to others. Similar results were observed for antioxidant activity.

Seaweeds are also reported to have various phytohormones and plant growth regulators viz. auxins, gibberellins, cytokinins, abscisic acid, ethylene, betaine and polyamines that can stimulate plant growth when applied exogenously. In the present study, IAA concentration varied from 15.61 $\mu g\ g^{-1}$ in *G. salicornia* to 19.56 $\mu g\ g^{-1}$ in *P. tetrastromatica*. In general no significant differences were found among the species studied. This is in consonance with reports of presence of IAA ranging from 1.1 to 46.9 ng/g Fw (fresh weight) in seaweeds collected from East China Sea (Lijun 2006).

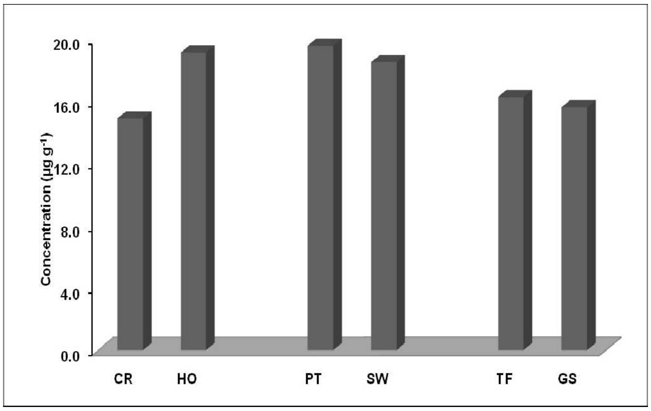

Fig. 3 Concentration of IAA in different seaweeds of Andaman coast

In comparison to common green manure crops grown in Andaman Islands, seaweeds contain comparable quantity of macro nutrients especially N and K, recorded higher amounts of Ca, Mg and trace elements like Fe (Table 3). The total carbohydrate content of seaweeds is also higher and contains soluble sugars, uronic acid and soluble fibers like starch. These sugars and sugar polymers decompose easily and can act as energy source for soil microbial population. Besides, the presence of plant growth hormones like IAA is an added advantage for exploiting the seaweed resources.

Table 3. Nutrient content common green manure crops grown in Andaman Islands

Crop	DM (%)	Ash (%)	Nutrient composition (%) on dry weight basis				
			N	P	K	Ca	Mg
Crotalaria juncea	14.3	12.1	2.30	0.50	1.80	1.23	0.42
Sesbania speciosa	17.3	8.5	2.71	0.53	2.21	1.41	0.38
Gliricidia sepium	25.3	10.0	2.76	0.28	4.60	1.19	0.45
Pongamia glabra	15.6	4.9	3.31	0.44	2.39	0.70	0.20

Conclusions

The mineral and biochemical characterization of six seaweed species collected from various locations of South Andaman coast were carried out. The study indicated the presence of comparable quantity of macro nutrients especially N, K and higher amounts of Ca, Mg and Fe in seaweeds than green manure crops. The higher concentration of Ca and Mg and presence of growth hormones makes seaweeds as better organic source for enhancing crop production in acid soils of the Island.

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