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Impact Of Blue Green Algae (Cyanobacteria) As A Natural Biofertilizers For The Sustainable Development Of Agricultural W.R.T *Capsicum Annuum* L.

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Abstract: The increased in the population has been one of the challenging courses of agriculture for many countries including India. As the population of the country increased, the pressure on agriculture fields too increased as india became the most populated country in the world. At the same time, Due to excess uses of chemical fertilizers the soil fertility has decrease and now the agricultural soil has been limited for the few crops only. To conquer the challenge there is a need of Natural Biofertilizers in large amount to secure soil natural elements for the crop growth and development. So, in agriculture field it's very important to make it sustainable for every element of nature. Biofertilizers is one of those practices in the agricultural field to make evolutionary changed as it is the need to achieved the sustainable goals. The current researched is focused on use of Blue Green Algae commonly known as Cyanobacteria as a biofertilizers for the sustainable development of agriculture. The study carried out in the agriculture field along with the farmers, Blue Green Algae particularly *Nostoc* has been used for the chilli (*Capsicum annuum* L.) crop and its development as it has nitrogen fixing ability. BGA has a really good effects in the combination of Farm yard manure and Vermicompost so these two biofertilizers have used as a carrier inoculant for the betterment of the crop. These biofertilizers has shown positive results for the yield properties of chilli crop. They enhance the growth of chilli fruits as well as the these biofertilizers increased the natural available nitrogen content of the soil by 60kg/ha, which will be very important to secure the soil for the years to come for the sustainable development of the society through agricultural field.

Keywords: BGA, Cyanobacteria, *Nostoc*, Chilli, Sustainable Development, Biofertilizers.

Introduction: Biofertilizer has become the need for 21^{st} century for sustainable agriculture in India. Biofertilizers like Blue Green Algae (Cyanobacteria) has a significant role in various aspect of agricultural field. It increases the fertility and aggregation of soil and makes atmospheric nitrogen available for plants which ultimately lead for the growth of the crops. Blue Green Algae (Cyanobacteria) has a wide range of application from crop production to soil fertility and even it helps in aggregation of soil (Venkatraman & Shanmuga 1992). Green revolution has been very important initiatives in India and it has been very impressive impacts on the Indian agricultural system where Cyanobacteria are used as potential fertilizer (Kant et al; 2006). The primary constraints restricting agricultural productivity up to the 20th century were plant nutrients, specifically nitrogen and phosphorus. The primary industrial phenomena for producing plant-available forms of nitrogen are the artificial nitrogen fixation process known as the Haber-Bosch process, which uses more than 1% to 2% of the planet's annual energy supply. Ironically, nitrogen is one of the most important nutrients that crops need in large quantities. Despite being present in large quantities in the atmosphere, crop plants have very little access to it. This is because the majority of crop plants are deficient in the necessary characteristic for assimilating atmospheric nitrogen. It so makes the creation of artificial nitrogen fertilizers necessary. Enhancing sustainable agriculture requires regulating soil fertility and physiochemical characteristics in a sustainable manner. The potential of cyanobacteria as a biofertilizer that can satisfy the needs of sustainable agriculture has just come to light. This is due to its efficient solar energy capture and biomass conversion by the simple application of carbon dioxide, water, and nutrients. In order to survive a variety of severe environments, cyanobacteria have undergone tremendous evolution. Dependency on the chemical fertilizer can decreases the fertility of the soil and can decreases the natural nutrients available for plants in the agriculture (Barman et al., 2017). Plants cannot uptake all the nutrients which are required to their growth and development applied by chemical fertilizers to the agriculture field (Bhardwaj et al., 2014) so because of this some amounts of nutrients are either fixed in the soil through some practices to increase the fertility and nutrient or through mixed with water bodies (Mahdi et al., 2010). For the sustainable development these biofertilizers have multiple positive impacts on the soil and can be relatively cheap and convenient for use (Ghosh 2004). Rice is one of the important food crops of worlds because more than 40% of the world's population depends on rice as a major source of calories. In India the production of Rice yield is about 1990 kg/ha compare to a maximum of 3346 kg/ha in Punjab. So, the production of rice yields in Punjab is highest in the country but low compared to China i.e., 5807 kg/ha. (B. D. Kaushik 2014)

In India the states like Punjab, Uttar Pradesh and Haryana are the states where the production of rice is higher as compare to the other states. And the study has shown as use of BGA resulted in 25.2% of urea reduction with an overall of 3.8% increase in the yield of rice and a marginal decrease in per acre cultivation cost (Bhooshan et al., 2018). Apart from rice the effect of Blue Green Algae (Cyanobacteria) as a Biofertilizers was seen on the wheat plant. Vermicompost and Farmyard Manure (FYM) enhances the abundance of BGA like Nostoc, Anabaena, Calothrix, Oscillatoria and Phormidium under the wheat crop which ultimately increases the yield of Wheat (Prasanna et al., 2008).

There are some other Biofertilizers other than BGA like Farmyard Manure (FYM) and Vermicompost is good for Sustainable agriculture. Blue Green Algae (BGA) has been successive to the rice field over the years but it has been observed that Blue green algae along with Vermicompost and Farmyard manure has shown significant results to crop growth like chilli for pot culture analysis (Sangita, 2015; Sundaram et al., 2019). Cyanobacteria are known to release biologically active substances like vitamins, carbohydrates, amino acids, proteins, polysaccharides and phytohormones that function as elicitor molecules to promote plant growth and development which help them to fight against biotic and abiotic stress (S. Singh 2014).

Material and Methodology

1. Occurrence and Distribution of algae

The algae are said to be ubiquitous, although the majority of them live in aquatic environments. These environments may include stagnant or flowing water bodies, but also include moist surfaces of any kind, such as moist soil, marshy tracts, moist rocky surfaces and moist surfaces of plants like leaves and tree barks. There are also extreme environments such as deserts, permanent snowfields and ice formations. In these environments also algae can survive and inhabit. Therefore, the statement that algae are ubiquitous is quite true.

However, most algae live in either stagnant or lentic and flowing or lotic waters. The water may be of low salinity when they are described as fresh water; alternatively, the salinity of water may be in a higher range of 33 to 40%, as in marine waters. It is therefore the custom to distinguish between fresh water algae and marine algae. There are also waters of an intermediate salinity range, described as brackish water, seen in estuarine regions of rivers and stream or in certain forms of inland waters which are rich in minerals. Some algae are found in such locations and these can be described as brackish water algae. Algae of moist surfaces are frequently described as subaerial algae. Algae of freshwater aquatic habitats may be suspended or free floating in the water and these are planktonic algae. Others may be bottom living or attached to objects submerged in water and these are benthic algae. Benthic algae may be epilithic (attached to stones), epipelic (attached to sand or embedded in mud), epiphytic (attached to other aquatic plants which may even be other algae) and epizoic (attached to aquatic animals). Similarly marine algae may be planktonic or benthic, Subaerial algae may be edaphic (occurring on moist soil), epilithic, epiphytic, epizoic, corticolous (attached to barks of trees) and epiphyllous (attached to surfaces of leaves).

Some soil algae are present in deeper layers of the soil and are not readily observed. There are also some algae which live in special cavities or chambers in the tissues of plants and animals, the endophytic and endozoic algae. There are also a few algal species which are parasitic. All algae are perfectly adapted for life in their particular environments and are affected in various way by environmental factors, physical, chemical or biological. These are concerns of the algal ecologists and do not concern those who are interested in collection and culture of the algae (Metting 1981).

2. Equipment used for collection of algal samples.

i) Containers: glass or plastic, bottles of various sizes or polythene bags either open or provided with a zip lock.
ii) Long glass tube with a rubber bulb at one end. (Perspex tubes can be used as well)
iii) Long forceps
iv) Scalpel, knife or scraper
v) Plankton net or plankton filter.
vi) Thermal box or bucket with ice.
vii) Hand lens or a field/handheld microscope
viii) 500 ml capacity plastic mug

3. Collection of algal samples

Collection of algae from different habitats requires different collecting equipment. Planktonic algae can be collected using a plankton net. It is made of a silk fabric of fine mesh (now-a-days nylon fabric is used) which is shaped into a cone, the broader end being stitched around a metal ring and the narrower end wrapped around the month of a small collecting bottle. The metal ring is attached to a towing rod of a desired length.

The plankton net is towed along the water several times, always in one direction so that the water enters the net and the towing force keeps the water flowing towards the collecting bottle. This process results in accumulating the plankton found in a large volume of the habitat water into a small volume in the collecting bottle. The accumulation of the planktonic algae can be noticed by the visible increase in the green / blue green colour of the water in the collecting bottle. When the colour has deepened sufficiently, towing can be stopped and the collecting bottle with the algae detached from the net.

A more simplified method of collecting the planktonic algae is to use a bottle or cylinder open at both ends. On one end is stretched and fastened a square of the silk fabric used for plankton net. A definite volume of the pond water (up to about 50 litres) is poured into the bottle through the open end. The plankton is held on the fabric while the water gets filtered. The fabric is then removed and the algae on the fabric washed into a container with a small quantity of the locality water. In either of these processes, the planktonic algae are concentrated several folds in a small volume of water, thus facilitating the study. The bottom living algae can be collected with the help of a long glass tube with or without a rubber bulb attached to one end.

A simple tube is used by first closing one end of the tube with the thumb and introducing the tube into the water, until the open end is in close proximity to the bottom sediment. Then release the thumb to allow the water from the bottom to be sucked into the tube along with the benthic organisms. Then close the top end of the tube with the thumb again and take the tube out of the water. Pour the contents of the tube into a clean container. If a bulb is used, keep the bulb compressed while introducing the tube into the water and then release the bulb, which has the effect of sucking the bottom living organisms into the tube.

Attached algae can be collected with the substrate if the latter is small and can be placed in a container without any difficulty. Later in the laboratory, the algae can be scraped off the surface of the substrate and transferred to another container. Often one encounters algae attached to large rock or stone. In such cases, one has to remove the algae from the substrate and transfer to a container. If the algae are filamentous, it is possible to use a pair of forceps to remove these. Sometimes one has to use a knife and a forceps if the alga is attached firmly and the forceps may be inadequate for removing the alga. In all cases, it is necessary to collect the algae without losing or damaging the attaching organ. So, it would be advisable to hold on to the algae with forceps and scrape the algae from the substrate, a procedure which can be mastered easily. If the attached alga is a crust forming one or forms a slimy layer on the substrate, it is possible to scrape the algae with a scalpel on a chisel, while holding a collecting vessel inverted over the alga. The collecting vessel may be a bottle or may be a plastic bag. Collecting vessels may be bottles of different sizes, polythene bottles are quite convenient. Alternately polythene bags of various sizes may be used. Bags with zip-lock are nowadays available and these are convenient to use.

6. Isolation of BGA: The isolation of algae has been done by the Venkatraman soil and water method. The soil pots were used as a base for the germination of Blue green algae. The selected algae have been introduced into the soil pots along with fresh water and kept it under sunlight for the germination. The soil pots were act as a soil base for algae growth. In this method a special care was required for water change and if they're in any additional growth along with BGA like Nostoc as it is easy to identified Nostoc as compare to other algae. Later on these grown algae were dried and made a fine powder out of it for further experiment.

8. Effect of Algalization on Yield properties of Chilli crop (flowers and fruits count)

a. Soil Analysis (Before and after the Experiment) Soil Analysis: Before the experiments soil analysis has been done through Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dhule, Maharashtra.
b. Agricultural Field Area for Experiment: Kundane village Agricultural field, Dhule, Maharashtra.
c. Variety selection of Chilli Crop: local cultivated variety of Chilli crop.
d. Treatments given: BGA, BGA+FYM, BGA+Vermicompost and Control.
e. Carrier Inoculants: Farm Yard Manure (FYM) and Vermicompost: The FYM and Vermicompost has been given to the field before plantation of the young one done for the betterment of the soil nutrients.
f. Preparation of Young plants from seeds: the traditional method has been used for the preparation of young plants. Simply small baskets were used into that soil has been deposited along with the treatments.
g. Plantation of young plants into the agricultural soil: after the formation of young plants from the seeds with various treatments of biofertilizers the plants has been transfer to the agricultural soil with all the necessary practices.

h. Final Combination of the treatments: Soil Application of BGA 4kg/Acre, Vermicompost and Farm Yard manure 4kg/Acre.

Results:

A) In-situ effect of Algalization on yield of *Capsicum annuum* L.

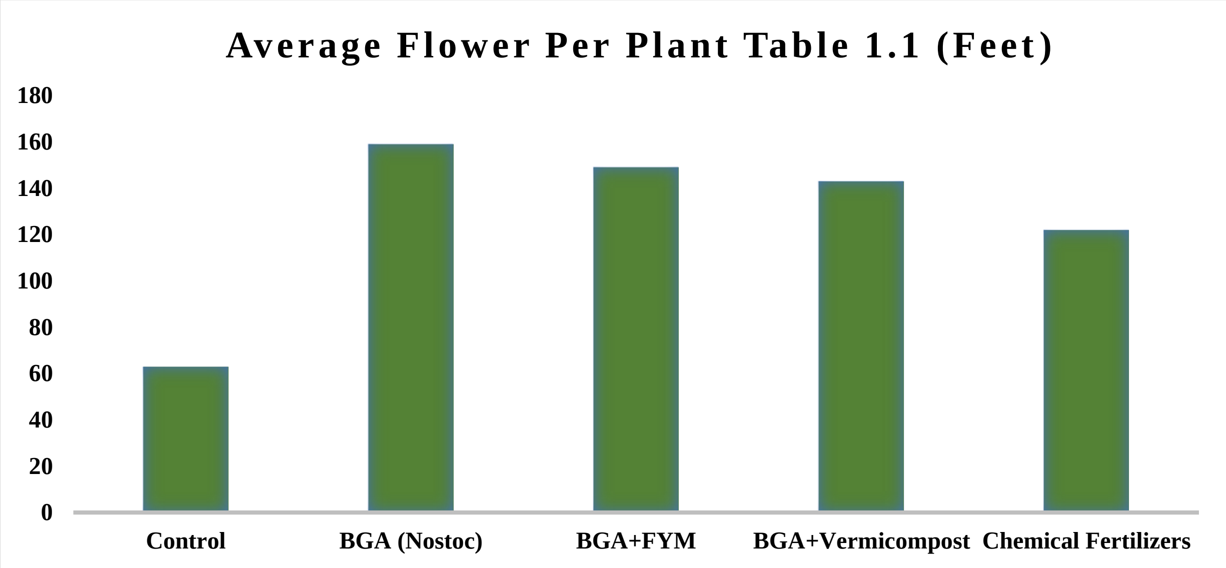
: In-situ experiment has been performed in the buffer area into the agriculture field along with farmers. The main purpose to performed all the field experiment with the farmers is to provide them confidence for the used of biofertilizers like BGA along with the carrier inoculants like FYM and vermicompost.

i) Total number of flowers per plant (Table no.1)

Sr. No.	Control	BGA (Nostoc)	BGA+FYM	BGA+Vermicompost	Chemical Fertilizers
1.	65	126	158	129	121
2.	59	160	156	128	115
3.	67	165	162	150	132
4.	59	168	128	134	110
5.	62	169	112	156	131
6.	68	153	118	162	120
7.	62	148	139	131	128
8.	73	159	153	149	131
9.	69	129	157	135	110
10.	61	149	165	148	102
11.	62	158	169	147	108
12.	67	151	153	148	115
13.	53	185	175	151	118
14.	57	178	159	135	117
15.	59	169	165	154	124
16.	65	154	148	156	127
17.	78	164	151	128	110
18.	71	159	157	149	131
19.	59	165	165	138	135
20.	67	159	128	122	129
21.	52	185	120	168	142
22.	75	135	138	167	131
23.	54	156	142	135	135
24.	52	163	125	128	121
25.	58	165	171	143	109

Sr. No.	Control	BGA (*Nostoc*)	BGA+FYM	BGA+Vermicompost	Chemical Fertilizers
Average Flower Per Plant (Feet)	63	159	149	143	122

Table no. 1.1- Average Flower per Plant in feet.



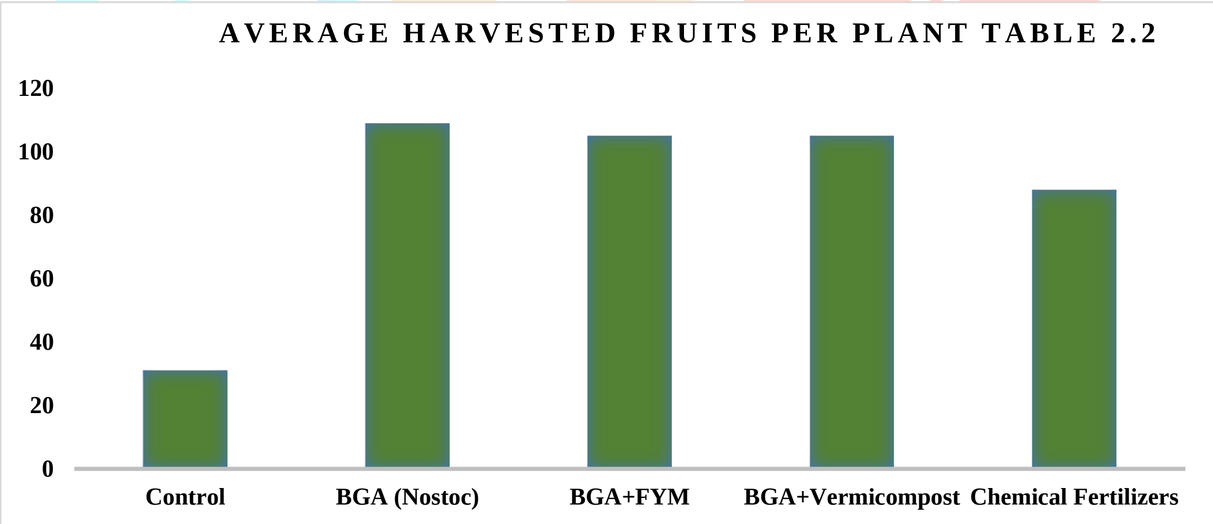
ii) Total number of harvested fruits per plants (Tabel no 2)

Sr. No.	Control	BGA (Nostoc)	BGA+FYM	BGA+Vermicompost	Chemical Fertilizers
1.	25	112	101	94	95
2.	35	105	110	95	84
3.	29	114	115	96	75
4.	28	119	98	97	89
5.	36	118	110	106	93
6.	31	111	104	101	85
7.	31	85	88	112	85
8.	29	86	84	117	81
9.	42	97	121	121	96
10.	36	105	120	119	105
11.	34	112	110	108	89
12.	29	106	103	97	75
13.	28	120	109	101	87
14.	31	119	117	109	86
15.	28	114	108	101	89
16.	30	107	124	108	89
17.	35	101	118	103	93

18.	29	98	117	99	97
19.	28	124	121	95	81
20.	29	117	107	111	76
21.	26	125	117	108	101
22.	27	123	121	117	107
23.	22	98	91	82	91
24.	35	95	89	108	77
25.	32	108	121	117	78

Sr. No.	**Control**	**BGA (*Nostoc*)**	**BGA+FYM**	**BGA+Vermicompost**	**Chemical Fertilizers**
Average Fruits Per Plant	31	109	105	105	88

Table no. 2.2- Average Fruits per plants.



iii) Soil Analysis:

a) (Before the Experiment): Three soil samples results have shown an average of **93.33 available N kg/ha** has been counted. This result shows that the present nitrogen content in the soil is low.

b) (After the Experiment): interestingly the soil analysis after the experiments shows a good amount of increased in the biological nitrogen of the soil i.e., **153 available N kg/ha** which can improve the soil fertility and will be helpful for the crop growth and development.

Figure 1. (a to i)

a) Blue Green Algae Fine Powder b) Local Cultivated Variety of Chilli c) Seeds has been planted in the baskets and the soil a long with treatments like Blue green algae (*Nostoc*), Farm Yard Manure and Vermicompost mixed. d) The Young plants planted into the agriculture field for further analysis e) Yo ung plants are fully grown f) Flower formation takes place almost after 10 weeks from the seeds plantation into the baskets g) Fruit formation after flo wering h) Single fruit e) ripened fruit of chilli crop

Discussion

Three species were utilized as inoculum in the pot culture of squash, tomato, and cucumber from these taxa. Algal extract can improve plant growth and seed germination in all treated plants as it increases plant height, root length, number of leaves, and fresh and dry weight of the root, leaf, and stem (Shariatmadari et al., 2010). Cyanobacterial strain extracts on multiple plant species, such as rice, wheat, maize, cotton etc., have demonstrated the synthesis of signalling metabolites (S. Singh 2014). Pre-soaking of seeds of pumpkin and cucumber with a Cyanobacteria extract can enhance their growth and germination (Nanda et al., 1991). Microalgal cellular extracts may be a more cost-effective and environmentally friendly option than synthetic liquid fertilizer (Supraja, K. V et al., 2020). Cellular extract, and dry algal biomass as biostimulants, foliar spray, and biofertilizer, respectively (Garcia & Sommerfeld 2016). Utilizing genetic engineering, biotechnological applications of cyanobacteria to produce distinctive products aim to enhance the product's quality. The potential applications of cyanobacteria include mariculture, food, fuel, feed, fertilizers, and secondary metabolites like vitamins, toxins, and enzymes (Kant et al., 2006). So, dew to these abilities these products have the potential to be highly profitable in the future provided producers and farmers have sufficient access to information through experience and communication. Together with contemporary agrochemicals, the Indian government has been attempting to apply more biofertilizers (Mazid and Khan 2014). Microalgal biostimulants, on the other hand, are known to positively impact crop development, growth, and yields; however, due to production costs and a lack of research, their commercial application is limited (Kapoore, R. V. 2021). Numerous characteristics of the organism directly or indirectly increase the amount of nitrogen (N), phosphorus (P), potassium (K), iron (Fe), and other minerals in the soils. They also help plants better utilize these minerals to promote plant growth and increase crop yield. Despite extensive research, the practical application of cyanobacteria's nitrogen fixation mechanisms remains to be seen (M Kumar et al.,2015). Algal biofertilizers boost plant growth, act as natural nutrient recyclers and reservoirs, and have all the previously mentioned benefits. Novel industrial processes have been developed for large-scale algae cultivation and the production of algal biofertilizers. A variety of algae have recently been investigated for their effects on cultivation, soil, and environment (Iqbal et al., 2021). Algal biofertilizer applied at the nanoscale offers enormous potential to increase agricultural productivity and promote appropriate development (Mahapatra et al. 2022).

Conclusion:

I. Impacts of Algalization on the yield of the crops.
To checked the yield properties in the form of chilli flower formation and then the fruits formation is one of the main aims of the research. By using these biofertilizers like BGA particularly Nostoc, shows a really good results as the count of flower are significantly more compare to chemical fertilizers. Even the rate of fruit formation from flowers is extremely good in BGA and also in the carrier inoculants used along with BGA as compare to Chemical fertilizers and control used as shown in table no 1 & 2.

II. Soil analysis has done before and after the experiments to checked the effects of biofertilizers on available soil nitrogen particularly. The nitrogen in the soil before applying biofertilizers was 93.33 N kg/ha which is very low and after the application of biofertilizers the nitrogen was 153 N kg/ha. So, increase in the soil biological nitrogen indicates the positive impacts of biofertlizers like BGA along with FYM and Vermicompost. So, it is concluded that the natural biofertilizers are really good for the agriculture soil as well as crops, it can secure the agriculture for the longer period as compare to the chemical fertilizers used agriculture field.

Conflict of Interest: Authors declares there is no conflict of interest.

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