



Review Article

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Harnessing Marine Algae Potential in Sustainable Crop Production



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Abstract

Modern based agricultural technology that results in higher production should also have the ability to reduce the negative environmental impact and augment the sustainability of the system. Use of bio-stimulants like seaweed extracts, the marine bioactive substances extracted from marine algae has great future in agricultural and horticultural crops production compared to conventional mineral fertilizers. Seaweed is amply rich in carbohydrates; which is good food source of many beneficial micro-organisms and unlike conventional forms of fertilizers, being a wealthy source of natural plant hormones viz. auxins, gibberellins, endogenous cytokinins etc; betaines and other growth-promoting substances. Being rich source of micro and almost all micronutrients in fully chelated form, seaweed fertilizers are especially useful in organic farming. All these are found in fresh seaweed or dried seaweed meal as well as liquid seaweed extracts. Seaweeds saps extracted from *Kappaphycus* and *Gracilaria* promises superior crop growth, yield and quality of many agricultural crops.

Keywords: Seaweed; Crop production; Soil fertility; Crop quality

Introduction

The downside of fertilizers is that some portion inevitably washes into waterways along with eroded sediments. This nonpoint source runoff occurs nationwide and the nitrogen fertilizer finds its way into rivers, lakes and the ocean where it causes eutrophication and “dead zones” that kill aquatic life. Eutrophication is a process whereby nitrogen feeds an algal bloom; but when the short-lived algae die, decomposing bacteria consume most of the available oxygen and thus suffocating the aquatic life. Runoff of synthetic fertilizer can enter the waterways, causing water to be polluted and to lose oxygen. Over time, chemical fertilizers can degrade the quality of the soil by building up toxins or leaching away natural nutrients, making the soil unfit for growing plants. Farmers who experience routine exposure to pesticides have exhibited neurological symptoms such as headache and hand tremors. Children, in particular, may be more susceptible to negative effects resulting from pesticide exposure. Pesticide runoff can have devastating effects on non-target organisms as well. For example, Roundup, a widely popular herbicide used in agriculture, is highly toxic to fish and amphibians. The National Coalition for Pesticide-Free

Lawns says, “Of 30 commonly used lawn pesticides, 19 are linked with cancer or carcinogenicity, 13 with birth defects, 21 with reproductive effects, 26 with liver or kidney damage, 15 with neurotoxicity, and 11 with disruption of the endocrine system”.

In India agro-chemicals account for as much as 25% of all occupational injuries in the agricultural sector and 15% of all fatal injuries. 69.4% pesticides are used in agrarian sector of India whereas in case of public health 30.6% pesticides are used. The ill impacts of excessive pesticide uses are the contamination of the environment, soil and ground water causing serious human health hazards vis-à-vis narrow nutrient holding capacity, severe micronutrient deficiency and sharp declination in carbon stock of soil. All these things ultimately offer directly or indirectly more and more crucial problems to the environment ultimately acting as some of the important agents in changing the climate as a whole.

It is the high time for reshaping our present package of practices in agriculture and introducing some alternative approaches to mitigate the hectic hazards of changed climate

vis-à-vis sustaining the food security. One such approach is the use of bio stimulants, which can enhance the effectiveness of conventional mineral fertilizers. The bioactive substances extracted from marine algae are used in agricultural and horticultural crops, and many beneficial effects may be attained in terms of enhancement of yield and quality. Some of such marine algal members are *Kappaphycus*, *Laminaria*, *Ulva lactuca*, *Haliotis tuberculata*, *Porphyra*, *Macrocystis pyrifera*, *Alaria esculenta*, *Lithothamnion corallioides*, *Phymatolithon calcareum*, *Ecklonia*, *Agars*, *Fucus*, *Andaria*, *Bryopsis*, *Sargrassum*, *Aschophyllum*, *Macrosystis*, *Palmaria*, *Gracilaria*, *Enteromorpha* etc. Liquid extracts obtained from seaweeds have recently gained importance as foliar sprays for many crops including various cereals, pulses and different vegetable species. It supplies nitrogen, phosphorous, potassium as well as trace minerals like Zn, Mn, Mg, Fe, etc. It also contains natural plant growth substances like auxins, gibberlins and cytokinins. As it is an excellent source of almost all plant nutrients, it can substitute the conventional chemical fertilizers to some extent.

The versatile utilities of these marine algae are making them popular day by day. Without mining into detail about the uses of these algae this article will be confined into their importance in the agrarian sector.

Table 1: Chemical composition of *Kappaphycus* sap.

Nutrient	Amount Present	Nutrient	Amount Present
Moisture	94.38g/100ml	Iron	8.58mg/100ml
Protein	0.085g/100ml	Manganese	0.22mg/100ml
Fat	0.0024g/100ml	Nickel	0.35mg/100ml
Crude Fibre	0.01g/100ml	Copper	0.077mg/100ml
Carbohydrate	1.800g/100ml	Zinc	0.474mg/100ml
Energy	7.54Kcal/100ml	Chromium	3.50mg/100ml
Sodium	18.10mg/100ml	Lead	0.51mg/100ml
Potassium	358.35mg/100ml	Thiamine	0.023mg/100ml
Magnesium	116.79mg/100ml	Riboflavin	0.010mg/100ml
Phosphorous	2.96mg/100ml	β-Carotene	0.0mg/100ml
Calcium	32.49mg/100ml	Iodine	160ng/100ml
Indole acetic acid	23.36mg/L	Kinetin+Zeatin	31.91mg/L
Gibberelin GA3	27.87mg/L		

Seaweed saps in soil management

Application of seaweed saps enhance the soil microorganism viz. bacteria, fungi etc and make the moisture more available to the plants. As alginic acid works as a soil conditioner, therefore, its presence in seaweed and seaweed products improves the water holding capacity of soil and facilitates formation of crumb structure. Alginic acid in the seaweed combines with metallic radicals in the soil to form a polymer with immensely increased molecular weight of the type known as cross-linked. Virtually, the salts formed by alginic acids with soil metals swell when wet and retain moisture persistently. Alginates, the sponge-like starches found in seaweeds hold water droplets near the plant roots,

Results and Discussion

Bio-chemical composition of marine algae

Seaweed is amply rich in carbohydrates; which is good food source of many beneficial micro-organisms. Unlike conventional forms of fertilizers, being a wealthy source of natural plant hormones viz. auxins, at least two gibberellins, endogenous cytokinins, betaines including beneficial vitamins like B₁ (thiamine), B₂ (riboflavin), B₁₂, vitamin E (tocopherol), vitamin K, vitamin C (ascorbic acid) as well as pantothenic acid, folic acid and folinic acid; alginic acids; antibiotics; and all essential nutrients in chelated form seaweed fertilizers are especially useful in organic farming. Such chelating properties are possessed by the starches, sugars and carbohydrates in seaweed and seaweed products. For this reason, these components naturally combine with iron, cobalt, copper, manganese, zinc and other microelements present in seaweed. Thus these trace elements in seaweed and seaweed products do not settle out even in alkaline soils, but remain available to the crops which need them. Alginic acid is a soil conditioner and the remainders are plant conditioner. All these are found in fresh seaweed or dried seaweed meal as well as liquid seaweed extracts (Table 1).

making moisture available to them without drowning them. The application of seaweed meal in sloppy land can check the washing away of seedlings and nutrients into the ditch by improving the soil structure. In exceedingly dry period, cultivation of second crop is possible only with the application of seaweed fertilizer, other fields dry out completely [1]. This incidence validates the water-retaining capability of seaweed which in turn leads to better aeration and capillary rise which stimulates the root systems of plants for further growth and thus motivates the soil bacteria. Acceleration in bacterial activity through the soil application of seaweed meal results into the secretion of organic chemical substances like polyuronides that ultimately condition

the soil thoroughly. Polyuronides are chemically similar to alginic acid that has soil-stabilizing properties. Thus seaweed fertilizer provides a couple of conditioning agents to the soil: alginic acid from the un decomposed seaweed in one hand and polyuronides from the soil bacterial secretion in another hand.

Seaweed saps in crop production

Application of seaweed saps have been revealed to be a successful technique to preserve proper plant health and improve the productivity without disturbing the overall ecological balance. It has been noticed that pre-sowing or pre-planting treatment of seed or vegetative part will germinate rapidly resulting in robust root growth and vigorous seedling at early stage. Simultaneously, higher survival rate can also be achieved [2]. Cuttings immersed in liquid seaweed solution produce profuse roots while soaking plant roots in seaweed extract reduces transplant shock and expedites root growth. Some often features of seaweed are frost and stress resistance, enhanced uptake of inorganic constituents from soil, reduction in storage losses of fruits, expansion of shelf life of fruits vis-à-vis vegetables and elongation of life of cut flowers. Seaweed can play an important role in the production of the plant's own auxins, because the enzymes formed with the help of trace elements from the liquid seaweed fertilizer activates auxin release [2]. The gibberellins plays the pivot role in simulating of roots, growth, flower initiation, fruit setting, fruit growth, fruit ripening, abscission and senescence when applied exogenously. The cytokinins available in liquid seaweed extract initiate and activate basic plant growth processes, enhances growth with bigger vigour through mobilising nutrients in the leaves. The betaines help the plants to fight against stress. They play vital role in the osmotic processes by helping the plants in increased water uptake even in dry condition and thus, as if, play the role of oasis in the desert. The antioxidants present in seaweed products effectively prevent lipid oxidation in agricultural produces, retarding the development of toxic oxidation products, maintaining nutritional quality and prolonging the shelf life of such commodities. Seaweed sprays also stimulate metabolic processes in the leaf and also feed the bacteria performing photosynthesis at the leaf surface to a considerable proportion and thus accelerate the process of photosynthesis. Such plants exhibit a resistance to pests and diseases. Owing to the presence of ample amount of soil fungi and bacteria increased production of natural antibiotics occurs in the soil rich in organic matter. These antibiotics taking entry to the plants improve their disease resistance. Seaweed encourages this process and thus holds down the population of plant pathogens.

Analytical studies and facts

Field trials conducted by different universities including Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal in association with Central Salt and Marine Chemicals Research Institute, a sister institute of Council of Scientific and Industrial Research revealed that seaweed can produce amazing

results in plants. Application of liquid seaweed extracts increased yield by 26%, 39%, 57%, 61% and 20% of rice [3], greengram [4], soyabean [5], tomato [6] and okra [7] respectively. Superior yields after seaweed treatments were measured in watermelon [8], wheat [9], Potato [10] and grape [11]. Besides, quality characters of different crops like cereals, pulses, oilseeds and tuber crops are largely influenced. It has also been found that use of seaweed as soil treatment substances results in strong and healthy growth vis-à-vis disease-resistance.

Conclusion

Thus seaweed extracts, the marine bioactive substances extracted from marine algae, without causing any negative environmental impact escalate the production of different agricultural and horticultural crops, improve crop quality and enhance the use efficiency of conventional chemical fertilizers. Now it has been undoubtedly understood that marine algal mass has sufficient potentiality in agricultural sector and for that reason it is gradually gaining market throughout India and abroad.

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