Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI: 10.21474/IJAR01/4941
DOI URL: http://dx.doi.org/10.21474/IJAR01/4941

RESEARCH ARTICLE

A REVIEW: SCOPE OF UTILIZING SEAWEED AS A BIOFERTILIZER IN AGRICULTURE.

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Manuscript Info

Manuscript History

Received: 24 May 2017
Final Accepted: 26 June 2017
Published: July 2017

Key words:-
Biofertilizer, seaweed, bio-diversity, nutrient content, micro- macro elements

Abstract

Biofertilizers offer a new eco-friendly technology which would overcome short comings of the conventional chemical based farming. Biofertilizers showed positive influence on both soil sustainability and plant growth. Biofertilizers are not only the alternative to chemical fertilizers but also tend to increase the soil fertility and plant productivity which discuss in present review study. Seaweed plays an important and vital role in the marine ecosystem and growing in large amount in the sea. Seaweed can be regarded as a potential source of bio-fertilizer in of dried or fresh form; it helps to enhance biochemical constituents like carbohydrates, lipids, proteins, fibers, ash, phenol, dietary fiber etc in plant. The seaweed also good source of micro & macro elements required for plant nutrition. Seaweed extract is effective for improves the quality of produce and soil conditioner. This technology can be implemented in form of organic farming for sustainable agriculture which is better solution for eco friendly approach.

Introduction:-

All plants need certain minerals nutrients to survive in environment. These minerals occur naturally in the soil and are taken up from the soil by the roots of the plants. Most soil usually has enough of these minerals to keep plants healthy. However, plants are gradually absorbed some nutrients or nutrients are washed out of the soil, and need to be replaced to maintain optimal growth and development of the plants. Most common mineral nutrients that need replacing are N, P, K. Fertilizers are manufactured by mixtures of products that contain N, P, K and other necessary nutrients. The fertilizers are necessary to add in the soil because the nutrients in the soil get used up due to repeated cultivation of the plant. The crop yield also starts decreasing so, in order of revive the fertility of the soil, fertilizers are necessary. Fertilizers are divided in two types: (1) Chemical fertilizers and (2) Organic fertilizers.

The excessive uses of chemical fertilizers (man - made or synthetic composition) in agriculture are costly with adverse effects on physico-chemical properties of soils, plant, animal and human life. Chemical fertilizers are more resistant in the environment which in some cases is harmful to the environment- especially, on soil fertility and are actually causing huge amount of soil and land degradation (Liu et al., 2009) because most of the microorganism

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decrease following the use of chemical fertilizers in increasing level (Katsunori, 2003). The ground water contamination is the biggest issues faced during the use chemical fertilizers. In the soil nitrogen fertilizers breaks down and converts into nitrates which are water soluble and travels easily through the soil and they can remain in that position for decades and these accumulation is causing the problem. These accumulations of chemicals lead to water pollution both surface and ground water.

Organic fertilizers are derived from natural products, which were once living organisms. Organic fertilizers are generally slow-acting because they have to decompose and to become plant nutrients; however, this also means their benefits are longer lasting. All natural nutrients to soil, increases soil organic matter, improves soil structure and improves water holding capacity, reduces soil crusting problems, reduces erosion from water and wind, slow and consistent release of nutrients.

Biofertilizer:-

The term of biofertilizer represent everything from manures to plant extracts. Biofertilizers consist of N fixers (Rhizobium, Azotobacter, blue green algae, Azolla), phosphate solubilizing bacteria (PSB) and fungi (mycorrhizae) which increase the supply or availability of macro (primary & secondary nutrient) and/or micro nutrients (growth stimulus) to the target crop. Biofertilizers have shown great potential as a, renewable and environmental friendly source of plant nutrient. Biofertilizers are ready to use and used as a live formation of beneficial microorganisms, when it amended to seed, root or soil, it mobilizes the availability and utility of the microorganisms and thus the power to improve the soil health and genesis to support microbial growth and vegetation.

Seaweed as a bio- fertilizer:-

Seaweeds are one of the most important marine sources of the world. The seaweed extract is available as fertilizer in different forms such as SLF (Seaweed Liquid Fertilizers), LF (Liquid Fertilizers) and powder form of seaweed manure have been used as a biofertilizer. In market, seaweed extracts available for several years as fertilizer additives and beneficial results from their use have been reported (Booth, 1969).

The components of seaweed such as macro and micro- element nutrients, amino acids, vitamins, cytokinin, auxins, and abscisic acid (ABA)- like growth substances affect cellular metabolism in treated plants to enhance growth and crop yield. The use of natural seaweed as fertilizer has allowed for partial substitution of prevailing synthetic fertilizer. Some studies have reported a wide range of beneficial effects of seaweed extract applications (like soil drench, foliar spray, soil drench+foliar spray) on plants, such as improving moisture- (water holding capacity) and by promoting growth of beneficial soil microbes enhanced soil health, which are conditioning substances of secretion of soil and which are promote root growth and development, improve nutrient uptake by roots, promote rooting of cutting, early flowering and increase fruit set & yield, elicit abiotic stress tolerance in plants, nematodes, enhance defense against pests and diseases, bacterial and fungal pathogens.

Nutrient content and Bio-chemical parameter of Different seaweeds:-

Table 1:- 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	Reference
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 obtuse	R	3.9	3.8	2	Safinaz and Ragaa *et al.*, 2013
Corallina elongate	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 2:- The comparison of different seaweed bio-chemical parameters review as per some references

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	142.94	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

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

Table 3:- The comparison of micro and macro 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

Review of literature:-

Role of seaweed extract on seed germination, plant growth and yield:-

The treatment of seaweed extract increased the seed germination, seedling growth and yield of crop. Nerissa Ali *et al*. (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). In this study, two field experiments and one greenhouse experiment were conducted to evaluate methods of application, dosage, the impact of each on plant growth parameters, the quality and yield of fruit. The higher concentration of ASWE resulted in a significant increase in plant height (37 %) and plant fruit yield (63 %) compared to control plants.

Rosalba Mireya Hernández-Herrera *et al*. (2014) have experimented the effect of different concentration of (0.2, 0.4, and 1.0 %) liquid seaweed extracts (LSEs) made from two green seaweed viz. *Ulva lactuca*, *Caulerpa sertularioides* and two brown seaweed viz. *Padina gymnospora*, and *Sargassum liebmannii* as biostimulants on the germination and growth of tomato (*Solanum lycopersicum*) under greenhouse and in laboratory conditions using two application of foliar spray and soil drench of LSEs. *Ulva lactuca* and *Padina gymnospora* at lower concentration (2%) showed better germination. The better germination response in germination rate related with lower mean germination time, maximum germination index and germination energy, and accordingly greater plumule and radicle length and seedling vigour. Application of foliar spray was found to be less effective in plant height (75cm) than the soil drench (up to 79cm).

Sivasangari Ramya *et al*. (2015) studied the effect on growth, biochemical and yield of brinjal by using liquid extracts of brown marine alga *Stoechospermum marginatum*. The different concentrations of liquid extracts were prepared and applied as foliar spray on the brinjal seedlings, raised in pots experimental with maintained under natural conditions. Their results revealed that the number of fruits and fruit weight were increased at lower concentration only (1.5 %). In contrast, liquid extracts at high concentration (5%) was found to have inhibitory effect on brinjal plants as compared to the control sprayed with water.

Sutharsan *et al*., (2014) were experimented the effect of foliar application of *Sargasssum crassifolium* extract at different concentration (concentration (10%, 20%, 50% and 100%) to apply on tomato plants at five times from 3 weeks after transplanting and the results was recorded after two weeks. At 20% of root dry weight (81.57%), shoot dry weight (80.92%), fruit number (57.87%) and fruit yield per hectare (58.70%), along with fruit total acidity (76.95%) and total soluble solids content (25.71%) of fruit significantly increased as compare to control, while all mentioned parameters reduced at 100% of foliar application. Therefore, it concluded 20% concentration of seaweed extract an be used to enhance the growth.

Safinaz and Ragaa, (2013) observed the effect of three species of red marine algae (*Laurencia obtusa*, *Corallina elongata* and *Jania rubens*) and it's mixture to use as biofertilizer to enhance growth of Maize (*Zea mays* L.) plants. The results indicated that the application of *Laurencia obtusa* + *Jania rubens* caused 48.21% increase in plant length, 61.84% increase in potassium content and increase in number of leaves.

Emmanuel *et al*., (2015) were determined the impact of seaweed liquid extract (SLE) of *Laurencia pinnatifida*, *Surgassum duplicatum* and *Caulerpa scalpelliformis* on seed germination and growth of the legume crop of *Vigna mungo. The effect on growth parameters of* different concentrations (5, 10, 20, 40, 60, 80 and 100 %; v/v) of SLE and the highest growth parameter was reported at 10 % concentration.

Mounir *et al*., (2015) were experimented the effect of seaweed extract (SWE) from two macroalgae species such as *Ulva rigida* and *Fucus spiralis* on drought stress tolerance in green bean plants (*Phaseolus vulgaris* L.). In their study, examination of growth parameters and some physiological and biochemical parameters showed that SWE extract enhanced vegetative growth with and without under drought stress condition in bean plant. Maximum plant height and dry weight were observed with 25 % of *U. rigida* and *F. spiralis* extract.

Fatma *et al*., (2014) were conducted the efficiency of using seaweeds (*Padina vickersiae*, *Enteromorpha compressa*, *Ulva fasciata*, *Gelidium crinale*, *Jania rubens and Laurencia obtusa*) as biofertilizers for improving growth and grain quality of maize (*Zea maize* L.) plants. Thus, using algae as biofertilizer improved growth, yield and grain quality of maize plants.

Rao and Chatterjee (2014) were observed the effect of Seaweed Liquid Fertilizer (SLF) of *Gracilaria textorii* and *Hypnea musciformis* on seed germination, growth and yield parameters such as number of leaves, weight of fruits of selected plants such as Brinjal, Tomato and Chilly and result to be effective in increasing the growth and yield in low doses (1:4 and 1:6 conc.) than 1:2, higher concentrations and the control of Seaweed Liquid Fertilizer.

Rinku *et al*., (2017) were determined the effect of *Gracilaria corticata J Ag., Kappaphycus alvarezii* and mixture of both as a biopriming agents (different concentration of 1%, 2%, 3%, 4% & 5%), that alters the responses of brinjal and tomato vegetables seeds germination and better results was found at 4% concentration in all treatment.

Deviand and Mani (2015) conducted the different concentration of (2.5%, 5.0%, 7.5%, 10% and 15%) of fertilizer of seaweed saps *Kappaphycus alvarezii* and *Gracilaria sp.* on growth, yield and quality of rice Var. ADT 43 and significantly higher growth, yield attributes and chlorophyll content were recorded at 15% *Kappaphycus alvarezii* sap with 100% RDF (Recommended Dose of Fertilizer) as compare to *Gracilaria sp.* sap with 100% RDF and the grain was increased in both seaweed fertilizer treatment as compare to control.

Chitra and Sreeja (2013) studied the effect of *Caulerpa peltata* and *Gracillaria corticata* liquid extracts on seed germination, growth and pigment content of green gram (*Vigna radiata* (L.). At low level of seaweed liquid fertilizer application was promoted the seed germination and *Gracillaria corticata* extract was better than *Caulerpa peltata*at 4% concentration of growth and pigment content.

Zodape *et al*., (2011) have determined the effect of *Kappaphycus alvarezii* sap (seaweed) with 5% concentration by foliar spray on growth and yield of tomato in field during Kharif season of 2006-07. The result was reported to increase in number of fruits per plant, size of fruit and yield of tomato fruit (60.89%) as compared to control.

El-Sheekh *et al*., (2000) were experimented the effect of three green seaweeds viz. *Cladophora dalmatica*, *Enteromorpha intestinalis*, *Ulva lactuca*and three red seaweeds viz. *Corallina mediterranea*, *Jania rubens*, and *Pterocladia pinnata* seaweed extracts on seed germination, seedling growth and some metabolic processes of 'Fabe beans' (*Vicia faba* L.). The crude extract from *Cladophora dalmatica* applied shows maximum increase in seed germination, length of main root and shoot system and number of lateral root at 60% treatment. Protein content in root and shoot systems, total soluble sugar and chlorophyll content of leaves increased in all crude extract of seaweed. The cytokinin content of red seaweed was lower than in green seaweed.

Zodape *et al*., (2008) found effect of different concentration of (2.5%, 5.0%, 7.5% and 10.0%) to obtain from *Kappaphycus alvarezii* onyield and quality. In the result, significantly increased in length (31.77%) and diameter (18.26%) of fruit, number of fruits (37.47%) and fruit yield (20.47%) per net plot and nutritional quality of Okra(*Abelmoschus esculentus* L.) as compared to control.

Ayun Vinuba *et al*., (2008) were found the beneficial effects of liquid seaweed fertilizer (LSF) made from *Gracilaria corticata* on seedling growth and biochemical parameters of pulses and cereals. LSF at 20% concentration increased the morphological parameters such as the lengths of shoot and root fresh and dry weight, the pigment of chlorophyll and protein contents *Vigna mungo* (black gram).

Rajasulochana *et al*., (2008) were found the effect of *Ulva lactuca* extract on the growth of *Brassica juncea* Hook. F, *Phaseolus mungo* L. and Thomas and *Trigonella foenum* graceum L. In this experiment, positive response showed in *Phaseolus mungo* and to promote over all seedling growth of the three test plants. The application of extract was found to promote over all seedling growth of the three test plants.

Thirumaran *et al*., (2009) were experimented the effect of seaweed liquid fertilizer (SLF) of *Rosenvigea intricate* alone or mixing with synthetic NPK chemical fertilizer on seedling growth parameters, pigment contents, yield and soil characters of 'Ladies finger' [*Abelmoschus esculentus* (L) Medikus].Before sowing, the seeds of selected plant were soaked in SLF of different concentrations (10 to 100%) for 12 hrs. The result shows that SLF of low concentration 20 % promoted seedling growth, fruit yield and pigment contents and at higher concentrations of SLF was noted minimum improvement in growth parameters.

Dogra and Mandradia (2012) was determined the effects of soil applications of different concentrations of seaweed extract from *Ascophyllum nodosum* on growth, yield and downy mildew severity of onion during the Rabi season of

2009. The seaweed granules were applied as the basal dose (1.5, 2.0, 2.5, 3.0 & 3.5 g/m^2). The highest yield recorded was with application of $2.5g/m^2$ followed by $3.0g/m^2$ that resulted in 120.8 per cent and 102.5 per cent respectively compared to control.

Sridhar and Rengasamy (2002) were experimented the effect of seaweed liquid fertilizer derived from the green seaweed *Ulva lactuca* to check its effect on physical & biochemical parameters and yield of *Capsicum annum* (Chilly). The seaweed extract was resulted to improve maximum growth and yield at 1.0% concentration of SLF.

Conclusion:-

As per the above review studied seaweeds can be utilized as an excellent source of macro & micro nutrients, fibers, ash, phenol, carbohydrates and higher content of plant growth hormones. Growth promoting substances released by biofertilizers improve plant's physiological & biochemical parameters. In addition to these advantages, biofertilizers are commercially promising too. They are also comparatively cheaper than the chemical fertilizers.

Acknowledgement:-

The authors are thankful to principal of our college Dr. B. D. Patel Sir for their thorough support & guidance.

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