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Seaweed Extract as a Tool for Sustainable Agriculture

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Abstract

The rational use of biologically active substances or plant growth stimulants from natural materials like seaweed is one of the most promising trends in agriculture, as seaweed is considered a safe and sustainable bio stimulant for improving plant growth, particularly under abiotic stress due to its high content of Cytokinin's, auxins, gibberellins, amino acids, phytohormones, Osmo protectants, mineral nutrients, and antimicrobial compounds. The current work explores the impact of seaweed extracts on different crops, the functional roles they play in plants, and the potential value of seaweed extracts in integrated crop management systems towards sustainable crop production. Various elements affect the effectiveness of seaweed extracts used in agriculture, such as the source of the seaweed, manufacturing methods, and concentrations, while the application technique is considered a determining factor in the effectiveness of seaweed extract in improving plant growth. Seaweed extracts are synthesized in two basic ways: through physical techniques and chemical methods. Extraction by using alkalis is the most commercial method and is extremely effective in sustaining biologically active components. Many reports have confirmed the efficacy of seaweed extracts in improving plant growth and their positive results in improving seed germination, improving the growth of the root system, increasing the survival rate of seedlings, improving plant growth and productivity under abiotic stress, and enhancing plant resistance to pathogens.

Keywords: Bio stimulants; Cytokinin's; Plant growth; Seaweed; Seedlings survival

Introduction

Crop productivity is negatively affected by abiotic stress, i.e., rising temperature, drought, salinity, and cold stress [1]. Thus, there is wide attention given to the use of natural materials in agriculture instead of synthetic chemicals to protect human health, reduce hazards to the environment, and reduce production costs. Seaweed extract is considered natural, cheap, abundant, and accessible. Furthermore, seaweed extract is a source of plant growth regulators that include Cytokinin's, auxins, and gibberellins, which are linked to nutrient availability. Therefore, there is more attention to using seaweed extract as a plant stimulant to increase plant immunity and improve plant growth, particularly under environmental stress [2]. Seaweed extracts positively affect the growth of the root system, consequently increasing nutrient absorption, which increases the productivity and quality of the crop. Seaweed contains many biologically active substances that are important for plants such as Cytokinin's, auxins, and gibberellins [3]. Therefore, they are widely used for different species of seaweed, particularly brown algae as plant bio stimulants, plant growth regulators, biofertilizers, or metabolism enhancers [4]. Seaweeds are marine algae that belong to the plant kingdom and vary in shape and size [5]. They usually grow in shallow areas, particularly in the tidal and subtidal areas, where there is enough light necessary to complete the process of photosynthesis. There are many benefits and usage for seaweed extracts in agriculture, its improving plant growth and productivity, i.e., improved seed germination, increased plantlet survival, accelerated seedling growth, improved plant development, and increased productivity of numerous crops [6]. Moreover, using seaweed extracts and their derivatives is considered a promising approach to sustaining plant production by incorporating them into an integrated cultivation system as a partial replacement for synthetic agrochemicals [2]. Furthermore, different factors influence the effectiveness of seaweed extracts in agriculture, and they do not depend solely on the habitat from which the algae are derived or on formation techniques. The current work discusses the role of seaweed extracts in agriculture, the most important functional effects they elicit in plants, and exploring their potential value in an integrated manner with other inputs to achieve agricultural sustainability and attain positive economic and environmental results.

Methods of Preparation of Seaweed Extracts

Choosing the appropriate extraction method is one of the determined factors for the efficiency of Seaweed extract, to preserve the bioactive molecules, which are considered valuable biological components and have an induced effect [7]. Seaweed extracts are manufactured in two basic ways, as follows:

a) Physical techniques by using heat, pressure, and radiation.

b) Chemical methods by using solvents, acids, and alkalis.

Generally, extraction by using alkalis is the most commercial method and is extremely effective in biologically sustaining a Seaweed Extract as a Tool for Sustainable Agriculture.

What are the Main Factors that Affect the Use of Seaweed Extract?

Many factors influence the effectiveness of seaweed extracts in reducing the adverse effects of environmental stress in agriculture, and they do not depend solely on the habitat from which the algae are derived (Figure 1), such as the source of seaweed, manufacturing technique, concentrations, and frequency duration [8].

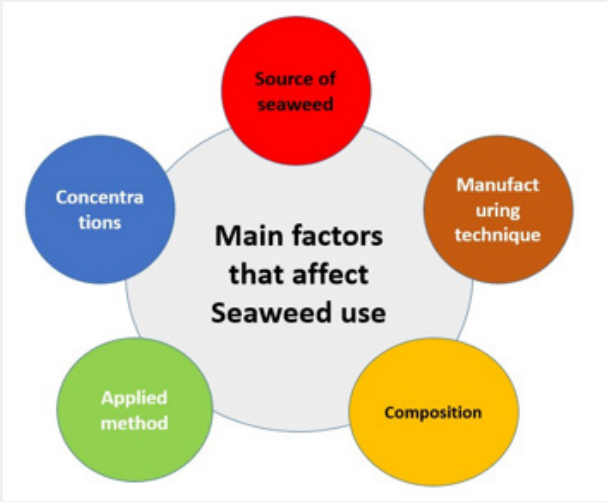

Figure 1: Main factors that influence seaweed efficiency.

Application Methods

Furthermore, the application technique of the seaweed extracts plays an important role in their use and response by plants. Most application types are either spray on vegetative growth, soil applications, or a combination of both, depending on the plant type [9]. Generally, foliar application of seaweed extract is considered the most applied method for most economic crops. The advantage of this method is its high efficiency in rapidly absorbing extracts through leaf tissue and transferring them to plant cells, thus stimulating plant growth [3].

Seaweed Extract Application in Agriculture

Seaweed extracts are organic substances rich in bioactive compounds, so they are used intensively in agriculture, particularly in organic farms, as organic fertilizers or plant stimulators. They are also used in the production of perishable crops under improper environmental conditions [8]. It is also an important input in integrated management systems for sustaining other crops [7]. Furthermore, seaweed extracts are considered an important source of nutrients in organic agriculture due to their rich content of many growth substances and mineral nutrients, which achieve many benefits and thus improve plant growth and productivity. It also acts as a promising soil amendment, contributes to protecting plants from the negative effects of biotic and abiotic stress, and increases plant resistance against pathogens [10].

Beneficial Roles of Seaweed Extract

Seaweed extracts contain numerous biologically active components that have unique biological effects. There is widespread use of seaweed-derived bio stimulants to improve plant growth and mitigate the negative effects of environmental stress on agricultural production [11]. The most important benefits of which are:

i) Plant stimulation leads to increased plant growth and improved production in different economic plants.

ii) Stimulates defensive responses in plants, which increases their immunity to many pathogens.

iii) Interaction of their components in plant cells activates plant hormones and regulates plant growth.

iv) Changes the components of the rhizosphere and activates microorganisms to support sustainable plant growth.

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v) Seaweed extracts help plants withstand harsh environmental conditions such as cold, drought, and salinity.

vi) Increases proline, soluble sugars, and unsaturated fatty acids in plant cells when exposed to cold stress.

Using of Seaweed Extracts in Crop Production

Many studies indicated that there are numerous beneficial effects of seaweed extract on numerous plant growth and productivity (Table 1) [11-29]. Arumugam R & Anantharaman P [17] reported that foliar application of Rosenvigea intricate improves chlorophyll content in Okra (*Abelmoschus esculentus* (l) medikus) plants. Moreover, using seaweed extract increases plant tolerance for abiotic stress that include salinity, cold, and drought conditions. Application of Seaweed extract improved the growth of canola plants under drought stress [14]. In addition, the application of *Ascophyllum nodosum* extracts protected Arabidopsis plants from stress by augmented chlorophyll content [30]. Also, treatment of the extract of *Ascophyllum nodosum* increases the cold tolerance of barley (*Hordeum vulgare* L.) plants [11,15] claimed that treatment with *Ascophyllum nodosum* extract alleviates the negative impacts of salinity stress on Arabidopsis thaliana plants and enhances plant growth. Furthermore, numerous reports indicated the positive effect of seaweed extract on flowering and fruit set, which led to an increase in yield of horticultural crops, [20] on Kiwi fruit; [21] on almond; [22] on strawberry; [23,24] on tomato; [27] on apple trees; [28] on date palms; [29] on Mango.

Table 1: Application of seaweed extract in agriculture.

Crop	Scientific Name	Action	Author
Barley	*Hordeum vulgare*	Improve cold stress tolerance	Babazadeh et al. [11]
Barley	*Hordeum vulgare*	Enhancing plant growth under salinity stress	Bensidhoum & Nabti [12]
Canola	*Brassica napus L.*	Improve productivity under salt stress	Ha et al. [13]
Canola	*Brassica napus L.*	Improvement of drought tolerance	Shahriari et al. [14]
Arabidopsis	*Arabidopsis thaliana*	Alleviates the negative impacts of salinity stress	Shukla et al. [15]
Arabidopsis.	*Arabidopsis thaliana*	Increases drought tolerance	Rasul et al. [16]
Okra	*Abelmoschus esculentus (L) Medikus*	Enhance chlorophyll content	Arumugam & Anantharaman [17]
Indian mustard	*Brassica juncea (L.) Czern & Coss*	Alleviate drought stress impacts	Sujata et al. [18]
Zucchini squash	*Cucurbita pepo L.*	Improve plant growth	Rouphael, et al., [19]
Kiwi fruit	*Actinidia deliciosa (A. Chev.)*	Increase yield and improve fruit quality	Rana et al. [20]
Almond	*Prunus Amygdalus*	Improve plant growth	Erogul et al. [21]
Strawberry	*Fragaria X ananases*	Increase yield and runner production	Rana et al. [22]
Tomato	*Solanum Lycopersicon L.*	Increasing yield, and improve fruit quality	Mzibra et al. [23]
Tomato	*Solanum Lycopersicon L.*	Enhancing plant growth and productivity	Hussain et al. [24]
Tomato	*Solanum Lycopersicon L.*	Improve growth and productivity under of tomato plants salt stress	Hernández-Herrera et al. [25]
Green Beans	*Phaseolus vulgaris L.*	Increase number of pods and plant yield	Medi & Manea [26]
Apple trees	*Malus domestica*	Enhancing fruit set and tree yield	Ayub et al. [27]
Date palms	*Phoenix dactylifera*	Improve fruit yield	Omar et al. [28]
Mango	*Mangifera indica*	Enhancing fruit set, yield, and fruit quality	El-Sharony et al. [29]

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Conclusion

Seaweed extract is considered a natural bio stimulant source and assists in improving plant growth and productivity. It's a rich source of bioactive compounds such as phytohormones, amino acids, Osmo protectants, and mineral nutrients. Seaweed extracts are synthesized using both physical and chemical methods, while extraction by alkalis is the familiar method and has superior effectiveness in reserving the activity of biological components. Hence, there is more interest in using it as an active and safe plant stimulant that improves growth and increases plant productivity under abiotic stress. Furthermore, seaweed extract plays a vital role in organic agriculture as a fertilizer and induces plant immunity against pathogens. Moreover, previous work indicated the stimulation effects of seaweed extracts in numerous crops, whereas plant growth and their positive results in improving seed germination, improving the growth of the root system, increasing the survival rate of seedlings, improving plant growth and productivity under abiotic stress, and enhancing plant resistance to pathogens.

Conflict of Interest

The Author declares that no conflict of interest exists.

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