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Marine microalgal extracts on cultivable crops as a considerable bio-fertilizer: A Review

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Around the globe, all countries whether developing or developed depend on agriculture. Nowadays due to advances in science and agricultural technology, the usage of chemical fertilizers, pesticides and genetically modified crops is increasing day by day to meet the demand of the rising population. This looks helpful to meet our demand but this is a great threat for the future generation as the water and food will be more toxic due to accumulation of pesticides and chemical fertilizers which in turn reduces the soil fertility and contaminate the ground water. Due to this condition, the food web is getting totally collapsed. Because of realization of these problems, people are shifting to organic farming. Current researchers are focusing on terrestrial organic sources for agro production but there are immense sources in the wide marine environment. The marine sources will play a substantial role on agricultural development in the future. Microalgae are the best, as they are cheap, renewable source, easily available and are cultural organisms. Moreover, microalgae contain all the essential nutrients needed for plant growth. The majorities of microalgae are capable to fix the atmospheric nitrogen and are effectively used as bio-fertilizers. This review focuses on the broad overview of bio-fertilizers with special reference on marine derived microalgal bio-fertilizers and its role in increasing crop production by altering various physiochemical parameters of diversified agricultural crops.

Keywords: Agriculture, Chemical fertilizer, Marine source, Microalgae, Pesticide

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Agriculture is the process of crop production by cultivating soil, for economic purpose. Due to population explosion and urbanization of farm lands, there is a great demand for production to fulfil the growing food needs[1]. There have been so many changes like exploitation of native crops and usage of new genetically hybridized crops which lead to alteration of the biological cycle and causes serious threats to the future generation[2]. Acidification of soils and pollution has a profuse impact on ground water. Aquifers, where the excess fertilizers get accumulated in the environment, are the main areas prone to this pollution. Aquifers are contaminated by nitrogen, which is very toxic and unhealthy and primarily causes long term illness in children leading to methaemoglobinemia in children and affects adults with gastric and oesophageal cancer[3,4]. Pests and useful insects are been killed by these chemical fertilizers and insecticides. Crops are made more resistant and high yielding, highly palatable, and highly productive and hence which naturally loses their natural resistance and productivity.

Eutrophication is caused by the nutrient rich fertilizer run off water from (ponds, rivers, lakes, bays, etc) which causes blooms in water and which automatically cutoff the oxygen supply and deliberately causes mass mortality. This eutrophication is highly deadly as it can kill all the bacteria and fungi holding the soil together which results in soil erosion loss of top soil, which will only give a temporarily yield which in a nutshell destroys productivity of the land. People nowadays are shifting towards bio products and biofertilizers avoiding chemical agents as are eco-friendly, more productive and efficient, economical and available to all at marginal rates. Moreover beneficial microbes accelerate the plant growth and protect from harmful pests[5]. Biofertilizers has the capacity to be renewable, eco-friendly and supplementary nutrients which are important components of integrated nutrient management.

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Rapid increase of people usage of sustainable agricultural practices by avoiding chemical fertilizers and promoting natural biofertilizers and other chemical free bio products which can create a greater impact in rejuvenating the polluted areas and bringing them back[6,7]. They enrich the soil with increased nutrients and beneficial microorganisms that are necessary for the growth of the plants and results in high yield. Most biofertilizers which are in current use are originated from terrestrial source like cow dung, animal waste, beneficial bacteria etc. but there are immense scope and wide variety of organisms from the marine source such as phytoplankton, sea grass, seaweed, corals and fishery wastesetc,[8,9,10].

Marine micro algae

Algae are profusely found in fresh, estuarine and marine water between a size range less than 2 μm to more than 60 m capable to thrive in different degrees of salinity temperature, torpid, mineral ions and organic matter. They constitute a diverse range of lower plants being photosynthetic, mixotrophic symbiotic and are even parasitic[11].

Micro algae also improve structure of the soil and also the porosity by polysaccharides and mucilages secretions[12]. Micro algal biofertilizers do play a symbiotic relationship with higher plants[13,14]. Nowadays there is a wide preference on usage of microalgae to produce good crops on integrated and ecological production has been analyzed over poor soils and adverse conditions were evidenced. Evident researches enclave new routes of biotic compounds from microalgae which can have a positive effect over sustainable plant production[15,16,17,18].

There are reports on blue-green algal extracts improves growth promoting regulators, vitamins, amino acids, polypeptides, antibacterial and antifungal substances which enhance plants by producing that exert phytopathogen biocontrol and polymers such as exopolysaccharides which in turn enhance productivity and plant growth. The agricultural significance of cyanobacteria in cultivation of rice can be directly correlated with its nitrogen fixing ability and several other positive effects for soil and plants. For plant growth, nitrogen is the second most limiting factor in many fields followed by water, and it can be met by fertilizers. Blue green algae (BGA) being used as a biofertilizer not only increases the yield but also enhance the soil physico-chemical properties.

Microalgae fix soil nitrogen and also improve the physico chemical properties of soil. There was gradual buildup of residual soil nitrogen and carbon, improvement in soil pH and electrical conductivity. The grain quality in terms of protein content improved. *Nostoc, Anabaena, Tolypothrix* and *Aulosira* being blue green algae of the same genera fix atmospheric nitrogen and they have been also used as inoculants for paddy crop grown both under upland and low land conditions. Numerous polysaccharides and mucilage in microalgae as improved he the soil structure and porosity is improved by the microalgae[12]. The biofertilizers do play a symbiotic relationship with higher plants[13,14]. In recent years, the increasing worldwide interest in the use of microalgae for the ecological and integrated production of energy crops over poor soils and adverse conditions were evidenced. Even though the application of chemicals in agricultural field is inevitable, there were opportunities in several regions of the world, where the organic farming was increased to meet the domestic export market. Organic farming not only promotes the yield but also helps in maintaining the soil biological activity. It also decreases the production cost and in the meanwhile increases the crop yield[19].

Role of Marine microalgae in soil fertility

15 million metric tonnes of algal products are produced annually on a whole whereas; a major part is used as biofertilizers as it enhances plant growth and yield. They are applied either fresh dried or even used as composts and their products used in agriculture have good tolerance, seed germination, plant growth, yield, tolerance to stress and resistance against disease infection or pests[20,21,22,23,24,25,26]. The inorganic fertilization of rice and lettuce seedlings is compared to the cyanobacterial fertilizers[27] and several varieties of are nitrogen fixing and they improve soil fertility for nitrogen fixation in place of N- rich fertilizers[28]. The cyanobacterium *Tolypothrix tenius* grown in cultures and added to the field, which is used widely in the rice fields around Asia.

Auxins play a major role in elongation growth of plant tissues by cell division ageing and mainly apical dominance by elongating plant tissue growth[29]. Lessening the process of ageing and performing cell division Cytokinineniss and Gibberellins perform seed germination, growth regulation, breaking bud dormancy flowering and fruit development Due to the

rich fibre content and increase the biological activity and microbial biomass of the soil.

Effect on plant diseases and pests

Naturally plants and animals have several basic defence mechanisms to withstand pests and other insects. Natural substances like algal extracts *laminarin* and *carrageenans* application are used to get rid of pests. They are observed in tobacco leaves to induce signaling and defense gene expression[30,31].

Several scientific study proves that different chemicals fungicides and insecticides are been replaced by microalgae[32] Major disease causing groups among plants are fungi and bacteria. *Sclerotinasclerotiorum* and *Rhizoctonia solani* Plant pathogens can be efficiently controlled by Cyanobacterium *N. mucorum*[33]. Certain substances produced by the free floating unicellular organism *Chlorella elliposidea* affect mosquito larvae growth and immunity[34]. Extracellular production by blue green algae has many evidences wide spread and important quantitatively[35,36,37]. Algal biofertilizers is also useful for the reclamation of marginal soils such as reclamation of soils like saline-alkali and calcareous soils can be done with the help of algal biofertilizers[38].

Field trialof Marine microalgalbiofertilizer selected crop cultivation (maize, onion, green gram and paddy)

Centre of Advanced Study in Marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai, India, has been working on marine conservation, biodiversity, taxonomy, drug designing, aquaculture, fish genetics and breeding, biofuel production and industrial products from marine organisms. As there is several agricultural problems arising nowadays we are using marine microalgae to produce very efficient and economic biofertilizer which has been successfully going on. Microalgae like Spirulina and chlorella vulgaris are isolated, cultured and given to crops like paddy, onion, maize, green gram, black gram and tomato as biofertilizer in various treatment methods. Microalgae like *Spirulina* and *Chlorella* when given to plants gave better yield compared with common chemical fertilizer and also the growth promoters in soils and fertility promoters hormones were increased. Currently we focus on biopesticides production from microalgae like *Spirulina, Chlorella, Dunaliella, Nannochloropsis, Tetraselmis,* and *Coscinodiscus*. Hence there can be a chemical free organic world Therefore, marine resources will be the suitable one used in lands and improve agriculture in a sustainable way so that there will be good yield without leaving traces of any chemicals or contaminants in the soil.

The review of this study was undertaken to evaluate the biofertilizer production of microalgae (*Spirulina platensis* and *Chlorella vulgaris*) and investigate the biofertilizer potential on Maize, Onion, Green gram, Black gram, Tomato and Paddy cultivation through field experiments. The biofertilizers were induced to the field through soil drench method, cowdung manure mixed with microalgal dry biomass and microalgal cell extract through foliar spray method. The field study was done in the experimental farm of Centre of Advanced Study in Marine Biology, Faculty of Marine Sciences, Annamalai University, Tamil Nadu India between 2015-2018 to harness the usage of microalgae as biofertilizers in Maize, Onion, Green gram, Black gram, Tomato and Paddy. The soil samples were collected from agricultural land area of Aalapakkam, Cuddalore District, and Tamil Nadu at the depth of 0-15 cm to analyze the fertility status of the soil. Then the composite sample was prepared and then analyzed for various soil characteristics in order to get information about the physico-chemical, biological and micro and macro nutrient composition of the field experimental soil.

Microalgae as biofertilizer maize (*Zeamays* L.*)*

The experiment lasted for 90 days. The *Zea mays* certified a seed (NK6240) of Plants *Zea mays* was collected from Tamil Nadu Agricultural University Coimbatore. The cow dung manure mixed soil with microalgal (*Spirulina platensis* and *Chlorella vulgaris*) dry biomass powder separately at the dose of 3 g algal dry powder +10 g cowdung manure+1 kg soil. Then the seeds were planted in 30 cm diameter. The shoot length and the leaves numbers were measured at the 50th day and the height of maize plants were measured at the 75th day. The growth parameters like plant height, leaves of the plant, shoot and root length, fresh and dry weight of shoot and root were measured. The estimation of plant growth hormones and pigments like in doles, phenols, chlorophyll a and b, carotenoids, total sugar and reducing sugar were done and the yield attributes *viz* number of plants, number of maize/plant, weight of one maize seed and total number of seed yield were also measured. The soil physical chemical and

biological activities were also analyzed. The biochemical and mineral content was analyzed on the harvested maize seed. The seed diameter, seed length, seed weight, germination percentage, germination rate, seedling length and seedling root length were measured after harvesting the maize seed. This experiment proves that Spirulina mixed with cow dung manure has evidenced with amazing results in Spirulina and minimum results was obtained from Chlorella vulgaris mixed with cowdung manure and control[39].

Influence of microalgal fertilizer on growth, yield and quality of Onion (*Allium cepa* L) plant

The growth, yield and quality of onion under the influence of microalgal biofertilizer were done during 2016-2017. The same experimental farm used for maize cultivation is used here. The potential of microalgal biofertilizer was tested by sowing onion seeds after 10 days of maize harvest. The same procedures of maize cultivation were followed for onion also. Randomly 10 plants were selected and quality parameters like plant growth, yield etc were observed and recorded. During observations one plant from both ends of the row was avoided. For the bulb nutrient analysis growth parameters like plant height, number of leaves per plant, Leaf weight per plant, Fresh weight/dry weight and Leaf area index were measured. Pigment content like estimation of chlorophyll and total Carotenoids were measured. Yield components like Neck thickness, Bulb diameter and Bulb weight and Biochemical composition like determination of total soluble sugar, total Phenol and total indoles and free amino acid were measured hydrocyanic acid, total oxalate, soluble oxalate, phytic acid, cyanogenic glycoside were the ant nutrient content being measured. Good results were observed in Spirulina platensis comparing chlorella vulgaris in the account of mixing of cowdung in onion plants[39].

Microalgal liquid Bio-fertilizer and bio-stimulant effect on green gram *Vignaradiata* (L.)

The experiments were done during the month of November in the year 2019. There were two different treatments, of four different concentrations and imprint of three in five kg pots. The collected concentrated microalgal biomass slurry of *Chlorella vulgaris* and *Spirulina platensis was* reconcentrated by centrifugation, frozen and was then remelted at room temperature. Later the slurry was centrifuged and the clear components and nutrients of cell sap were obtained in 5000 rpm and were used for analysis. Foliar spray treatment was given to green gram three times, 10 days pre blooming (first week or month), after berry sitting (second month of first off of one week) and finally 21 days later (second months last week). The microalgal extract of solution was sprayed with solution till run off of one litre by algal extract of treatment was arranged so there was much difficulty to study all the experimental plants at their different stages so randomly only 5 plants in each plot were selected and tagged for further studies

Plant height, number of branches/plant, leaf area index, shoot and root length per plant, fresh and dry weight of shoot and root, root nodules per plant and fresh weight of root nodules are the growth parameters were measured. The observations on yield attributes of green gram *viz* number of pods/plant; weight of pods per plant, weight of seeds per plants and weight of 100 seeds were also measured. Physical characteristics of green gram viz analysis water absorption index and water solubility index, water absorption capacity, oil absorption capacity, proximate composition, mineral analysis, extraction and estimation of total proteins and protein fraction, analysis of anti-nutritional compounds and quantitative determination of Phytohaemagglutinating (Lectin) activity were also measured Evidently, *Chlorella vulgaris* cell extract showed better result in green gram cultivation[39].

Microalgae as Bio-fertilizers for paddy Growth and Seed Yield Productivity

The present study was to investigate the impact of different application methods of marine microalgae (*Chlorella vulgaris* and *Spirulina platensis*) at different levels and to analyse the fertilizing performance in paddy plants on a clay loamy soil by surface irrigation. The bio fertilizers were used in different application methods of air, soil drench application dried algal biomass with algal culture suspension and the combination of soil drench in the presence of 25%, 50% 75% and 100% of recommended dose were used for this experiment on rice. The plants were divided in to 5 groups, where Group 1 served as control (without fertilizer), Group 2, 3, 4 and 5 were treated with 25%, 50%, 75% and 100% of algal dried powder of *Chlorella vulgaris* and *Spirulina platensis* respectively. The parameters were measured like plant height, plant leaves, leaf area index, shoot and root fresh and dry weight, seed yield, number of seeds/pod, 100- seeds weight, seed weight per plant, seed yield per pods and

physical, chemical and biological activity of soil were analysed. *Chlorella vulgaris* and *Spirulinaplatensis* both microalgae showed better results in paddy cultivation. But when comparing both Spirulina was found to be bit better[40].

Conclusion

The upcoming generations faces threat of pollutants not only due to industrial revolution but also owing to the improper and excessive applications of chemicals especially in the form of fertilizers, pesticides and other agriculture related inputs that will have an adverse environmental impact. Besides its unfavourable ecological impacts, even the consumable agricultural products are being bio accumulated with these chemicals that might cause deadliest diseases including cancer, nervous disorder and sterility, meanwhile it also ends up with infertility of the soil which makes the soil uncultivable. Thus, it is mandatory to find out a suitable, safe and eco-friendly product that can serve well than the chemicals without any side effects. Maximum yield can be achieved within a short duration by the implications of bio-fertilizers, for instance the use of microalgae will be a best alternative. There are also several terrestrial biofertilizer sources like cow dung, plant remains, etc are used but microalgae is efficient, cheap, easily cultivable and renewable source comparing to the chemical fertilizer. So, by using microalgae it is able produce organic products without degrading the soil fertility. Therefore shifting to organic agriculture is possible, reducing the root cause of various diseases and create a chemical free organic world. Thereby we can conclude that microalgal biofertilizers have the capability to enhance the various physical, chemical and biological properties of soil and also impart better growth, yield, hormone content, and nutritional quality of the crops.

Conflict of interest statement: We declare that we have no conflict of interest.

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