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Seaweed: A Novel Organic Biomaterial

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Authors' contributions

This work was carried out in collaboration among all authors. Author NV designed the study and wrote the first draft of the manuscript. Author ARS guide the work. Authors DP and BKP managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The seaweeds are macroscopic living resources having significant amount of growth regulators, macronutrients as well as micronutrients which are essential for the growth of crop plants. The fertilizers that are derived from seaweeds are known as new generation fertilizers or modern fertilizers which are devoid of harmful effects of chemicals. Seaweeds contains considerable amount of nutrients which are easily absorbed by plants hence beneficial for the positive growth of crop plants. In the present situation seaweeds are found to be more suitable to crop plants to increase growth parameters as compared to chemical fertilizers. The positive effects of seaweed have been observed in many crops like *Cajanus cajan*, *Abelmoschus esculentus*, *Arachis hypogea*, *Cyamopsis tetragonoloba*, *Lablab purpureus*, *Cicer arietinum* etc. This review helps in encouraging the students and research scholars towards the uses of different seaweeds on growth and development of many crop plants.

Keywords: Seaweed; crop plant; fertilizers; nutrients.

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1. INTRODUCTION

The word seaweed means the large marine algae (macroalgae or seaweed) that grow almost entirely in the shallow water. Seaweeds are the plants having thalloid body (body is not differentiated into root, stem and leaves and not having complex conducting tissues) and synthesis their food through photosynthesis [1]. Because of thalloid or simple body as compared to land plants, these absorb require nutrients from their surrounding water. The seaweeds are classified into mainly three groups on the basis of pigments and synthesizing food namely green algae (Chlorophyta), red algae (Rhodophyta) and brown algae (Phaeophyta). To call these seaweeds are “weeds” is totally incorrect because these are so beneficial in nature and directly more useful to human. Seaweeds are rich in macronutrient as well as macronutrient, proteins, vitamins, lipids, carobohydrates etc. Seaweeds have been used as phycocolloid extraction (agar, alginic acid and carrageenan), cattle feed, food, manure and [2]. In many countries like china and Japan seaweeds are harvested as staple food. Recently seaweeds are used in cosmetics, pet food, stabilizers, emulsifiers, gelling agents, cloth dyeing, to flavour milk, pizza toppings and ingredient of toothpaste and dental moulding [3,4]. From the red seaweeds a jelly like compound “Agar” is obtained that is used as irreplaceable medium in laboratory to culture explants, bacteria and fungi for research programs [5].

2. SEAWEED FERTILIZER

The fertilizers that are derived from seaweeds are known as seaweed fertilizer. The seaweed fertilizers contain growth promoting hormones, vitamins, antibiotics and all essential amino acids that increase seed germination, microbial and insect resistance so quantitatively as well as qualitatively increase yield of crops [6,7,8]. In fertilizers from seaweeds the basic nutrients (N, P and K) are present in adequate amount that make it suitable fertilizer for crop plants. Seaweed acts as excellent activator when added into the soil in the form of mulch and compost heap and changes soil physical and biological properties that are beneficial for plant growth [9, 10,11]. The alginate oligosaccharides in seaweed help in binding of soil particles and trace elements together. The seaweed manure improves the soil texture by increasing water holding capacity and by adequate supply of essential nutrients [12].

The fertilizers that are derived from the seaweed are more superior to chemical fertilizers because chemical fertilizer makes soil acidic so decrease the fertility of soil. On the other the organic fertilizers that derived from seaweed (*Ascophyllum*, *Sargassum*, *Fucus*, *Ecklonia maxima* etc.) are nontoxic, easily degradable, eco-friendly and favourable to birds, animals and human [13]. In areas where fresh seaweed is not available easily the dried seaweed in the form of 'concentrated liquid meal' is available on cheap prices. In India many brands of seaweed fertilizers are available like Biovita, Kelpak 66, Shaaktizyme, Seagrow, Plentozyme, Maxicrop, Algifert etc [14]. In modern techniques an adequate amount of fertilizer is sprayed on roots and shoots (foliar). There are many methods of preparation of Seaweed Liquid Extract (SLE) from seaweeds. Firstly seaweeds were collected from the coastal regions. These were gathered in netted basket to removal of all sea water. After this the seaweeds were washed with water to remove all impurities, dirt and any contamination. After this the seaweeds were finally chopped and boiled for 50-60 min. Then the material was cooled down and filter through paper or cloth. This concentrated extract was taken as 100% Seaweed Liquid Extract (SLE) [15,16,17,18].

3. EFFECT ON RHIZOSPHERE COMMUNITIES

Besides increasing growth of plants and water holding capacity of soil seaweeds also increase microbial community of soil that are beneficial for plant growth. However limited data is available on beneficial effect of seaweed on of soil micro fauna. The alginates of seaweed increase growth of vesicular arbuscular mycorrhizal (VAM) that increase growth in orange seedlings [19]. Red and green algal extracts increase mycorrhizal infection which as a result increases growth in *Carica papaya* and *Passiflora edulis* [20].

4. EFFECT OF SEA WEED ON DIFFERENT PLANTS

India is a developing agricultural country approximately; 70% population of rural area makes backbone of Indian economy. The fast-growing population in country develops tremendous pressure on food production. To meet the needs of this increased demand

Table 1. List of different seaweed with their effects on plants

S. No	*Seaweed*	Common name	*Scientific name*	Effects on plants	Reference
1.	*Sargassum tenerrimum*	Horse gram	*Dolichos biflorus*	Better results in all aspects of growth and yield	[21]
2.	*Laurencia obtuse*	Maize	*Zea mays*	Enhance yield of maize plants	[22]
3.	*Kappaphycus alvarezii* and *Hydropuntia edulis* (formerly *Gracilaria edulis*)	Wheat var. 'GW 496'	*Triticum aestivum*	Increase in yield and nutrient contents in grains	[23]
4.	*Sargassum myryocystem*	Lady's fingers or bhindi	*Abelmoschus esculentus*	Increase in organic, photosynthetic and protein content	[24]
5.	*Kappaphycus* and *Gracilaria*	Green gram	*Phaseolus radiata*	Improved crop quality and nutrient uptake	[25]
6.	*Ascophyllum nodosum*	Snap bean	*Phaseolus vulgaris*	Fresh and dry weight of leaf and stem	[26]
7.	*Ascophyllum nodosum*	Tomato	*Lycopersicon spp.*	Increase in Germination and Seedling Growth of Tomato	[27]
8.	*Sargassum myriocystum*	Black gram	*Vigna mungo*	High protein and reducing sugar content in seedling and increased α and β amylase activity in shoots	[4]
9.	*Sargassum wightii Ulva lactuca*	soyabean	*Glycine max*	Increased seed germination and growth rate	[28]
10.	*Ulva lactuca*	chilli pepper, bell pepper or paprika	*Capsicum annum*	Sugar, chlorophyll and protein content increased	[29]
11.	*Ecklonia maxima* and *Saragassum spp*	Maize	*Zea mays*	Induced seed germination	[30]
12.	*Sargassum wightii*	Peanut or groundnut	*Arachis hypogea*	Increased biochemical and pigment content	[31]
13.	*Caulerpa recemosa Gracilaria edulis*	Cow pea	*Vigna catajung*	Increased seedling, fresh and dry weight	[32]
14.	*Dictyota dichotoma*	lady's fingers or bhindi	*Abelmoschus esculantus*	increased biomass of leaf, roots, flowers and fruits	[33]
15.	*Padina pavonica.*	Green gram	*Vigna radiata*	Increased seed germination, growth and yield	[34]
16.	*Ascophyllum nodosum*	Cucumber	*Cucumis sativus*	Reduce fungal diseases	[19]
17.	*KELPAK Ecklonia maxima*	Irish potatoes	*Solanum tuberosum*	increase vigour by increasing rooting system that results more tuberisation	[10]

S. No	*Seaweed*	Common name	*Scientific name*	Effects on plants	Reference
18.	*Padina tetrastromatica* and *Sargassum linearifolium*	black mustard	*Brassica nigra*	Increased content of amino acid, protein and carbohydrate	[35]
19.	*Sargassum wightii*	Sunflower	*Helianthus annuus*	Increased biochemical and antioxidant content	[36]
20.	*Sargassum wightii*	Marigold	*Tagetes erecta*	Increased height as well as number of branches	[37]
21.	*Kappaphycus alvarezii*	Green gram	*Phaseolus radiata*	Improved nutritional value and yield	[8]
22.	*Ascophyllum nodosum*	Mouse-ear cress	*Arabidopsis thaliana*	Improved root and shoot growth	[13]
23.	*Ulva lactuca*	Cowpea	*Vigna unguiculata*	Increase in fresh and dry weight	[38]
24.	*Chaetomorpha linum*	Tur dal	*Cajanus cajan*	Improved root and shoot length and organic content	[39]
25.	*Sargassum wightii*	Asian rice Kidney bean Black gram Peanut	*Oryza sativa* *Lablab purpureus* *Vigna Mungo* *Arachis hypogea*	Better results of root and shoot	[40]
26.	*Rosenvigea intricata*	Lady's fingers or bhindi	*Abelmoschus esculentus*	Increased yield and pigment content	[6]
27.	*Rosenvigea intricata*	Gavar, Guwar or Guvar bean	*Cyamopsis tetragonoloba*	Improved growth	[37]
28.	*Ulva lactuca* (formerly *Ulva fasciata* and *Caulerpa racemosa*)	Common beans	*Phaseolus vulgaris*	Better yield	[41]
29.	*Laurencia obtusa, Padina tetrastromatica* and *Stoechospermum polypodioides* (formerly *Stoechospermum mariginatum*)	Tea	*Camellia sinensis*	Increased quality and productivity	[6]
30.	*Hydroclathratus*	Durra or jowari	*Sorghum*	Increased growth	[42]
31.	*Ulva intestinalis* (formerly *Enteromorpha intestinalis*)	Sesame	*Sesamum indicum*	Increased seed germination, chlorophyll and root, shoot length	[43]
32.	*Codium lyengarii* (formerly *Codium iyengarii*)	Gram Sunflower spinach	*Cicer arientinum* *Helianthus annuus* *Spinacea oleracea*	Increased yield, nutritional values and resistance against diseases	[44]

S. No	*Seaweed*	Common name	*Scientific name*	Effects on plants	Reference
33.	*Cladophora dalmatica, Ulva lactuca, Jania rubens* and *Pterocladiellacapillacea*(formerly *Pterocladia pinnata*)	Broad bean or faba bean	*Vicia faba*	Increased protein content	[45]
34.	*Ulva lactuca, Sargassum wightii* and *Gelidella Acerosa*	Ragi	*Eleusine coracana*	Induced germination root and shoot growth	[1]
35.	*Kelpak 66 Ecklonia maxima*	Table beet or red or golden beet	*Beta vulgaris*	Plants grew significantly better	[46]
36.	*Hypnea musciformis, Spatoglossum asperum, Stoechospermum polypodioides* (formerly *Stoechospermum marginatum*) and *Sargassum*	Red pepper Turnip pineapple	*Capsicum frutescens* *Brassica rapa* *Ananas comosus*	Enhanced the rate of seed germination	[12]
37.	*Sargassum wightii*	Zunna berry	*Ziziphus* rugosa	Increased fruit yield	[18]

farmers, use chemical fertilizers to increase the yield of crops. Chemical fertilizers release various toxic metals (arsenic and cadmium) which are stored in plant products and cause many health-related problems through biomagnifications [47]. The fertilizers that are derived from seaweeds act as biostimulants for crop plants. The term 'biostimulant' is totally opposite to fertilizer, the biostimulants is also known as 'metabolic enhancers' that increase the growth of plants when applied in small quantity [8]. Nowadays, natural seaweed products are used in replace of chemical fertilizers that increase plant growth, delay fruit senescence and provide ability to crop plants to withstand against adverse environmental conditions [46]. The effective elicitors that are present in algal polysaccharides provide defence to plant against many plant diseases [17]. In brown seaweeds (*Ascophyllum sp.*, *Fucus sp.*, *Saccharina sp.*) have laminaran and alginate polysaccharides that play important role in biological activity [48, 20,49].

5. SIGNIFICANCE OF THE STUDY

Seaweed fertilizer is suitable for all crops and for most methods of applications Physiological mechanism of action of compounds present in seaweed can be of immense help to use seaweed as a source of organic fertilizer.

- Increased yield quantity and seed germination
- Improved overall vigour and ability to withstand adverse environmental conditions
- Biodegradable, non-polluting and non-hazardous
- Supply adequate trace elements
- Effective elicitors in seaweed help the plant defence against plant diseases
- Excellent biofertilizers as compare to chemical fertilizers

6. CONCLUSION

A number of researches have been done by many researchers in all parts of world to know various bioactive compounds in seaweeds. These bioactive compounds play active role in plant growth as well as in medicinal, pharmaceutical and industrial uses. The present review gives information of seaweed as an effective fertilizer compared to chemical fertilizer but more research is needed that provide information of seaweed secondary metabolites (flavonoids, steroids, alkaloids) that have many medicinal and insecticidal use.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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