Seaweed Extract: A Biostimulant in Agriculture

Aditi Saha Roy*

Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India -741252

Corresponding Author
Aditi Saha Roy
Email: aditisaharoy16@gmail.com

OPEN ACCESS

Keywords

Seaweed, Biostimulants, Stress tolerance, Sustainable agriculture

How to cite this article:

Roy, A. S. 2024. Seaweed Extract: A Biostimulant in Agriculture. *Vigyan Varta* 5(1): 339-342.

ABSTRACT

Seaweed extracts, emerging as organic agricultural inputs, exhibit multifaceted benefits for plant growth and resilience. Their complex biochemical composition influences physiological responses in plants. Extracts enhance crop vigor, mitigate stress, and improves yield across various crops. Integrating seaweed extracts into farming practices reduces chemical dependency while improving yields. Their non-toxic nature and versatility position them as eco-friendly options within integrated crop management.

INTRODUCTION

With the advent of climate change, the development of pesticide resistance, and the persistent loss of land due to expanding populations, there's an increasing need for innovative sustainable agricultural practices. Within this realm, extracts derived from seaweed are emerging as a new category of agricultural inputs of organic origin and is gaining momentum. At present, seaweed extracts (SE) find extensive application as plant biostimulants, defined as, any substance or microorganism applied to plants to improve nutritional efficiency, quality characteristics of crops, irrespective of its nutrient composition and provide tolerance to abiotic and biotic stress. Seaweeds, are macroscopic, multicellular marine algae, naturally originate from coastal ecosystems and act as bio-stimulating substances. Roughly 700 species of marine algae thrive along the Indian coast, among which around 60 hold significant commercial importance. Approximately 10,000 species of seaweeds or macroalgae are estimated to exist, primarily classified into three categories based on their pigmentation: Phaeophyta (Brown),

Rhodophyta (Red), and Chlorophyta (Green), among these brown algae are mostly used in agriculture.

Table1. Classification of some important seaweeds

Phaeophyta	Rhodophyta	Chlorophyta
Sargassum spp.	*Kappaphycus alvarezii*	*Ulva lactuca*
Laminaria digitata	*Gelidium serrulatum*	*Enteromorpha prolifera*
Ascophyllum nodosum	*Gracilaria edulis*	*Codium tomentosum*
Fucus spp.	*Porphyra perforate*	*Ulva armoricana*

The biochemical composition of seaweed extracts is intricate, encompassing polysaccharides, minerals, vitamins, oils, fats, acids, antioxidants, pigments, phytohormones (like auxins, gibberrelins, cytokinins) and trace elements (Fe, Mn, Cu, Zn, Co, Mo and Ni) (Khan et al., 2009). Algal extracts function as biostimulants rather than fertilizers, as they prompt both defense mechanisms and growth responses in plants.

Method of preparation

Seaweed extraction employs both physical (like heat, pressure, microwaves) and chemical (such as solvents, acids, alkali) methods, integrity of biologically active molecules must be ensured. The commonly favored approach involves high-pressure alkaline extraction, with the advantage of efficient extraction of valuable components like polysaccharides, which are transformed into oligomers with moderate degradation (Ali *et al*. 2021).

Mode of application

Typically, application methods include foliar sprays, root application, or a combination of both. These extracts can be administered to the soil via fertigation, drenching, or dripping techniques. Foliar sprays at concentrations equal to or less than 0.05% v/v are optimal for crops, leading to enhanced disease control and increased yields. Foliar application's superior performance is attributed to its immediate interaction with plant tissues, facilitating rapid absorption.

Table 2. Chemical composition of some seaweeds

Parameters	*Ulva* sp.	*Kappaphycus* sp.	*Gracilaria* sp.
Carbohydrate (%)	43.9	57.3	65
Protein (%)	21.5	4.5	11.8
Fat (%)	0.5	0.89	1.42
Ash (%)	22.7	28.9	14.49

Benefits of seaweed

- Seaweed strengthens crop resilience against common abiotic stresses like low moisture, high salinity, and freezing temperatures. These seem to arise from physiological alterations prompted by seaweed application, such as improved energy storage, enhanced root structure, and increased metabolic capacity, ultimately empowering plants to withstand adverse conditions more effectively.
- Seaweed fertilizer serves as a soil conditioner, enhancing the physical attributes of soil, including aeration and water retention. Particularly, clay soils, which often lack organic content and adequate porosity, experience improvements owing to the presence of humic acid and soluble alginates derived from seaweed. *Sargassum* are known to have valuable soil conditioning properties.
- Seaweed exhibits bio-remediation properties by adsorbing harmful

pollutants, facilitated by functional groups—like ester, hydroxyl, carbonyl amino, sulfhydryl, and phosphate—present on the algal surface. Certain seaweed species, such as *Gracilaria*, *Grateloupia* efficiently remove various heavy metals, like chromium, mercury, lead and cadmium from their surroundings.

- Incorporating seaweed into soil can boost crop vitality and resistance against diseases. Seaweeds encompass a broad spectrum of bioactive compounds, such as steroids, terpenes, acetogenins, and amino acid-derived polymers, capable of addressing diseases and pests.

Effect of Plant Growth

Numerous researchers worldwide have documented the positive impacts of seaweed extracts, on the growth and yield of various field crops. Seaweed products have demonstrated the ability to boost germination rates and substantially improve seedling vigor by amplifying root size and density. Several accounts have highlighted improved growth and yield characteristics in rice through the application of seaweed via both soil and foliar methods, thereby decreasing reliance on chemical fertilizers. The extracts have shown to protect seedlings from transplantation shock in tomato, cabbage, and marigold (Aldworth and Staden, 1987). Applying *Kappaphycus alvarezii* extract on maize during the grain filling stage observed 15% rise in seed yield (g/plant) (Trivedi *et al*. 2018). Research indicates that seaweed extracts and their constituents have the ability to regulate the activation of genes that control the endogenous production of growth hormones like auxin, cytokinin, and gibberellin.

An Input for Integrated Crop Management Program

In the light of integrated management practices, both scientists and farmers are actively seeking eco-friendly alternatives. Among these, seaweed extract biostimulants have emerged as a prominent option at the forefront. The primary attraction of seaweed extracts stem from non-toxic nature and their manifold beneficial effects on both crops and environment, potentially resulting in reduced disease and pest incidences, ultimately contributing to higher yields. Feasibility studies indicate that farmers express readiness to incorporate seaweed extracts and products as "green alternatives" into their current cropping systems. Various studies have shown, by increasing the utilization of seaweed extracts and other organic inputs, the conventional application rate of chemicals was decreased by two-thirds, without any negative effect on yields. The majority of seaweed-based products fall into categories such as biostimulants, organic nutrients, or plant boosters, earning them recognition as organic inputs. This broad classification significantly contributes to the widespread adoption of seaweed products in organic-certified crop cultivation, environmentally conscious production, and their routine use within integrated crop management systems.

CONCLUSION

Multiple reports have affirmed the beneficial impacts on plant growth, vitality, increased resilience against pests, diseases, and environmental stresses, alongside a comprehensive enhancement in overall plant productivity. The mechanisms through which seaweed extract triggers physiological responses remain largely unidentified. Seaweeds and their derived products offer numerous organic resources that can fulfill the increasing demands of crops. It's essential to persist in research and development in these avenues to fully harness the potential usefulness of seaweeds in sustainable agriculture.

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