



## Effect of Seaweed Extract on Ornamental Plants

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### Abstract

Seaweed extracts have been used in organic agriculture to encourage the development and strengthen the quality performance of floricultural crops. The effectiveness of the seaweed extract is built entirely on hormone levels of plants or otherwise micro nutrients in the crude extract (primarily cytokines). A review of the use of seaweed on ornamental plants is carried out in the most modern research. Concerning their growth and flowering possibilities, the effectiveness of algae in ornamental plants has been validated. The purpose of this systematic review was to illustrate progress throughout the treatment of seaweeds for growth regulators to summarize the organic compounds of seaweeds as well as to investigate the challenges that encourage the application of macroalgae to manipulate various biotic and abiotic stress of crops. Seaweeds are still completely unaffected internationally; we emphasize several of the subsequent preferences for research and innovation. This whole review aims to facilitate the reader's attention to utilize various seaweeds to increase the features and yield of ornamental crops.



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### Introduction

Marine vegetation considers as ocean lungs because of those plant-like Life Forms which generate 70 to 80 percent atmospheric oxygen through photosynthesis. The wide increment of the Flower and Ornamental Plants is due in particular to the favorable social and economic condition and the changes in customer demand.<sup>2</sup> Ornamental plants are a wide variety of beautiful plants, such as cut foliage, cut flowers, bedding plants that provide aesthetic value for the surrounding.<sup>3</sup>

As a result, ornamental plants eventually bring aesthetic feelings to our surroundings. The major determinant influence not only for development, productivity but also for the harvest index of ornamental floras is either quality or dosage of fertilizer application.<sup>4</sup> The total revenue of the floral and ornamental crop market share in 2018 was R\$ 7.9 billion, with an annual net increment of 8-10 percent in Brazil in 2019.<sup>5</sup> The floriculture sector seems to be quite profitable for exports on the global market and has a significant effect on the

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improvement of socio-economic perspectives in developing nations.<sup>6</sup>

The positive impact of natural stimulant forms of treatment on chlorophyll content might have been addressed most of these seaweeds behaves even as crop growth regulatory compounds in extended photosynthesis in plants.<sup>7</sup> Throughout the sustainable agriculture sector and gardening crop varieties, almost over 15 million tons of seaweeds have been used either as bio stimulants or supplementation.<sup>8</sup>

Here include seaweed extract encompassing a collection of multiple micro elements, plant growth hormones that have a favorable role in promoting bloom initiation to improve efficiency through raising volume and performance of flower crops.<sup>9</sup> Therefore, this review helps to obtain knowledge about the influence of different seaweeds for enhancing the vegetative and reproductive features of ornamental plants before conduct the research work on the influence of seaweed extract on rose plants.

### Significance of Seaweeds

Seaweeds seem to be macroscopic vegetation picked up even in the marine environment where near to the coastal line which has different protein concentrations according to the weather effects.<sup>10</sup> The extent of plant nutrients available in soil including such nitrogen, potassium and phosphorus as well as several trace elements essential for vegetation growth is strengthened by cytokines, gibberellic acids were provided significant influence of algae extracts on the biosphere that helps to promote crop stress tolerance for rejuvenation even after harm.<sup>11</sup> Abundant contents of marine macroalgae often include potassium, sodium, calcium, magnesium, zinc, iodine, etc.<sup>10</sup> Seaweed extract was often applied in environmentally friendly farming practices of bio stimulants to encourage performance, the vase life of flowers. Several more researchers have found positive consequences of macroalgae aqueous extract on a diverse variety of agricultural plant species including not only grains but also decorative floral crops.<sup>4</sup>

Seaweeds in coastal shallow aquatic environments, considering high salt concentrations in the ocean habitat. Within hyperosmotic circumstances, biological molecules known as polyamine, sorbitol,

or betaines were synthesized and created at elevated concentrations which were specifically associated with osmotic pressure alteration for marine aquatic vegetation.<sup>12</sup> Macroalgae foliar spray was another affordable solution that environmentally approachable solution for raising the potential and achieving higher levels of productivity.<sup>13</sup>

The macroalgae crude extract is a kind of the more valuable ocean reserves in the future, but also that extracted were marketed for several decades mostly as manure, although it has been investigated for a prolonged period, the capability which uses in industrial farming or even in multiple kinds.<sup>14</sup> Seaweed preparations were widely recognized to have many preferable influences on plants since they constitute growth promoters including either auxins or cytokines.<sup>15</sup> Seasol TM was a sales representative in Melbourne through ever accurate exploration with various forms of cytokines including zeatin.<sup>16</sup>

Over subsequent generations, increasing gas emissions that cause global warming through agrochemicals seems to be a critical challenge. Therefore, the implementation of botanicals is a sustainable solution not only for improving crop yield but also enhance soil fertility.<sup>17</sup> Fertilizers manufactured from diverse marine vegetation could further accelerate crop development due to economical and simple to implement. Therefore, this makes it a replacement for the artificial competing agrochemicals.<sup>18</sup> The huge assortment of physiological functions gained through the exposure of such seaweed crude extracts.<sup>19</sup> Betaines, which are discovered in marine botanical remedies, were equally reactive in crops equivalent to cytokine.<sup>20</sup>

### Influence of Seaweed Extract on Plant Growth Plant Height

The species of *Padina* had antibacterial, antifungal, phytotoxic as well as insecticide action.<sup>57</sup> *Padinagymnosopora*, its general term is funnel weed and these have a broad ability of biologically active functions as an antimicrobial, antioxidant reaction, and growth-enhancing influence.<sup>58</sup> Seaweed foliar spray not only promotes growth-enhancing functions as well as bio-stimulants for plant yield.<sup>59</sup> Crop growth enhances by alginate polysaccharides effectively.<sup>60</sup> Treatment with seaweed extract recorded the maximum plant height in *Petunia*.<sup>61</sup>

**Table 1: Collection of specific seaweeds with a consequence on ornamentals**

No	Ornamental Crop	Scientific Name	Seaweed	Effect on crop
1	Gerbera	<i>Gerbera jamesonii</i>	<i>M. pyrifera</i>	Yield enhanced <sup>21</sup>
2	Autumn pineapple lily	<i>Eucomis autumnalis</i> (Mill.) Chitt.	<i>Ecklonia maxima</i> (Osbeck)	Increased growth and bulb numbers <sup>22</sup>
3	Marigold	<i>Tagetes erecta</i>	<i>Ecklonia maxima</i>	Number of florals and seeds per blossom head amplified <sup>23</sup>
			<i>Kelpak (Ecklonia -maxima)</i>	Decrease transplant distress in seedlings of marigold, improve the dry mass of roots, enhanced rooting <sup>24</sup>
			<i>A. nodosum</i>	Enlarged root length and expansion of the shoot; treated transplanted saplings bloomed young <sup>25</sup>
			<i>Sargassum wightii</i>	The greater height as well as the number of branches <sup>26</sup>
4	Rose	<i>Rosa</i> sp.	<i>Ascophyllum nodosum</i>	Improved rooting capacity and chlorophyll and protein contents in rose shoots <sup>27</sup>
5	Freesia hybrid	<i>Freesia</i> sp.	Unspecified seaweed extract	Increase the number of flowers <sup>28</sup>
6	Sweet basil	<i>Ocimum basilicum</i> L.	Unspecified seaweed extract	Increased crop height, the number of shoots, fresh and dry weight <sup>29</sup>
7	Primrose	<i>Primula acaulis</i> L.	Unspecified seaweed extract	Primrose growth and flower productivity (highest number of flowers/plant) <sup>30</sup>
8	Black locust	<i>Robinia pseudo-acacia</i> L.	<i>Ascophyllum nodosum</i>	Developed optimum plant height, node number, longest root, leaf number, dry weight, fresh weight <sup>31</sup>
9	Begonia	<i>Begonia</i> sp.	Unspecified seaweed extract	Plant height, dry weight/plant and total carbohydrates increased <sup>32</sup>
10	Sunflower	<i>Helianthus annuus</i>	<i>Ascophyllum nodosum</i>	Significantly improve germination and seedling progression <sup>33</sup>
			<i>Codium lyngarii</i>	Enhanced harvest, disease resistance <sup>34</sup>
			<i>Kappaphycus alvarezii</i>	Sunflower head circumference expanded <sup>35</sup>
11	Ornamental pepper	<i>Capsicum annuum</i> L.	Stimplex® <i>Ascophyllum nodosum</i>	Enhanced stem diameter, fresh and dry weights of stem <sup>36</sup>
12	Amaranthus	<i>Amaranthus tricolor</i>	<i>Ascophyllum nodosum</i>	Special effect for improved stem length of inflorescences, extent and number of inflorescences <sup>37</sup>
13	Gladiolus	<i>Gladiolus italicus</i>	Unspecified seaweed extract	Increase leaf photosynthetic pigments <sup>7</sup>
14	Chinese carnation	<i>Dianthus chinensis</i>	Unspecified seaweed extract	Not only increase leaf chlorophyll number but also enhance the leaf stalk of

15	Daffodil	<i>Narcissus poeticus</i>	Unspecified seaweed extract	flowers. <sup>38</sup> The increased fresh and dry weight of the vegetative plant, superiority in vase life, flower stem length, fresh and dry weight of flowers. <sup>39</sup>
16	Tuberose	<i>Polyanthasgracilis</i>	<i>Ecklonia maxima</i> (Osbek)	Better-quality vegetative and reproductive growth. <sup>18</sup>
17	Chrysanthemum	<i>Chrysanthemum indicum</i>	<i>Ascophyllum-nodosum</i>	Positive response as the surge in aerial organ dry weight <sup>4</sup>
18	Strut's Desert Pea	<i>Clianthus formosus</i>	Natrakelp (Seaweed concentrate)	Provide longevity to flowers <sup>40</sup>
19	African daisies	<i>Gazaniarigens</i>	Unspecified seaweed extract	Enhanced leaf chlorophyll content and number of flowers <sup>38</sup>
20	Geranium	<i>Pelargonium</i>	<i>E. maxima hirsutum</i>	The enhanced buildup of phenolic, chlorophyll pigments <sup>41</sup>
21	Calibrachoa (Million Bells)	<i>Calibrachoa -rviflora</i>	<i>Ascophyllum -nodosum</i>	Respiratory activity of leaves measured on a dry weight basis <sup>42</sup>
22	Rose	<i>Rosa sp.</i>	<i>Ascophyllum -nodosum</i>	Considerably improved vegetative growth <sup>43</sup>
23	Zinnia	<i>Zinnia acerosa</i>	<i>Sargassumc-rassifolium</i>	Upsurge the growth and flowering <sup>44</sup>
24	Daylilies	<i>Hemerocallis</i> sp.	<i>Ascophyllum-nodosum</i>	Amplified seed germination <sup>45</sup>
25	Pot marigold	<i>Calendula officinalis</i> L.	<i>Ascophyllum-nodosum</i>	improved the number of propagules (crown divisions) per plant <sup>46</sup>
26	Poinsettia	<i>Euphorbia pulcherrima</i>	Sargassum sp., <i>Ascophyllum-nodosum</i> , and <i>luminaria</i> sp.	Increments in flower stalk length, flower diameter, and carbohydrates content <sup>32</sup>
27	Carpet bentgrass	<i>Agrostisstolonifera</i>	<i>A nodosum</i>	The superior number of florals; prolonged life of blooms. Short plants. Provide optimum metabolic activity <sup>47</sup>
28	Lily	<i>Liliumcandidum</i>	<i>Ascophyllum-nodosum</i>	Drought tolerance <sup>48</sup>
29	Bunch flowered daffodil	<i>Narcissus tazetta</i>	<i>A. nodosum</i>	Foliar applications enhanced stem, leaves and bulb biomass <sup>49</sup>
30	Pink periwinkle	<i>Catharanthusroseus</i>	Unspecified seaweed extract	Important properties on the vegetative growth and flowering features and offered high length of stalk flowers <sup>50</sup>
31	Loretta turf	<i>Loliumperenne</i> cv.	Unspecified seaweed extract	Growth and blossoming of the plant had become superior <sup>14</sup>
32	Begonia	<i>Begonia</i> sp.	Alginure (a sea-weed extract)	Improved growth <sup>51</sup>
33	Dracaena	<i>Dracaena marginata</i> L.	<i>Ecklonia maxima</i>	Greater rooting <sup>25</sup>
34	Anthurium	<i>Anthuriuman dreanum</i>	Oligo-X® Seaweed extract	Increasing rooting characters <sup>52</sup>
			<i>Sargassumcra-ssifolium</i>	Increased leaf number and leaf area <sup>53</sup>

**Table 2: Auxin and cytokinin hormone composition of seaweed**

Seaweed	Auxin	Cytokinin
<i>Ulvalactuca</i>	65.04 µg/g	163.06 µg/g <sup>54</sup>
<i>Padinapavonica</i>	115 µg/g	317µg/g <sup>55</sup>
<i>G. verrucosa</i>	11.2 µg/g	4.5µg/g <sup>56</sup>
<i>E. intestinalis</i>	22 µg/g	14.2µg/g <sup>56</sup>

The major phytohormones recognized in seaweed extracts are auxins, cytokinin, gibberellins, abscisic acid, ethylene and auxins, which are accountable for elongation of plant tissue growth and apical dominance, cell division. Cytokinins involved in the activation of cell divisions responsible for plant growth.<sup>10</sup> Brown seaweeds help to enhance the growth, elongation of branches in various vegetation through the alginate depolymerization which results in the alginate associated oligosaccharides due to its function to stimulate the assimilation of nitrogen and metabolism.<sup>62</sup> Total plant features were enhanced through the influence of seaweed foliar spray because it influences crop growth, manufacturing of carbohydrates, protein, chlorophyll and enhance photosynthesis because seaweed considers as a crop growth stimulant.<sup>63</sup>

Application of a lower concentration (20 %) of seaweed foliar spray recorded significantly highest plant height in maize plants compare to control while a higher concentration (100%) had an inhibitory effect on plant height due to the high salt index of higher concentration of seaweed liquid extract.<sup>64</sup> It is also clear that maize seedling performance increased up to 20% but decreased at higher concentrations.<sup>64</sup> Furthermore, among the most appropriate strategies for application of macroalgae foliar spray were provided the greatest height and dimension for shoots of Amaranths tricolor plant.<sup>37</sup> Spraying of seaweed foliar spray (*Sargassum crassifolium* and *Turbinaria turbinata*) one in a week amplified plant height in two soybean varieties Pb-1 and MISB -01.<sup>65</sup> Undernutrition of potassium in sunflower species exhibited a slight decline in crop height as well as some leaves even a great reduction in root extension. Increased harvest productivity and improved performance could be indicating the existence of plant hormones as well as several essential minerals together with potassium mostly in the supplement of marine algae.<sup>35</sup>

### Plant Biomass

Through the use of organic fertilizers could well strengthen the nutrient accumulation of chrysanthemum species, potentially even though those that encourage vigorous root framework just due to the involvement of growth hormones encompassed in the extract from marine vegetation.<sup>4</sup> Seaweed extracts introduced in various forms show a wide variety of positive feedback including enhanced germination, growth of roots, improved chlorophyll as well as leaf area content, and resistance to the pathogen.<sup>66</sup> Seaweed extracts as foliar sprays have been shown to increase the aggregation of plant biomass and yields.<sup>64</sup> On *Carpobrotus edulis*, *Kalanchoe daigremontiana*, and *Kalanchoe tubiflora*, the ability of selected algae extracts to significantly improve and increase plant quality, as well as increase vegetative and root biomass.<sup>67</sup> Cytokinin was also discovered in fresh seaweed and seaweed extracts. Cytokinin present in seaweed mixtures have included trans-zeatin, trans-zeatinriboside and also encompassed BAP (benzyl amino purine).<sup>68</sup>

In terms of treatments consist of macroalgae, overall valuation including foliage, blossoms as well as stem were enhanced.<sup>4</sup> Marine vegetation extract also having a straightforward consequence on vegetative growth parameters of ornate sunflowers. Its changes were reported on improving crop biomass and also intensified shoot fresh and dry weight of plants.<sup>33</sup> Even more impacts with cytokines in vegetation were amplification of mitosis and expansion, and even postpone cell death in crops. Marigold saplings supplemented by concentrates of seaweed seem to be most vigorous in texture as well as healthy.<sup>35</sup> Through the application of the seaweed foliar spray pest like an aphid, inhabitants were drastically minimized.<sup>69</sup> Marigold seedlings which applied seaweed extract provide more rigorous in looks as well as healthful compare with control. Seaweeds not only increased dry weight but also greatly diminished insect infection like aphids in chrysanthemum cultivars.<sup>69</sup> Seaweed liquid extract of *Sargassum crassifolium* contains macro and micronutrients as well as growth-promoting stimulants such as auxin and cytokinin.<sup>70</sup>

The maximum fresh mass of the entire sunflower crop had become observed on 10% dilution of macroalgae extract while 5% concentration provides

maximum dry mass. Sunflower plant species have the highest level of protein, fat as well as fiber for application of 20 percent.<sup>34</sup> Through 10% dilution of marine algae, the maximum fresh mass of the entire sunflower crop had been recognized correspondingly maximum dry mass provided through 5% concentration. Sunflower crop species report increased biomolecules in 20% dilution of macroalgae extract.<sup>34</sup>

#### Number of Plant Leaves and Leaf Area

Leaf area index measures the number of leaf areas readily accessible for extracting energy for every division of exerted vegetation, which is a useful characteristic for plant modeling.<sup>71</sup> Expanding the leaf area often through a higher concentration of such seaweed extract possibly due to micronutrients in the supplement, which include potassium, improves the plant's metabolism, the production of amino acids and proteins, as well as the emergence of photosynthetic pigments, that further improved the performance of the leaf area index may result in weight gain from plant development while handled mostly with supplement.<sup>39</sup>

*Calibrachoa x hydride* is frequently included as flowering shrubs in America. As either an origin of bioactive metabolites their ability can be improved by implementations for seaweed extract. The drenched and foliar remedies of marine vegetation preparation greatly improved the number of leaves and zones, dry weight, plant height, antioxidants and phenolic, flavanol, and tannic content of *Calibrachoa* varieties. Each growth and structure changes in phenols, flavones, and tannins are due to the stimulating effect of seaweed extract.<sup>43</sup>

The photosynthetic pigment condition of the crops was reinforced with a foliar application of macroalgae supplement. Throughout the elevated Mg as well as Fe in *Sargassum* analysis, photosynthetic pigment production may have been impaired and the soil application of the aqueous extract in all cases yields considerably better chlorophyll versus foliar uses in the handled plants. However, these effects can be clarified by higher amounts of chlorophyll in the foliage that can also be collected through using betaine solvent or adding the land of marine concentrate.<sup>15</sup>

#### Effect of Seaweed Extract on Flowering

##### Number of Flowers

Marigold seedlings had been allowed to applied seaweed extract subsequently after transplantation, the number of blooms, as well as seeds per flower heads, enhanced.<sup>59</sup> The highest number of flowers/plants was proved in marigold with the application of seaweed liquid extract<sup>19</sup> and also seaweed foliar spray was enhanced flowers in okra plants (*Abelmoschus esculentus* L.).<sup>72</sup>

The existence of not only plant growth regulators such as cytokines, gibberellins but also trace minerals, vitamin supplements, essential amino acids in aquatic vegetation has strengthened yield potential as well as quality, likely having a positive impact on either dramatically lessened fall of blossoms and buds or steadily enlarged dimension of florals.<sup>73</sup>

From a previous scientific study, it could be ascertained which sunflower conformed very well with the commercial seaweed bio-stimulant with steadily accelerated annual flower production.<sup>35</sup>

The existence of higher potassium levels than other macronutrients in *Sargassum* and other growth regulators can stimulate flower initiation and thus increase the number of flowers per plant. Seaweed liquid extract of *Sargassum crassifolium* was rich in potassium macronutrients that contribute to enhancing the number of flowers in the tomato plant<sup>70</sup>. The eco-friendly option of seaweed foliar application increased significantly the average number of flowers per plant of cowpea (*Vigna unguiculata* L.) to increase growth and yield.<sup>71</sup>

The biggest and best number of flowers is obtained due to the influences of nutrient elements in marine macroalgae extract and at the greatest concentration that enhances the floral diameter<sup>38</sup>. Foliar application with such a low dosage of seaweed extraction promotes the flower initiation compare to controls in *Vince rose* plant species.<sup>50</sup>

##### Flower Size

Foliar spray mostly with macroalgae extract is better in comparison in floral quality policy owing to the supplement of seaweed, which encompasses zinc,

a reagent for oxidation in cell membranes, governs sugar consumption, rapid progress energy, engages in skew synthesis, accelerates carbon content, and therefore lengthens flowering lives<sup>39</sup>. Treatment with *E. grandiflorum* variety, Florida only with *Macrocystispyrifera* extract has significantly enlarged the flower diameter.<sup>75</sup>

Consequently, the use of seaweed greatly increases spikelet percentage and thickness, flowering volume, fresh and dry weight, meanwhile, of the florets over control material. The potential advantage of even the algae is mainly due to the more cytokine content, which can have considerable impacts, including crop production, flora and chemicals. The cytokines were also effective at quite low levels and govern a wide variety of different capabilities such as cell division, protein, the formation of enzymes, leaf senescence and cell death, shooting elongation.<sup>37</sup>

The brand name including its growth of *Algren* is commercially referred to as the growing bio stimulant hundred percent extracted by the marine algae *Ecklonia maxima*. This was more positive and has improved the flower size and shape, floral length, chlorophyll and fresh floral weight. Furthermore, at quite small doses it has not always been profitable, while the strong dose declined the biomass production. Seaweed extracts could have cytokine and auxin just like physical activity and other plant growth regulators, the foliar application either from extract made from *Ecklonia Maxima* had increased. Assessment of nearly thirty marine algae with annealing has shown that cytokines were found in marine extracts. This research found that increased reproductive and herbal parameters also in tuberose were focused on cytokine and an increased absorption by natural manure of the mineral nutrient mostly in soil containing algae.<sup>18</sup>

The circumference of the sunflower head expanded sequentially by 31.78% with seed production of 51.03% in evaluation.<sup>35</sup> A certain impact has been associated with the higher exposure levels of seaweed foliar spray at which accelerated plant heights and leaves have risen significantly.<sup>50</sup> Noticeable influence upon on calyx wet weight of even the application of marine extract treatments. Flowers are influenced by cytokine and seaweed

extract sprayers, which influence certain features of the plant's growth, production and chemical composition of *Roselle hibiscus sabdariffa*.<sup>9</sup>

#### **Vase Life**

The consequence of macroalgae concentration expanded the life span of *Strut's* desert pea blossoms, perhaps it contributed to elevated concentration of wax texture, chlorophyll related to cytokines.<sup>40</sup> The post-harvest physical progressions of ornamental plants rely heavily on a life span that would be the greatest duration of time before the senescence of blossoms.<sup>76</sup> Blossoms were monitored for their petal wilting or otherwise neck bent condition as well. Days just after harvest from now until fully withering of floral were encountered as the termination of post-harvest longevity.<sup>77</sup> The post-harvest longevity identified ornamentals that splashed with marine algae extract was eight days particularly in comparison against control which had six days.<sup>39</sup>

#### **Conclusion**

The evidence from previous research through various seaweeds might be further investigated again for ecological possibilities of the production of new biological products. Seaweed extract consists of various organic compounds that enhance multiple ranges of ornate crops. The existent review is accountable for awareness of seaweed as an effective stimulant related to available synthetic fertilizers. Therefore, seaweed provide not only growth hormones but also micro and macro nutrients for enhance the growth and quality of the broad range of ornamental crops. Some research gaps identified and we recommend to study the methods of mass multiplication methods of seaweeds in artificial manner and production of commercial products in seaweeds.

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#### **Conflict of Interest**

The authors declare that there is no conflict of interest in the manuscript.

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