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Seaweeds As A Biofertilizer

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Seaweeds are large plants growing in the sea, especially various marine algae like the rockweeds, kelps, sea lettuce and dulses. Dried or fresh seaweeds and liquid extracts have been increasingly employed by horticulturists, gardeners, farmers, and orchadists as a fertilizer. Seaweed extracts are now commercially available as maxicrop, seasol, SM3, kelpak, and cytokin .The effect of seaweed extract is due to the microelements and plant growth regulators such as cytokinin present in it. Seaweed extract is used as a foliar spray, application to soil and for soaking of seeds before sowing. It enhances the germination of seeds, increases uptake of plant nutrients, and gives resistance to frost and fungal diseases. Seaweed extract is effective for ripening of fruits, increasing shelf-life of the produce, improves the quality of produce, and serves as an excellent soil conditioner.

Introduction

As the population is growing at a fast rate, the agrobased products should also increase. With the agrobased products, fertilizer industry is bound to grow, as it is one of the major components for increasing food production. At present there is a shortage of about three to four million tonnes of fertilizer[1]. As the disadvantages of chemical fertilizers are becoming more apparent, farmers are slowly but surely turning towards organic fertilizers. With increasing demand, availability of organic fertilizers from one or two sources is not adequate. To meet the increasing demand many viable options as possible have to be explored[2] and one of such options is the use of seaweeds as a fertilizer.

Seaweeds belong to a rather ill defined assemblage of plants known as the algae. The term " seaweed" itself does not have any taxonomic value, but is rather a popular term used to describe the common large attached (benthic) marine algae found in the groups of Chlorophyceae, Rhodophyceae, Phaeophyceae or green, red, and brown algae, respectively [3].

Seaweed extracts have been marketed for several years as a fertilizer additives and beneficial results from their use have been reported [4]. Many claims have been made for seaweed extracts including better seed germination and deeper root development, increased frost resistance, increased nutrient uptake and changes in plant tissue composition, increased resistance to fungal diseases, reduced incidence of insect attack, higher yields, longer shelf-life of produce and improved animal health when livestock is grazed on treated crops or pasture[5]. It has been shown that the performance of seaweed manure is superior to the conventional organic manure viz., farm yard manure[6]. Therefore the interest in seaweed as a fertilizer has been increasing as a supplemental fertilizer, in which the importance is being given to be the source of microelements and as a soil conditioner[7].

Liquid extracts derived from marine algae have been used over the past 40y on various crops to promote growth and development. Interest in these seaweed concentrates (SWC) in agricultural system is focused on their use as an inexpensive source of naturally occurring plant growth regulator. Much of the benefit from the application of seaweed extract has been attributed to the presence of the plant hormones, especially cytokinins. Various seaweed concentrates contain significant amount of cytokinin in addition to other phytohormones [8]. The main seaweed extracts known to play a useful role in agriculture are Maxicrop (seaborn), Algifert (marinure),Goemar GA 14, Kelpak G6, Seaspray, Seasol, SM3, Cylex and Seacrop16(ref 9), Algistim[10], and cytokin[8].

Work Done At CSMCRI, Bhavnagar

Thivy[11] has studied the seaweeds as manure for vegetable and field crops. Bokil *et al.*[6] continued the work

and reported superior performance of seaweed manure over the conventional manure as farm yard manure. Rama Rao[12] has carried out work on liquid seaweed fertilizer(LSF) and recorded promotional effect on *Zizyphus mauritiana* Lamk. Since then, the work is continuing in this Institute. .

After doing exhaustive study, CSMCRI has been able to develop a process for manufacturing a liquid seaweed fertilizer. The process is already been commercialised by this Institute.

Some of the Methods for the Preparation of Liquid Seaweed Fertilizer

Seaweed extract is an organic manure and is beneficial due to the presence of trace elements and other organic substances such as amino acids, antibiotics, auxins, gibberellins and vitamins in it. Some of these substances are decomposed by heat and hence it is essential that they should be conserved if they are to benefit the crops [13]. The method of extraction and the species used could be of great importance to the plant growth activity of the extract. Many seaweed constituents are known to undergo marked seasonal variations, which are being considered, in both commercial seaweed extract production and in the evaluation of inconsistent field trial results[4].

Many species have been reported to be used for the preparation of LSF such as *Fucus vesiculata, Furcelaria fastigiata, Hypnea musciformis*[14], Sargassum *plagiophyllum*[15], *Ascophyllum nodosum* (Algifert)[16], *Ulva lactuca, Durvillea potatorum, Sargassum wightii*[17], *Saragassum plagiophyllum* and *Padina pavonica* [18], *Sargassum, Champia, Padina,* Turbinaria, *Helminthocladia* [19], *Laminaria saccharina, Fucus serratus, Fucus vesiculosus*[13] , *Pterocladia* and *Ecklonia radiata*[20], *Padina tetrastomatica* and *Sargassum tenerimum* [21].

Method 1 — Challen and Hemingway [13] have described the method wherein two samples of commercial seaweed meal, one derived from *Ascophyllum nodosum* and another derived from *Fucus vesiculosus* were used to prepare extract according to the following method:

The powder was mixed with distilled water and allowed to stand. The mixture was boiled, allowed to stand for some time, then passed through a fine sieve to remove the solids and the liquor obtained was centrifuged. The solids from the sieve and centrifuge were pressed and the liquor obtained was mixed with the main liquor. The combined liquors were then concentrated under reduced pressure to yield a brown fluid. The percentage of total solids was determined and the extract diluted with sufficient water to contain the same percentage of total solids as the commercial seaweed extract. The extract of dry seaweed was further diluted when required .

Method 2 — The method is given by Bhosale *et al.*[21] in which chopped *Sargassum tenerimum* or *Padina tetrasomatica* was boiled with distilled water and then filtered. The filtrate was taken as 100 per cent concentration of the seaweed extract and from this different concentrations were prepared using distilled water.

Chemical Constituents of Seaweed Extract

It has been already established that the beneficial effect is due to the presence of trace elements and in particular the growth hormone like substances such as cytokinin in seaweeds. The chemical constituent for different seaweed extract have been reported by various workers [17,22,5]. Similarly the presence of natural cytokinin in seaweed extract has also been already reported in *Ecklonia maxima* [23] *and Ascophyllum nodosum* [24,25].

Effect on Seed Germination and Seedling Growth

The treatment of seaweed extract increased the seed germination.However, concentration plays an important role to impart desired effects. In higher concentration the respiratory activity was higher and the percentage germination was less. But when the concentration was such that the respiratory activity was only moderately increased the germination percentage also was increased[26]. More rapid germination of rice seeds was observed when soaked in seaweed extract of *Phormidium foveolarum* [14].

Venkatraman *et al.*[15] have experimented with the prepared extract from *Sargassum plagiophyllum* and commercial seaweed extract (SM3) and reported that liquid seaweed fertilizer promoted seed germination and enhanced early seedling growth upto a concentration of 0.75 per cent in black gram and upto a concentration of 1.5 per cent in green gram. The significant growth of the seedling of black gram and green gram have been reported when the seeds were soaked in 0.1 per cent and 0.05 per cent solution of seaweed extract Algifert [16]. Mohan *et al.*[19] prepared extracts from five selected

seaweeds namely *Padina, Sasrgassum* , *Turbinaria, Champia* and *Helminthocladia* and carried out studies on the effect on germination of seed and seedling growth in *Cajanus cajan*. They found that crude extracts obtained from brown seaweeds especially that of *Sargassum* and *Padina* were more effective when the seeds were soaked in extract for 24 h.

Results from seaweed research on citrus showed that many of the metabolic stimulations observed at the low rate of seaweed extract were probably the indirect result of IAA (Indole Acetic Acid) induced growth[27].

Effect on Yield

Aqueous extract from *Sargassum wightii* (Ag), when applied as foliar spray on cultivated race of *Zizyphus mauritiana* plants before harvest of fruits, enhanced overall growth of fruits in terms of length, breadth and weight by 11.23 per cent, 9.2 per cent and 25.36 per cent ,respectively, over the control [12].

Three different trials with strawberries gave respective increases in the yield over the control of 14.8, 31.9 and 28.0 per cent . With the turnips the mean yield per root was: control 22 g, seaweed extract 27 g. Each of these differences were statistically significant[28].

The increase in the yield of cucumber has been recorded to the tune of 41 per cent over the control[5] ,while Booth [29] has reported the increased yield of potatoes by 20 per cent through the application of seaweed extract at 10 gal/ac.

The field trials using seaweed extract (SM3) carried out by Blunden[4] indicated that banana bunches shot on an average 8.5 weeks earlier when seaweed extract was given in the form of foliar spray. Application at 0.75 gal/ac gave the average bunch weight 17.69 kg as against the control (14.51 kg), registering the increase in the yield by 22 per cent over control. The increased corn weight from five different blocks was in the range of 6.2 per cent to 29.44 per cent . It has also been reported that the yield of tomato increased by 20 percent after application of seaweed extract at the rate of 1 gal / ac.

The increase in the fresh and dry weight was observed in case of *Vigna ungiulata* L. (Walp) when treated with o.25 per cent of liquid seaweed fertilizer obtained from green seaweed *Ulva lactuca* . It also enhanced the accumulation of total nitrogen and phosphorus [17].

From the results, it is likely that the increased yield can be attributed to the cytokinin like substances present in the seaweed extracts. However the effect of increased yield may well be an expression of the effects considered elsewhere (i.e. resistance to diseases, root development). The effect of minerals supplied in situation of marginal deficiencies should also be considered [5].

Effect on Shelf-life and Storage of Produce

It has been reported that seaweed sprays applied to peach trees generally resulted in greater shelf -life of treated fruits. After 21 d, more than 50 per cent of untreated peaches were unmarketable, compared to less than 20 per cent of the fruit receiving seaweed sprays. Earlier applications, begining with full bloom gave better results than did sprays during the last of the growing season. Seaweed applied to peach trees has no appreciable effect on pH, firmness, soluble solids or total titrable acidity [30].

Similar results were observed when peaches sprayed with seaweed extract before harvest kept longer. Sixteen days after harvest it was observed that 32.2 per cent of the controls were rotten, compared with only 14.7 per cent of the fruit from treated trees[5]. Applying two foliar sprays of seaweed (DSWE Algifert) extract to Cox's orange apple trees two weeks and four weeks before harvest led to statistically significant increase in shelf- life as measured by visual appearance and the hardness of the flesh. The spraying did not change the nutritive value estimated through sugar content, acidity and soluble dry substance[31].

Peepers harvested from each block were kept in the darkness at 23°C for 8 d by which time all the control fruits were unmarketable due to softening and colour changes but those from seaweed extract (0.5 gal/ac and 1 gal/ac) treated plants were still marketable[4].

Blunden *et al.*[10] have reported that the shelf -life of produce was significantly increased by immersion in seaweed extract. They have investigated the effects of post harvest dipping of fruits in seaweed extract solutions of known cytokinin activity and found no significant effect on ripening time as a result of dipping aubergines, avocados, and pears in either diluted seaweed extract or in aqueous solutions of kinetin. However, bananas showed a significant increase in the ripening rate after being dipped in diluted seaweed extract or in an aqueous solution of kinetin. Mature green fruits of mangoes when dipped in SM3 with an activity equivalent to 7.5 ppm kinetin gave significant results but most effective treatment was found to be immersion in marinure at 30 ppm kinetin- equivalents. The marked reduction in the " degreening " of limes were noted when

immersed in diluted seaweed extracts for 1 h and which is of potential economic value. Immersing capsicum in seaweed extract solutions with a kinetin equivalent of 15,7.5 and 2.5 ppm, caused a significant reduction in the reddening.

Seaweed extract can also be used on flowers. Trials at Clemson University with Poinsettias have shown that there is an increase in the number, weight of the flowers increased as much as 27 per cent and quality of the flower with low concentration[26].

Effect of Seaweed Extract on Resistance of Plants

Soon after the seaweed extract came into use, it was noticed that it virtually eliminated "black spot" from roses. In some breeding experiments with the green peach potato aphid on turnip leaves, it was found that there was much less mildew on leaves which had been sprayed with a seaweed extract. It has been reported that mildew was much less prevalent on melons, which had been sprayed with seaweed extract. It has also been shown to reduce the incidence of brown rot of peaches from 3.7 per cent to 1.5 per cent. It was observed from the experiment undertaken to investigate claims by growers that seaweed extract seemed to reduce the incidence of *Botrytis* infection in strawberries[29].

Stepheson[28] has observed that the hydrolysed seaweed greatly reduced the incidence of damping off. The mean number of tomato seedlings to reach fourth leaf stage without damping off was 45 per cent in the control and 90 per cent in those treated with maxicrop. Overhead watering of plants with 1: 120 dilution of seaweed extract (Maxicrop standard) each week reduced the incidence of infected fruit to 4.6 per cent compared with 22.5 per cent for the control plants. It was further reported that when aphids were given the choice of treated and untreated sugar beet leaves of the same physiological age the majority of the alate aphids always went to the controls. The mean percentage distribution of young black bean aphids over a 5 h period was 20 per cent from maxicrop treated vs 83 per cent from control. The significant reduction in the population of red spider mite and aphid was reported by the application of seaweed extract on chrysanthemum. Seaweed extract have been shown to ensure improved resistance of plants to unfavourable conditions of environment (frost and drought) and reduce incidence of fungal, insect, and nematode attack [9].

It is now well known that substances with growth regulating properties also have an inhibitory effect on disease and insect pests. Since seaweed extract contains growth-promoting substances it now seems logical that they should also inhibit the growth of insect pests and fungal diseases[14].

Seaweed Extract As A Soil Improver

The modern trends of seaweeds utilization as soil manure were set in 1951 in the European countries and the seaweeds were used along with the farm yard manure as soil conditioner in those countries [32]. Since seaweed fertilizer supply trace elements, it is particularly very useful on alkaline soils where deficiency diseases are common[14] and help in improving the soil condition.

It has been already mentioned that seaweeds are not only used in the form of liquid, but all forms of seaweed have for centuries been applied to the land as a fertilizer. Liquid seaweed application results in improvement in plant growth and soil texture. Improved soil structure is invariably associated with better aeration, enhanced nitrogen fixation, and generalized raised proliferation of soil organisms. Capillary action is also increased and as a result, root system of plant are stimulated into further growth. The application appears to bring about mobilization of certain trace elements in soils where these tend to be in unavailable form[33].

Thivy[11] has reported that brown seaweeds such as *Sargassum* are valuable as manure, since they contain some of the soluble alginates (polyuronides) which serves as soil conditioners and alginic acid which accelerate decomposition of organic matter by bacteria. Seaweed manure steps up bacterial populations including nitrogen fixers. The waste products excreted by soil bacteria contain other polyuronides that serve as additional soil conditioners. Seaweed manure can rectify unusual deficiencies and defects of the soil and has other advantages also. A remarkable capacity for retaining water is noted in *Sargassum* manure.

Soils that contain large amounts of clay and only minimum of organic material are not porous and are said to lack crumb structure. Humic acid, and to a greater extent soluble alginates in seaweed, bind particles of clay into larger aggregates or create crumb structure by combining chemically with metallic radicals present in the soil. They bring about aggregation of soil particles. In the case of soluble alginates, each metallic radicals combine with two or more alginate molecules to form a polymer or large molecule with branched chains. The polymers are responsible for the formation of crumb structure.

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