Volume: 11 Issue: III Month of publication: March 2023

DOI: https://doi.org/10.22214/ijraset.2023.49561

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue III Mar 2023- Available at www.ijraset.com

Seaweed Utilizing as a Biostimulants in Agriculture Sector: A Review

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Abstract: The marine environment depends on seaweed, which is abundant in the water and plays an essential and crucial function in it. Many researchers have been studying seaweed for more than seven decades. According to our needs, research has been done separately in different aspects. There are several chemical fertilisers commercially available today, but they significantly reduce or harm soil fertility, growth, and yield. The amount of fertiliser needed by the plant or crop will determine the fertility of the soil. When compared to terrestrial foods, the seaweed fertilisers had a lot of nutrients including nitrogen, phosphate, potassium, and important vitamins. They also helped to improve biochemical components like proteins, lipids, polysaccharides, enzymes, and plant growth hormones and trace elements. Finally, this paper would be helpful to a common man and farmers to know and aware about such a great living resource which is present in and around us and their agricultural products are beneficial to our society.
Keywords: Seaweed, Biostimulant, Application, Agriculture, Review

I. INTRODUCTION

Over the past decades, numerous crops have been given growth and development boosts by biostimulants made from marine algae. The agricultural system is the main focus of interest in this seaweed due to their potential usage as a cost-effective source of naturally occurring plant growth regulators. However, the performance of plants subjected to environmental challenges can be improved by applying seaweed- based products, which are eco-friendly alternative to the use of fertilizers and synthetic biostimulants (Carvalho and Castro 2014, Shukla et al.2018, Sharma et al. 2019). In the last few decades, there has been a significant growth in the usage of seaweed extracts as biostimulants in agriculture (Khan et al. 2009, Craigie 2011, Carvalho and Castro 2014, Hernandez-Herrera et al. 2016). Biostimulants are a combination of hormones with substances with various chemical characteristics (such as amino acids and minerals), which can have an effect on plant development (Machado et al. 2014, Castro et al. 2017, Pacheco et al. 2019).

There have been positive reports from using seaweed extracts, which have been marketed for a number of years as fertilizer additions. Seaweed extracts provide a variety of benefits, some of which including better seed germination and deeper root development, increased frost resistance, increased nutrient uptake and changes in plant tissue composition, increased resistance to fungal disease, reduced incidence of insect attack, higher yields, longer shelf-life of produce and improved animal health when livestock is grazed on treated crops or pasture (Blunden, 1972; Zodape, 2001; Govindasamy et al., 2011). Current research on the use of macroalgal extracts in agriculture is focused on three key areas: (1) fertiliser or growth stimulant and development; (2) fostering plant resistance to pathogens or environmental stress; and (3) phytopathogen and phytophage control. Uses of seaweeds have been cited as early as 2500 years ago in chinese literature (Tseng CK. 2004).

A. Seaweed Resources

India is located on 08.04-37.06 N and 68.07-97.25 E, a tropical South Asian country has a stretch of about 7500 km coastline, excluding its island territories with 2 million km2 Exclusive Econimic Zone (EEZ) and nine maritime states. Indian seas have produced approximately 271 genera and 1153 species of marine algae, including forms and variants (Subba Rao PV, Mantri A., 2006). The seaweeds can be found in shallow coastal waters, estuaries, intertidal zones, and deep-sea locations up to a depth of 180 meters.

They are typically divided into three groups: Rhodophyceae (red algae), Phaeophyceae (brown algae), and Chlorophyceae (green algae) (red algae). More than 10,000 different types of seaweeds, with a potential global production of 7.5-8 million tonnes (wet weight), which are being produced along the coastal regions of the world (McHugh DJ., 2003). Around 40,000 tonnes of seaweeds are used every year to make agar and algin.

Subba Rao has provided a thorough analysis of the seaweed resources, cultivation, and uses in various Indian coastal waters. The distributions of species encountered during the surveys are represented in table 1. Along the Indian coast, the total standing crop ranged from 6,77,308.87 to 6,82,758.87 tonnes (fresh weight). The seaweed is widely distributed along the coastline of India, including its nine maritime states and islands (Gujarat-1600, Maharastra-572, Goa-104, Karanataka-280, Kerala-560, Tamil Nadu-980, Andhra Pradesh-960, Orissa-432, West Bengal-280, Andaman and Nicobar Islands-1500 (approx.), Lakshadweep Islands-120 (approx.) in km). The places of algal interest along coastal states of India are noted in the table 2.

B. *Seaweed as a Biostimulants*

Several scientific studies have been made and proved that seaweeds derived products can be effective in promoting growth and physiology of plants. Indeed, the market has probably doubled in the last decade because of the wider recognition of the usefulness of the seaweed derived products and the increasing popularity of organic farming, where they are specially effective in the growing of vegetables and some fruits. Seaweed meal was found useful as a fertilizer for grass, trees, and vegetables besides as a soil conditioner.

Moreover, seaweed extract had been introduced in Iceland, where it had been successfully employed as an additional fertilizer for greenhouse tomatoes, flowers, and vegetables. According to Smith (1961), seaweeds include 32 elements as well as vitamins A, B, C, and D. It has been discovered that seaweed manure boosts disease resistance. Most of the nutrients in seaweed were in ionic form and hence crop plants easily absorb them.

Ascophyllum nodosum (L.) Le Jolis (Phaeophyceae), a seaweed extensively utilised for agricultural purposes, stands out among the seaweeds commonly used for extracting algal species that inhibit marine water (Ugarte et al. 2006, Khan et al. 2009, Craigie 2011, Arioli et al. 2015).

Table I: Distribution of Species encountered during different surveys along the Indian coast

State	Green	Brown	Red	Blue-green	Total Source	references
Gujarat	29	24	39	Nil	92	Chauhan and Mairh 1978
Gujarat (subtidal)	Nil	Nil	Nil	Nil	35	Dhargalkar and Deshmukh 1996
Maharashtra	11	11	14	Nil	36	Chauhan 1978
Karnataka*	16	10	16	1	43	Agadi 1985
Kerala	13	3	17	2	35	Chennubhotla et al.1988
Tamil Nadu (intertidal)	113	83	225	5	426	Anon.1978
Tamil Nadu (subtidal)	8	8	12	1	29	Kaliaperumal et al.1998
Andhra Pradesh	23	7	34	1	65	Anon.1984
West Bengal*	9	Nil	5	Nil	14	Mukhopadhyay and Pal 2002
Orissa* (Chilka lake)	8	Nil	6	Nil	14	Sahoo et al.2003
Lakshadweep Islands	33	10	39	Nil	82	Anon.1979
Great Nicobar Island*	18	15	18	Nil	51	Ravindran et al.2004
South Andaman Islands	29	15	11	Nil	55	Muthuvelan et al.2001
Middle and North Andaman Islands	11	11	5	Nil	27	Muthuvelan et al.2001
Diu*	27	14	29	Nil	70	Mantri and Subba Rao 2005

Qualitative survey only, Source: Subba Rao and Vaibhav A. Mantri (2006)

Table II: Distribution of seaweeds in different maritime state/union territories along the Indian coast

State	Coastline (km)	Places of algal interest
Gujarat	1700	Okha (22.15 N, 69.1 E), Dwarka (22.14 N, 69.1 E)
Maharashtra	572	Malvan (16.03 N and 73.30 E)
Goa	104	Panaji (15. 03 N and 73. 55 E)
Karnataka	280	Karwar (14.48 N and 74.11 E)
Kerala	560	Quilon (8.54 N and 76.38 E), Varakala (8.28 N and 76.55 E)
Tamil Nadu (including Pondicherry)	980	Krusadai Island (9.14 N and 79.13 E), Idinthakarai (8.10 N and 77.43 E)
Andhra Pradesh	960	Visakhapatnam (17.44 N and 83.23 E), Pulicat lake (13.20–13.40 N and 80.14– 80.15 E)
Orissa	432	Chilka lake (19.50 N and 85.30 E)
West Bengal	280	Sundarbans (21.33–22.45 N and 88.06–89.05 E)
Andaman and Nicobar Islands	1500 (approx.)	6–14 N and 92–94 E
Lakshadweep Islands	120 (approx.)	8–12 N and 72–74 E

Source: Subba Rao* and Vaibhav A. Mantri (2006)

However, other species from the genera *Durvillaea*, *Ecklonia*, *Fucus*, *Kappaphycus*, *Laminaria*, *sargassum* (Phaeophyceae), and *Ulva* (Chlorophyta) are also employed for the manufacturing of plant biostimulants that are generally supplied to farmers as liquid concentrate and soluble powder. Products made from seaweed extract can influence plant growth even at low concentrations, indicating the presence of bioactive compounds (Khan et al. 2009). Their organic matrix is generally complex, being composed of macro and micronutrients, amino acids, lipids, carbohydrates and plant (or plant like) hormones (Santaniello et al. 2017, Dumale et al. 2018, Farid et al. 2018, Michalak et al. 2018, Torres et al. 2018).

C. Nutritional Value and Biochemical Composition of Seaweed

Seaweeds is a good source of fibers, carbohydrates, proteins, vitamins, and minerals (Paul MA, Christopher IR Gill, Ross Campbell, Ian R Rowland). Many species of seaweed are rich in minerals like sodium, calcium, magnesium, potassium, chloride, sulphur, and phosphorus as well as micronutrients like iodine, iron, zinc, copper, selenium, molybdenum, fluoride, manganese, boron, nickel, and cobalt (table 3 & 4). In addition, it is a rich source of iodine, which is commonly found in brown seaweed. In general, brown seaweeds have a lower protein level (up to 15%), while green and red seaweeds have higher protein contents (up to 30%). (Kolanjinathan K, Ganesh P, Saranraj P). Moreover, this can differ depending on the habitat and the depth. As seen in table 5, different genera and species within the same genus have variable protein, carbohydrate, lipid, fibre, ash, and phenol contents.

Chlorophyceae members generally have high carbohydrate content than Rhodophyceae and Phaeophyceae (Parthiban C, Saranya C, Girija K, Hemalatha A, Suresh M, Anantharaman P) but this may also vary according to the species type and habitat. The maximum carbohydrate content was recorded in the green seaweed *E. intestinalis* 28.58% and minimum was found to be 10.63% in brown seaweed of *Dictyota dichotoma* (Parthiban C, Saranya C, Girija K, Hemalatha A, Suresh M, Anantharaman P). In green seaweed of *U. lactuca* (35.27%) and *E. intestinalis* (30.58%) also contain higher carbohydrate content (Chakraborty S, Santra SC).

Table III: **-** The comparison of different seaweeds macro- nutrient content review as per some references

Name of seaweed	Type	N mg/g	P mg/g	K mg/g	References
Sargassum wightii	B	174.02	45.56	72.83	K. Divya et al., 2015
Sargassum crassifolium	B	0.4	0.009	1.520	S. Sutharsan et al., 2014
Padina pavonica	B	0.01090	0.00926	0.16013	Chabani et al., 2013
Dictyota dichotoma	B	175.02	44.56	71.84	K. Sasikumar et al., 2011
Laurencia obtusa	R	3.9	3.8	2	Safinaz and Ragaa et al., 2013
Corallina elongata	R	3.4	3.8	1.6	
Jania rubens	R	4	3.5	1.6	
Padina pavonica	B	0.07985	0.00069	0.00278	Chabani et al., 2015
Ulva linza	G	0.05716	0.00120	0.01265	
Ulva lactuca	G	0.12609	0.00300	0.01634	
Ulva lactuca	G	174.02	45.56	75.83	K. Divya et al., 2015

Whereas, G= Green Seaweed, B= Brown seaweed, R= Red Seaweed, N-Nitrogen content, P-Phosphorus content and K-Potassium content

Table IV: - The comparison of secondary macro and micro element of different seaweeds as per some references

Name of seaweed	Type	Fe mg/ 100g	Zn mg/ 100g	Cu mg/ 100g	Mg mg/ 100g	K mg/ 100g	Na mg/ 100g	References
Caulerpa sp.	G	7.14± 0.27	3.41± 0.35	<0.55	949± 2.05	4411± 79.4	7042± 21.8	D. Krishnaiah et al., 2008
Ulva lactuca	G	4.65± 0.41	1.87± 0.07	<0.55	560± 4.85	6026± 22.2	3901± 71.6	
Sargassum sp.	B	6.83± 0.07	3.74± 0.30	<0.55	953± 2.52	10040± 32.1	4024± 25.1	
Eucheuma denticulate	R	6.45± 0.07	6.38± 0.45	<0.55	725± 3.70	3636 ±72.6	4448± 45.1	
Gracillaria sp.	R	3.65± 0.26	4.35± 0.34	<0.55	565± 3.51	3417 ±76.3	5465± 27.4	
Gelidiella acerosa	R	10.60± 0.34	5.25± 0.21	<0.55	657± 7.60	30.34 ±41.6	3976± 18.1	
Kappaphycus alvarezii	R	5.47± 0.17	5.09± 0.14	<0.55	639± 2.90	3877 ±25.1	3944± 52.0	
Stoehospermum marginatum	B	0.50	1.58	3.014	17.31	0.107	5.77	S. Sivasangari Ramya et al., 2015
Cladophora glomerata	G	27	0.57	0.9	60	---	---	P. Anatharaman et al., 2010
Ulva reticulata	G	28	0.64	1.62	180	---	---	
Halimeda macroloba	G	59	0.72	1.42	115	---	---	
Halimeda tuna	G	18.5	0.48	1.0	32	---	---	
Dictyota dichotoma	B	20	0.47	0.85	105	---	---	
Padina pavonica	B	34	0.64	1.38	80	---	---	
Gracillaria crassa	R	24	0.57	1.0	80	---	---	
Gelidiella acerosa	R	28	0.43	0.8	54	---	---	
Hypnea musciformis	R	40	0.53	0.095	86	---	---	
Ulva pertusa	G	---	0.8± 0.2	1.0± 8.3	3670± 533	1224.1± 349.2	376.7 ±63.3	Ommee Benjama and Payap Masniyom, 2011
Ulva intestinalis	G	---	1.5±0.2	0.9± 0.3	3098±1 157.2	2538.6 ±320.3	1064.5 ±489.1	

Whereas, G= Green Seaweed, B= Brown seaweed, R= Red Seaweed

Lipid content in marine macroalgae was low. According to some research, *U. rigida* has a 12% (Satpati G, Pal R) lipid content while *K. alvarezii* has a 1.09% lipid content (Rajasulochana P, Krishnamoorthy P, Dhamotharan R). Seaweeds are a good source of both fat- and water-soluble vitamins.

Name of seaweed	Type	P %	C %	Ph%	L%	F%	A%	References
Chaetomorpha crassa	G	25.48	26.94	-	1.50	34.29	26.94	Pakawan Setthamogkol et al., 2015
Chaetomorpha linum	G	30.70	26.08	-	1.30	31.94	26.08	
Gracillaria tenuistipata	R	26.13	41.45	-	0.75	12.21	41.45	
Gracillaria fisheri	R	26.71	47.47	-	0.62	11.78	47.47	
Caulerpa racemosa	G	23.42	48.10	-	0.67	6.68	48.10	
Caulerpa branchypus	G	26.34	54.38	-	1.42	6.04	54.38	
Caulerpa lentilifera	G	12.68	27.19	-	1.09	4.83	27.19	
Caulerpa taxifolia	G	33.83	41.24	-	3.26	7.17	41.24	
Ulva rigida	G	13.32	67.84	-	0.15	5.69-	67.84	
Monostroma latissimum Wittrock	G	0.14	0.6	0.071	-	-	-	Nirmal Kumar J. I et al., 2014
Cladophora sp.	G	0.12	0.73	0.066	-	-	-	
Padina sp.	B	1.84	0.62	0.380	-	-	-	
D.acrostichoides	B	0.04	0.7	0.21	-	-	-	
Sargassum tenerimum	B	0.4	0.4	0.36	-	-	-	
Sargassum cinctum J. Agardh	B	0.13	0.63	0.26	-	-	-	
Sargassum cinerrum	B	0.13	0.63	0.277	-	-	-	
Caulerpa indica	B	0.14	0.92	0.27	-	-	-	
Caulerpa trinoids	B	0.08	0.29	0.12	-	-	-	
Dictyota dichotoma Lamouroax	B	0.08	0.39	0.088	-	-	-	
T. ornate	B	0.05	0.57	0.18	-	-	-	
Gracillaria corticata J. Agardh	R	0.19	0.225	0.96	-	-	-	
Gracillaria micropterum	R	0.09	0.29	0.1	-	-	-	
Ulva lactuca	G	20.12	44.81	-	4.09	-	22.08	H. M. Khairy and S. M. El. Shafay, 2013
Jania rubens	R	12.93	42.18	-	2.39	-	39.25	
P. capillaceae	B	23.72	50.49	-	2.71	-	13.02	
Enteromorpha intestinalis	G	16.2	24	-	1.4	-	-	K. Manivannan and G. Thirumaran, 2008
Enteromorpha clathrata	G	11	23	-	4.5	-	-	
Ulva lactuca	G	3	23	-	1.5	-	-	
Codium tomentosum	G	6	20	-	2.5	-	-	
Padina gymnospora	B	17	21	-	1.2	-	-	
Colpomenia sinuosa	B	10.5	22	-	2.3	-	-	
Sargassum tenerimum	B	12.0	24	-	1.2	-	-	
Sargassum wightii	B	11	23.5	-	2.2	-	-	
Turbinaria conoides	B	-	24	-	2.0	-	-	
Gracilaria folifera	B	6	22.5	-	3.0	-	-	
Hypnea valentiae	B	8	24	-	1.4	-	-	
Acanthophora spififera	B	11.8	24	-	1.5	-	-	
Ulva faciata	G	14.98	39.86	5.987	0.21	-	-	P. Anantharaman et al., 2014
Chaetomorpha antennina	G	13.45	34.96	6.342	0.34	-	-	
Spyridia hypnoides	R	12.87	47.09	8.94	0.42	-	-	
Amphiroa anceps	R	7.86	25.76	4.456	0.21	-	-	
Sargassum wightii	B	16.34	54.09	16.482	0.51	-	-	
Chnoospora maxima	B	9.87	55.86	19.351	0.54	-	-	
Caulerpa racemosa	G	18.3	83.2	14.3	19.1	-	-	Rameshkumar S. et al., 2013
Ulva faciata	G	14.7	70.1	18.1	0.5	-	-	
Chnoospora minima	B	11.3	28.5	19.7	0.9	-	-	
Padina gymnospora	B	10.5	38.3	32.3	11.4	-	-	
Acanthopora spicefera	R	18.9	65.6	34.7	2.1	-	-	
Laurencia obtusa	R	142.9 4	199.69	0.529	-	-	20.25	Funda Turan et al., 2015
Laurencia papillosa	R	23.63	155.23	0.246	-	-	23.33	
Jania rubens	R	13.82	374.02	0.053	-	-	26.50	
Codium fragile	G	25.49	643.93	0.095	-	-	21.79	
Ulva lactuca	G	56.76	506.69	0.221	-	-	12.37	
Amphiroa fragilissima	R	7.31	18.77	-	-	3.52	-	Narasimman, S. and K. Murugaiyan, 2013

Table V: - The comparison of different seaweed bio-chemical parameters reviews as per some references

Whereas, P= Protein content, C= Carbohydrate content, L= Lipid content, F= Fiber content, A= Ash content, Ph= Phenol content, TDF= Total Dietary Fiber, G= Green Seaweed, B= Brown seaweed, R= Red Seaweed

D. Seaweed Biostimulants used as a Plant Growth

The seeds of *Cajanus cajan* soaked in SLF of *Padina sp*. *Sargassum sp*. *Turbinaria sp*. *Champia sp*. and *Helminthocladia* achieved 100% germination besides significantly increasing their growth parameters (Mohan et al., 1994). The SLF of *Ulva lactuca* improved the growth characteristics of *Vigna unguiculata*, including fresh weight, dry weight, root and shoot length, number of lateral roots, and leaf area (Seker et al., 1995). Blunden and Wildgoose (1977) reported that the marked increase in lateral root development in potato plants was due to the application of SLF.

Green gram showed maximum seedling growth and lateral roots at 1.5% concentration of *S. plagiophyllum* and 1.0% of commercial seaweed liquid fertilizer SM3. However, there was an inhibitory effect when applied at 2.0% concentration (Kumar et al., 1993). In cowpea, 0.5% and 0.75% extract of *Sargassum polycystum* showed better germination, seedling measurements and dry matter production (Ramamoorthy et al. 2006).

During SLF spraying in field trials, Booth (1966) noticed an increase in the uptake of several major and trace nutrients in potato leaf from 7 to 28%. Commercial SLF was added to increase the yield of some crops, including banana, potato, sweet corn, pepper, tomato, and orange (Blunden, 1972). According to Stephenson (1974), maize grew at a faster rate when SLF made from *Ascophyllum* and *Laminaria* was used at lower concentrations. The extracts of *Sargassum sp*., *Sargassum polycystum*, *Hydroclathrus sp*., *Turbinaria ornata* and *Turbinaria murrayana*, were able to induce the growth of rice plants (Sunarpi et al., 2010).

In an experiment with cluster beans, it was found that the growth was boosted by using 1.5% *Sargassum wightii* and 1.0% *Ulva lactuca*, although the highest concentrations inhibited the plant's development due to stress and leaf wilting (Sivasankari Ramya et al., 2010). The number of branches and concentration of photosynthetic pigments increased after SLF treatment (Sridhar and Rengasamy, 2010).

The application of seaweed extracts improved crop yield, seed germination, and seedling growth. Nerissa Ali (2016) observed the effect on grown under tropical field conditions with an alkaline seaweed extract made from *Ascophyllum nodosum* (ASWE) on tomato plants (*Lycopersicum esculentum* Mill).

The effect of *Gracilaria corticata* J. Ag., *Kappaphycus alvarezii*, and a combination of both as biopriming agents, which alters the responses of brinjal and tomato vegetable seeds germination, was shown to be most effective at 4% concentration in all treatments (Rinku, 2017). At low level of seaweed liquid fertilizer application was promoted the seed germination and *Gracillaria corticata* extract was better than *Caulerpa peltata* 4% concentration of growth and pigment content (Chitra and Sreeja, 2013).

Hashmath Inayath Hussain., (2021) observed the effect of seaweed extract on tomato plant growth, productivity and soil. He found that the effect of SWE on plants significantly increased numerous plant growth parameters: number of flower clusters and flowers, fruit number, dry weight of foliage and roots and root length.

E. Seaweed Biostimulants Increases Biochemical Component in Plants

The SLF contains carbohydrates (alginate, laminarin, mannitol), protein, aminoacids and organic nitrogen (Verkleij, 1992). Apart from these, it also contains Plant Growth Regulators (PGRs). Seaweed extracts contain naturally occurring auxins, cytokinins and gibberellic acids. The presence of auxin was demonstrated in *Ascophyllum nodosum*. *Laminaria spp*. (Mowat, 1964) and *Sargassum polycystum* (Sumera and Cagipe, 1981). Indole acetic acid was identified in *A. nodosum* by Kingman and Moore (1982) and Boye and Dougherty (1988). The presence of cytokinins in seaweeds and in commercial seaweed products was first demonstrated by Brain et al. (1973) and confirmed in many other studies (Blunden 1977; van Staden and Davey 1981; Tay et al., 1985, 1987).

The liquid extract of brown alga *Hydroclathrus clathratus* increased chlorophyll a and b contents of the leaves of *Sorghum vulgare* (Ashok et al., 2004). Iron, copper and magnesium are the essential elements which act as catalyst for the synthesis and maintenance of chlorophyll (Paul and Nangkynrih, 1996). Nickel at low level also increases the chlorophyll (Narwal et al., 1996). The aqueous extract of *Ascophyllum nodosum* applied as foliar spray enhanced leaf chlorophyll levels in tomato, wheat, barley and maize (Blunden et al., 1997). Anantharaj and Venkatesalu (2001) reported that seaweed liquid fertilizer from *Caulerpa racemosa* and *Gracilaria edulis* treated on *Vigna catjang* promotes the total chlorophyll content at lower concentration. Anantharaj and Venkatesalu (2002) have shown that the seaweed extracts *Caulerpa racemosa* and *Gracilaria edulis* on *Dolichos biflorus* enhances the total chlorophyll content at lower concentration. The SLF prepared from the green seaweed *Ulva lactuca* enhanced the total chlorophyll, chlorophyll a, chorophyll b and cytokinin content in *Vigna unguiculata*.

The SLF prepared from the green seaweed *Ulva lactuca* enhances the total protein content of *Spirulina platensis*. Anantharaj and Venkatesalu (2001, 2002) reported that the SLF on *Vigna catjang* and *Dolichos biflorus* enhances the protein content at lower concentration (10%). In *Zea mays* and *Phaseolus mungo*, 1% and 0.5% concentrations respectively increased the photosynthetic pigment, free amino acids, leaf soluble protein and starch (Lingakumar et al. 2004). Nedumaran and Perumal (2005) reported that 0.75% concentration of liquid seaweed fertilizer from *Padina boergesenii* increased the content of total sugar, protein and amino acid in *Sesamum indicum*. Higher concentrations of the extract found to be inhibitory in all the parameters.

Dubey and Singh (1999) reported that the contents of total reducing and nonreducing sugars increase in shoots of rice plants of the salt sensitive cultivars more markedly than in salt tolerant ones. Anantharaj and Venkatesalu (2001) reported that the seaweed extract from *Caulerpa* and *Gracilaria* promotes the reducing and total sugar content in *Vigna catjang*. The storage cells of *Phaseolus vulgaris* contain extensive reserves of protein and starch that are hydrolysed during the early stages of germination.

Himani Patel., (2019) reported that significant effect of treatment with seaweed extract from *Ulva lactuca* on bio-chemical parameters of Chlorophyll a, b & Total, carotenoid, protein and carbohydrate.

F. Seaweed Utilizing in Another Field

Seaweeds are used as a source of food, in industrial applications, and as fertiliser in many maritime nations, particularly in Asia, Japan, Korea, and China. Seaweeds are currently used as human meals, cosmetics, fertilisers, and to extract industrial chemicals and gums. In Japan, kombu and kombu in Chinese (The common food item with low cost but highly nutritious) is used in the preparation of soups, fish, meat dishes and also as a vegetable with rice. Algo therapy is a science in which, seaweed extracts are used in health or beauty treatments. At the end of the 19th and the start of the 20th centuries, seaweed baths were a common feature of coastal resorts in numerous southern and western regions. Arthropathy, rheumatism, and other aches and pains can be treated with seaweed baths. Seaweeds contain strong anti-inflammatory and antioxidant characteristics that are essential in the fight against a number of illnesses, including cancer, atherosclerosis, chronic inflammation, and cardiovascular disease as well as the ageing process. Seaweeds are not only utilised in the pharmacological and medicinal use but also used in Poultry and cow husbandry. It has a good water-binding capacity. It improves product yields, boosts texture, replaces fat better, and aids in analogue seafood binding. It is used in dairy products such low-fat cheese and cheese alternatives, frozen desserts, flans, puddings, chocolate milk, and UHT milk. Moreover, it offers milk stability, emulsion stability, milk gelling, and cocoa suspension.

II. CONCLUSION

This review article involved a thorough study of different literatures from India as well as from world scenario. The main objective of writing this review is to provide information about seaweed resources in India and Gujarat and uses or application of seaweed both in past and present scenario in agriculture sector. For better understanding, distribution and resources were developed according to coastal areas. This is an attempt to provide information in the field of science and awareness for a common man and farmers about such a great noble resource. Essential vitamins, trace elements, proteins, lipids, polysaccharides, enzymes, fibers, ash, phenol and minerals are mostly present in seaweeds. Growth promoting substances released by biostimulants improve plant's physiological & biochemical parameters. In addition to these advantages, biostimulants are commercially promising too. They are comparably less expensive than chemical fertilisers.

III. ACKNOWLEDGMENT

I am very thankful to my Ph.D. Guide Dr. Shailesh Mehta, Sir P.P. Institute of Science, Bhavnagar for guidance and moral support of my work.

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